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ComEd

February 27, 1997

JSPLTR: 97-0042

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-0001

SUBJECT: Dresden Nuclear Power Station Units 2 and 3
Additional Information Regarding Application for Amendment to Facility Operating Licenses DPR-19 and DPR-25, Appendix A, Technical Specifications, **Section 3/4.7.K, "Suppression Chamber," and Section 3/4.8.C, "Ultimate Heat Sink."**
Docket Nos. 50-237 and 50-249

Reference: J. Stephen Perry Letter to U.S. NRC, dated February 17, 1997; Dresden Nuclear Power Station Units 2 and 3, Application for Amendment to Facility Operating Licenses DPR-19 and DPR-25, Appendix A, Technical Specifications, Section 3/4.7.K, "Suppression Chamber," and Section 3/4.8.C, "Ultimate Heat Sink."

Pursuant to 10 CFR 50.90, ComEd has requested your approval of changes to Facility Operating Licenses DPR-19 and DPR-25 through the above reference. The purpose of this letter is to 1) provide the Staff with an additional set of benchmark calculations to validate the pressure response, both short and long term, of the SHEX containment analysis model used to support the License Amendment, 2) provide information regarding the status of activities which were incomplete at the time of submittal of the above reference, 3) clarify which attachments to the above reference were considered proprietary in nature, and 4) provide the Staff with the mass and energy release rates for the short and long term accident scenarios.

Benchmark Analysis

Previously, report GENE-770-26-1092 (reference 11 to the above February 17, 1997 Application for License Amendment) provided the suppression pool temperature response to benchmark the General Electric SHEX code against the Dresden UFSAR analysis. Based on our discussion with the NRC Staff at the January 30, 1997 meeting, ComEd has now completed an additional benchmark analysis for suppression pool temperature and suppression chamber pressure using a combination of two Low Pressure Coolant Injection (LPCI) Pumps and two Containment Cooling Service Water Pumps. The results of this analysis are provided as attachment A to this letter.

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The SHEX benchmark analysis provides excellent comparison of the long term pressure response, and the short term analysis also compares favorably. In the short term pressure response, minor differences exist over a nominal period which is attributable to uncertainties associated with the actual ECCS vessel injection modeled in the original analysis.

Supporting Calculations

Environmental Qualification-This item has changed due to the higher suppression pool temperature of 176 degrees F. The increased temperature parameter affects the following areas:

Reactor Building Corner Rooms-The calculation to determine the environment has been completed and all environmentally qualified equipment is qualified to the postulated environmental conditions.

Torus Area-The environment was conservatively chosen to equal the suppression pool water temperature and all environmentally qualified equipment is qualified to this postulated temperature.

Reactor Building General Areas-The temperature will increase by 6 degrees F due to the higher Suppression Pool Temperature. The calculation for this temperature rise will be finalized by March 7, 1997. The temperature increase of 6 degrees F will bring the temperature in the reactor building general areas to 110 degrees F, which is still below 120 degrees F that is considered the upper limit for a mild environment.

Electrical Loading-The impact of the higher than rated pump flow on the brake horsepower requirements for the motors has been reviewed and the conclusion in the UFSAR is not changed. The brake-horsepower varies slightly at runout conditions and the electrical load monitoring project evaluation will be updated by March 7, 1997.

Torus Attached Piping-Currently, 40 % margin exists in the current piping design and 20 % margin exists on pipe supports. Due to the suppression pool temperature increase to 176 degrees F, the increased thermal loading will effect the available margin, however, the piping including pipe supports and torus penetrations remain within UFSAR allowables. The only remaining item is update of the calculation to represent this fact. This will be completed by April 1, 1997.

The final results of the Environmental Qualification Temperatures, Electrical Loading and Torus Attached Piping loads will be supplied by April 1, 1997.

Proprietary Information

Proprietary information was provided in reference (a), however some attachments were erroneously mis-identified as proprietary. The actual proprietary attachments are as follows:

NEDE-30911, SHEX-04 User's Manual, Class II (GE Company Proprietary Information), dated August 1985,

NEDE-30911-1, SHEX-04V User's Manual (Addendum to SHEX-04 User's Manual), Class II (GE Company Proprietary Information), dated June 1994, and

384HA497, Heat Exchanger (RHR), Heat Transfer Calculation Computer Program, Revision 2, (GE Company Proprietary Information), dated October 3, 1979.

The proprietary references described above are reference 15 and 25 to the February 17, 1997 Application for License Amendment. This is the only proprietary information provided to you through the reference submittal; other references are non-proprietary. An affidavit was provided for these documents.

Mass and Energy Release Rates

The available containment pressure is a combination of accident scenarios case 6A2 (less than 600 seconds) and case 2A1 (greater than 600 seconds). The results of these accident scenarios were provided to you in reference 4 and 19 to the February 17, 1997 Application for License Amendment. The mass and energy release rates for these cases are provided in attachment B to this letter.

If there are any questions regarding this issue, please contact Frank Spangenberg of my staff at (815) 942-2920, extension 3800.

Sincerely,

J. Stephen Perry
Site Vice President
Dresden Station

Attachment: a) Letter to J. Nash from S. Mintz, Dresden Containment Analyses for Limiting DBA-LOCA, dated February 17, 1997.

b) Letter to J. Nash from S. Mintz, Dresden Containment Analyses for ComEd NPSH Evaluations. Transmittal of Mass and Energy Release Rates, dated February 25, 1997.

cc: A. Bill Beach, Regional Administrator - RIII
Senior Resident Inspector -Dresden
J. F. Stang, Dresden Project Manager, NRR
Office of Nuclear Facility Safety - IDNS

GE Nuclear Energy

General Electric Company
175 Curtner Avenue, San Jose, CA 95125

February 17, 1997

cc: N. Shirley
DRF T23-00740

To: J. Nash

From: S. Mintz

Subject: Dresden Containment Analyses for Limiting DBA-LOCA.

References:

1. Proposal for Analysis of Hx Performance and Suppression Pool Temperate and Chamber Pressure and Request for Fifth Change Order to Purchase Order 118064, (GE Proposal No. 523-1GY5D-EB0)," Letter K. Dias to S. Konrad (ComEd). February 10, 1997.

Attachment A to this letter provides the results for the work scope as defined in Reference 1. These tasks are performed to benchmark the results of the GE SHEX calculations of suppression pool temperature and suppression chamber pressure to the UFSAR analysis results. This benchmarking is performed for Case C of Section 6.2 of the Dresden UFSAR. This case assumes a two-LPCI/Containment Cooling pump flow of 10700 gpm and a two-CCSW pump flow of 7000 gpm for long-term containment cooling. Attachment B contains a digitized time history of suppression pool temperature and suppression chamber pressure obtained from the SHEX benchmark analysis.

The results in Attachment A are verified and can be used by ComEd to perform NPSH evaluations for LPCI/Containment Cooling pumps and CS pumps.

If you have any questions, please, contact me.

Performer	Verifier
S. Mintz	S. K. Rhow
Plant Upgrade Projects	Plant Upgrade Projects
M/C 172 Ext. 1791	M/C 172 Ext 1356

ATTACHMENT A
CONTAINMENT PRESSURE AND TEMPERATURE ANALYSIS FOR DRESDEN NPSH EVALUATIONS.

BENCHMARK OF CASE C OF UFSAR SECTION 6.2

ATTACHMENT A

1 Introduction

References 1 and 2 provided the long-term containment response to the DBA-LOCA for Dresden Units 2 and 3. Analyses described in these two references assumed two long-term containment cooling configurations: a) one LPCI/Containment Cooling pump and one containment cooling service water (CCSW) pump, b) two LPCI/Containment cooling pumps and two CCSW pumps.

References 3, 4 and 5 provided the suppression pool temperature and suppression chamber pressure responses to the DBA-LOCA assuming the following ECCS and containment cooling configuration.

> 2 LPCI/Containment Cooling Pump and 1 core spray (CS) pump up to 600 seconds following the DBA-LOCA.
>
> 1 LPCI/Containment Cooling Pump, 2 CCSW pumps and 1 CS pump after 600 seconds.

In response to a request by ComEd (Reference 6), the suppression pool temperature and suppression chamber pressure responses to the DBA-LOCA have been calculated using assumptions which are consistent with the assumptions used for Case C of Section 6.2 of the UFSAR. This case is used to benchmark the results of the GE SHEX code analysis results to the UFSAR analysis results for Case C of Section 6.2. Case C assumes 1 Containment Cooling loop with one heat exchanger, 2 LPCI/Containment Cooling pumps and 2 CCSW pumps are available for long-term containment cooling. This case provides an additional benchmark to that provided in Reference 2.

2. Analysis Results

Calculation of Suppression Pool Temperature and Suppression Chamber Pressure for UFSAR Case C

Two cases, Cases 7 and 7a, are used to benchmark the GE SHEX code to the Dresden UFSAR containment analysis in Section 6.2. Case 7 is used to benchmark the long-term response (from 600 seconds to past the time of peak suppression pool temperature). Case 7a is used to benchmark the short-term response (from approximately 30 seconds to 600 seconds in the event). The results of these analyses then compared to the results for Case C of Section 6.2 of the Dresden UFSAR. Case C corresponds to a long-term containment cooling configuration of 2 LPCI/Containment Cooling Pumps and 2 Containment Cooling Service Water (CCSW) Pumps.

Case 7 Long-term SHEX Benchmark Analysis

Case 7 is used to benchmark the SHEX code to the UFSAR analysis for a 2 LPCI/Containment Cooling Pumps and 2 Containment Cooling Service Water (CCSW) Pump long-tern containment cooling configuration. The benchmark analysis will use the same inputs and assumptions as used originally to analyze the containment response for a 2 LPCI/Containment Cooling Pumps and 2 Containment Cooling Service Water (CCSW) Pumps long-tern containment cooling configuration (Case C of Section 6.2 of the Dresden UFSAR).

Case 7 will be performed through the time of the peak suppression pool temperature and will be used to benchmark the SHEX results to the UFSAR curve for Case C from 600s to past the time of the peak suppression pool temperature.

The key inputs include:

Initial Suppression Pool Temperature of 90°F.

Initial Drywell and Wetwell pressure = 1.0 psig
(Based on a review of Figure 6.2-19 of the Dresden UFSAR which shows a wetwell pressure of 1.0 psig at 0.1 seconds which will be the same as initial value. It is expected that the initial drywell pressure is equal to the initial wetwell pressure).

No Feedwater Addition

No Pump Heat for Pumps Taking Suction from the Suppression Pool

May-Witt Decay Heat

A 2 LPCI/Containment Cooling pump flow of 10,000 gpm and a Core Spray (CS) pump flow of 4500 gpm for vessel injection prior to 10 minutes. A CS pump flow of 4500 gpm for vessel injection after 10 minutes. (Case C assumptions).

A LPCI/Containment Cooling Heat Exchanger Heat Removal Rate of 416.7 BTU/sec-°F

(Corresponds to a heat removal rate of 105 MBTU/hr for a combined 2 LPCI/Containment Cooling Pump Flow rate of 10,700 gpm and a combined 2 CCSW pump flow of 7000 gpm and with a heat exchanger cold side inlet water temperature of 95°F and a hot side inlet water temperature of 165°F. This is Mode B of the LPCI/Containment Cooling System Process Diagram, Reference 10)

100% Mixing of Break Fluids with the Drywell Atmosphere

Mechanistic Heat and Mass Transfer between the suppression pool water and suppression chamber atmosphere.

Use of drywell and suppression chamber sprays which are initiated at 600 seconds.

Case 7a Short-term SHEX Benchmark Analysis

Case 7a is used to simulate the time period prior to 600 seconds (when containment sprays are assumed to be initiated). Case 7a is used to benchmark the SHEX results to the UFSAR curve for Case C prior to 600 seconds.

Case 7a uses the same assumptions as for Case 7 with the exception that inputs are used to simulate thermal equilibrium between the suppression chamber airspace and suppression pool. This assumption is consistent with the UFSAR assumptions for the short-term containment response.

Note that for benchmarking purposes only the time period between approximately 30 seconds and 600 seconds from Case 7a will be used. This is since other models are used to better simulate the containment response at earlier times.

The GE computer model SHEX-04 (References 7 and 8) was used in the analyses.

Except as described above, key input assumptions for the present analyses are consistent with the general containment parameters used in the analyses of References 1, 2, 3, 4 and 5 as confirmed in Reference 9.

SHEX Analysis Results

Table 1 summarize the results for of the containment analyses performed for Dresden.

The results in Tables 3 include the suppression pool temperature and suppression chamber pressure at 600 seconds (at initiation of operator actions) from Case 7a , the minimum suppression chamber pressure following initiation of containment (drywell and suppression chamber) sprays from Case 7, the peak suppression pool temperature from Case 7 and the peak secondary suppression chamber pressure from Case 7.

Figures 1-4 show the full suppression pool temperature and suppression chamber pressure responses from Cases 7 and 7a. Figures 5 and 6 show combined suppression pool temperature and suppression chamber pressure plots respectively using data from Case 7a (for t < 600) seconds and from Case 7 (for t > 600 seconds). Figure 6 also contains the UFSAR curve for Case C superimposed over the SHEX curve for comparison. Attachment B contains the digitized suppression pool temperature and suppression chamber pressure used to generate Figures 5 and 6.

Results Discussion

Suppression Pool Temperature

As shown in Table 1, the peak suppression pool temperature is 163°F. The Dresden UFSAR does not contain suppression pool temperature for this Case. However, Figure 6.2-20 of Section 6.2 shows the drywell temperature. A peak long-term drywell temperature of approximately 168°F is indicated for Case C. According to the text in the UFSAR the drywell temperature is equal to the temperature of the break flow and drywell spray mixture plus 5°F. It can be demonstrated that the suppression pool temperature is approximately 1°F lower than the drywell mixture temperature and therefore approximately 6°F lower than the drywell temperature reported in Figure 6.2-20 at the time of the peak suppression pool temperature (see Appendix 1 to this Attachment). Therefore a peak suppression pool temperature of 162°F can be inferred from the Dresden UFSAR by subtracting 6°F (see Appendix 1) from the peak long-term drywell temperature shown in Figure 6.2-20. This temperature is very close to the SHEX calculated value of 162.5°F for the benchmark case.

The results of the Quad Cities plant UFSAR containment analysis can be also be used to benchmark the SHEX results since the Quad Cities is very similar to Dresden with respect to vessel size and containment parameters. Case C in Section 6.2 of the Quad Cities UFSAR also assumes 2 RHR pumps and 2 service water pumps for long-term containment cooling. The peak suppression pool temperature for Case C of Section 6.2 of the Quad Cities UFSAR is 162°F which is within 1°F of the value of 162.5°F obtained with the SHEX analysis for this case.

Suppression Chamber Pressure.

Short-term pressure

The suppression chamber pressure at 10 minutes is within 1 psi of the value from Figure 6.2-19. The difference in the depressurization rate between initiation of drywell depressurization and 10 minutes may be attributed to differences in assumptions regarding number of pumps used for vessel injection. In the UFSAR there is a single curve shown for all pump configurations prior to 10 minutes. There is also no reference to the use of LPCI/Containment Cooling pumps for vessel injection. Therefore there is some uncertainty in the number of LPCI/Containment cooling pumps assumed for vessel injection in the UFSAR analysis which may contribute to the difference between the SHEX benchmark analysis results and the UFSAR curve of Figure 6.2-19.

Long-term pressure

The minimum suppression chamber pressure following initiation of drywell and suppression chamber sprays is lower for the SHEX benchmark case than for the UFSAR curve. This is in part attributed to the fact that the drywell and wetwell were assumed to be at the same pressure in the UFSAR, while SHEX models the drywell and wetwell separately. However, as shown in Figure 6, the long-term suppression chamber response compares favorably with the UFSAR curve. The peak long-term suppression chamber pressure for this case is 6.4 psig which is close to the value of approximately 6.5 psig estimated from Curve C of UFSAR Figure 6.2-19.

3. References

1. GENE-770-26-1092, "Dresden Nuclear Power Station, Units 2 and 3, LPCI/Containment Cooling System Evaluation," November 1992.

2. GENE-637-042-1193, "Dresden Nuclear Power Station, Units 2 and 3, Containment Analyses of the DBA-LOCA to Update the Design Basis for the LPCI/Containment Cooling System. February 1994.

3. GE-NE-T2300740-1, "Dresden Nuclear Power Station, Units 2 and 3, Containment Analyses of the DBA-LOCA Base on Long-Term LPCI/Containment Cooling System Configuration of One LPCI/Containment Cooling System Pump and 2 CCSW Pumps, "Class II, December 1996.

4. Letter, S. Mintz to J. Nash, "Dresden Containment Analyses for Limiting DBA-LOCA," November 18, 1996

5. Letter, S. Mintz to J. Nash, "Dresden Containment Analyses for Limiting DBA-LOCA," December 26, 1996

6. Proposal for Analysis of Hx Performance and Suppression Pool Temperate and Chamber Pressure and Request for Fifth Change Order to Purchase Order 118064, (GE Proposal No. 523-1GY44-EB0)," Letter K. Dias to S. Konrad (ComEd). February 10, 1997.

7. NEDO-10320, "The GE Pressure Suppression Containment System Analytical Model," May 1971.

8. NEDO-20533, "The General Electric Mark III Pressure Suppression Containment System Analytical Model," June 1974.

9. Letter, J. W. Dingler (ComEd) to J. Nash (GE), "Inputs Parameters for Suppression Pool Pressure and Temperature Analysis," October 1996.

10. GE Drawing 729E583, Process Diagram , "LPCI Containment Cooling System"

TABLE 1 - SUMMARY OF DRESDEN CONTAINMENT ANALYSIS RESULTS

	SHEX BENCHMARK ANALYSIS	UFSAR CASE C
Suppression Chamber Airspace Pressure at 600 sec (psig) (At initiation of operator actions)	10.2 (Case 7a)	~11.0***
Minimum Suppression Chamber Pressure Following Initiation of Containment Spray (psig)	4.8 (Case 7)	~6.0***
Peak Long-Term Suppression Pool Temperature (°F)	162.5 (Case 7)	~162* 162**
Secondary Peak Long-Term Suppression Chamber Airspace Pressure (psig)	6.4 (Case 7)	~6.5***

*Estimated from Dresden UFSAR Figure 6.2-20 by subtracting 6°F from the long-term drywell temperature peak for Curve C.
** Value obtained for Case C From Table 6.2-3 of the Quad Cities UFSAR.
*** Estimated from Dresden UFSAR Figure 6.2-19 for Curve C.

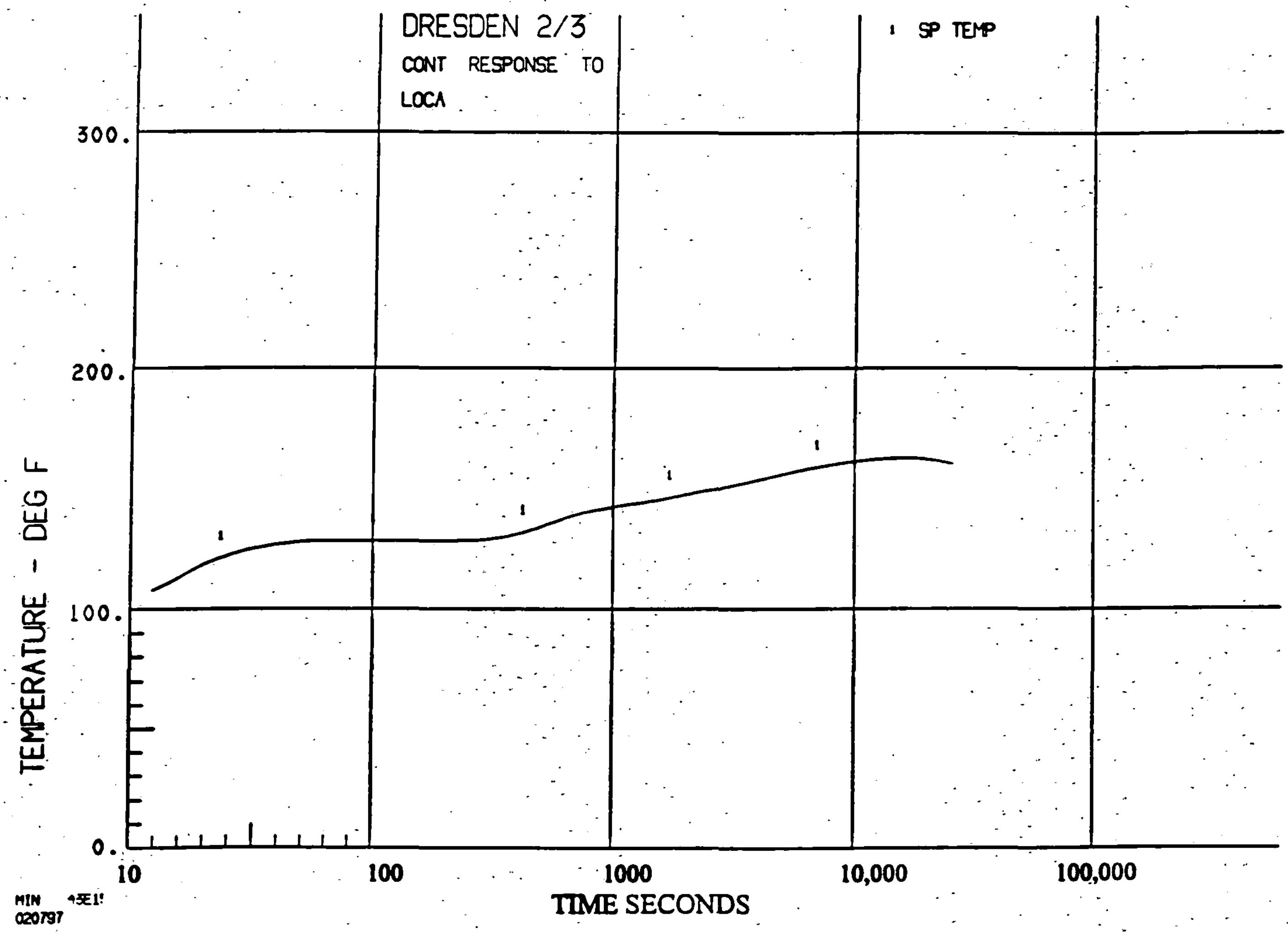

Figure 1 - DBA-LOCA UFSAR CASE C Suppression Pool Temperature Response.
SHEX Case 7

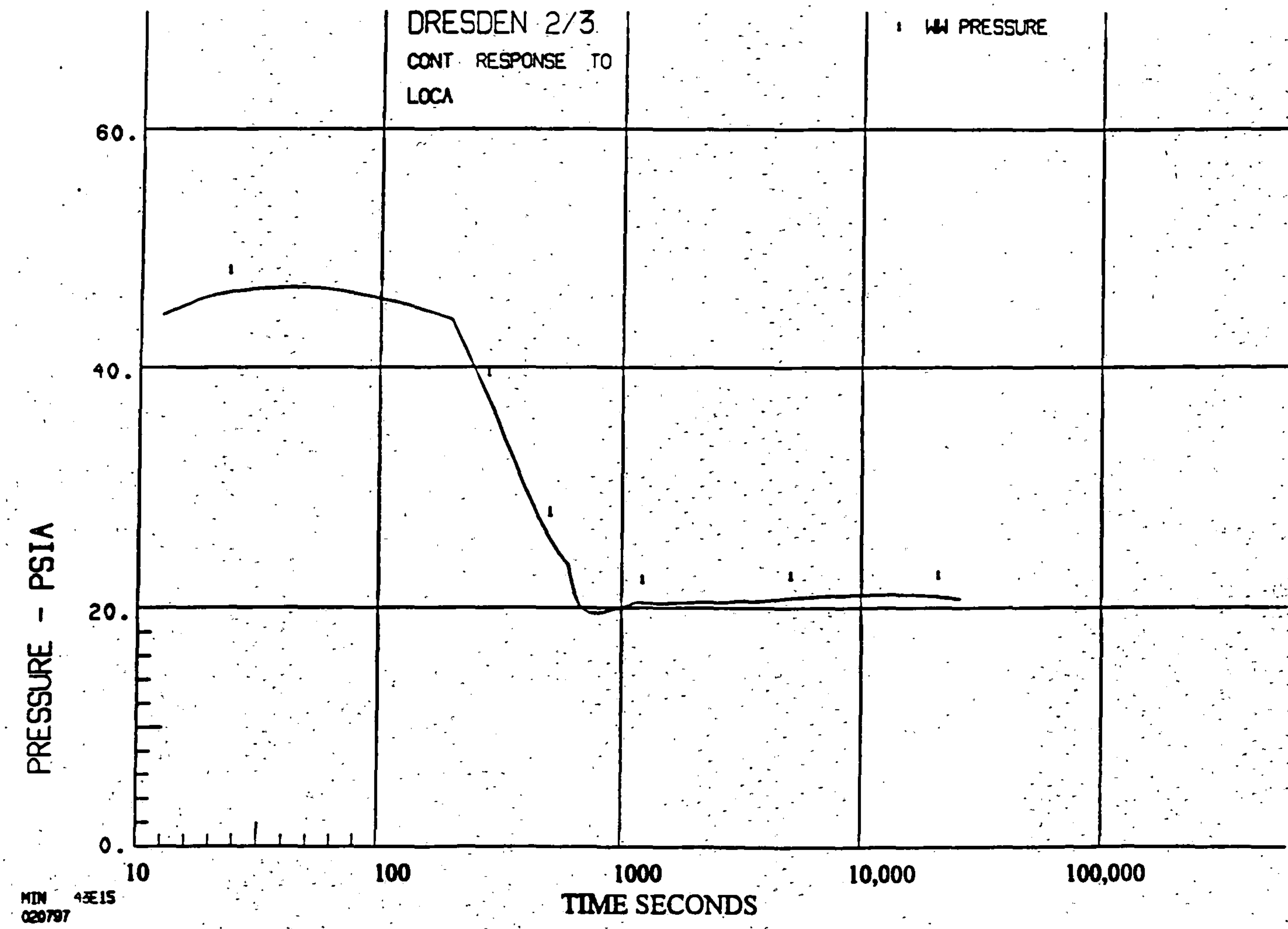

Figure 2 - DBA-LOCA UFSAR CASE C Suppression Chamber Pressure Response.
SHEX Case 7

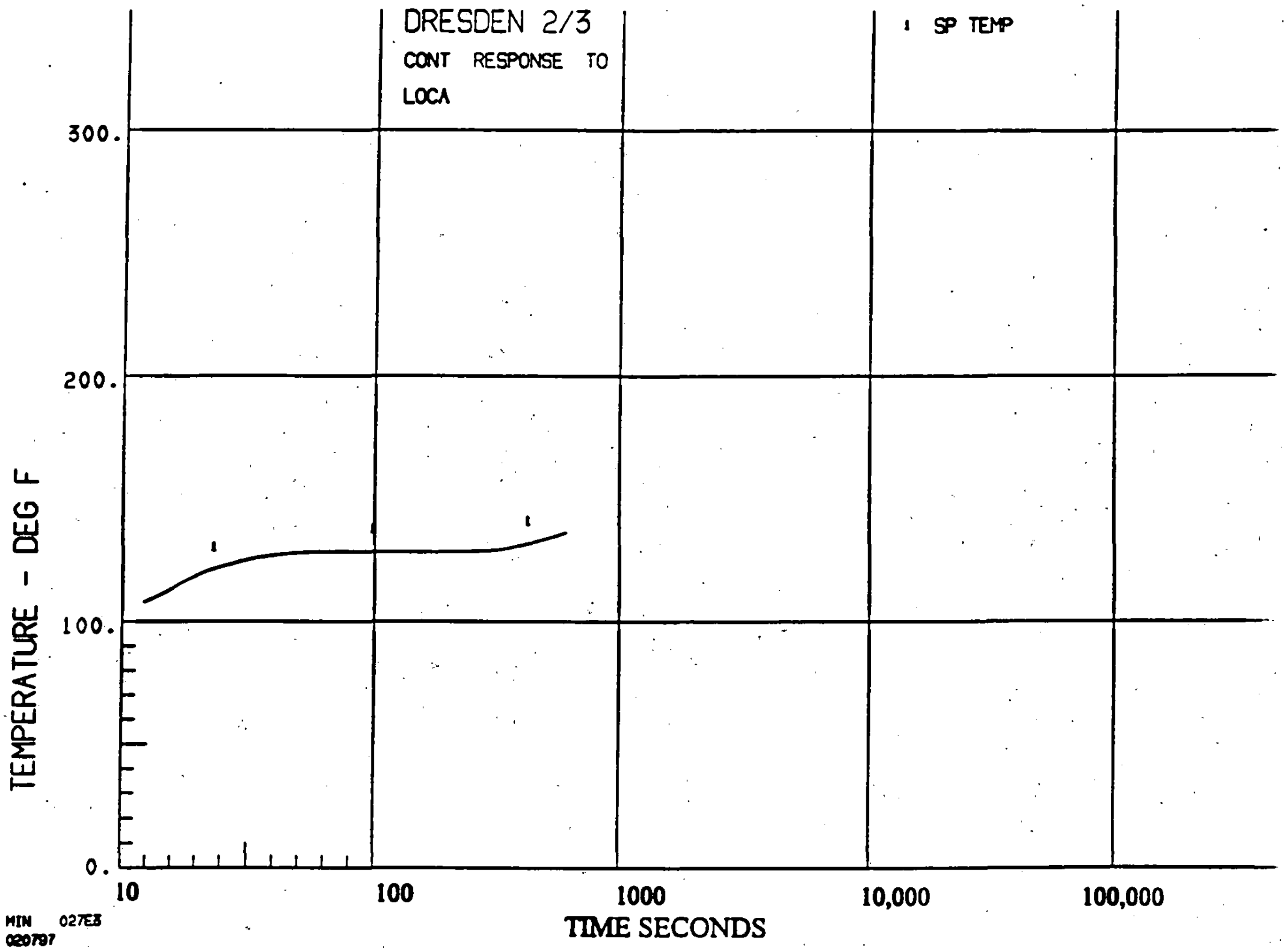

Figure 3 - DBA-LOCA UFSAR CASE C Suppression Pool Temperature Response.
SHEX Case 7a - Thermal Equilibrium in Suppression Chamber

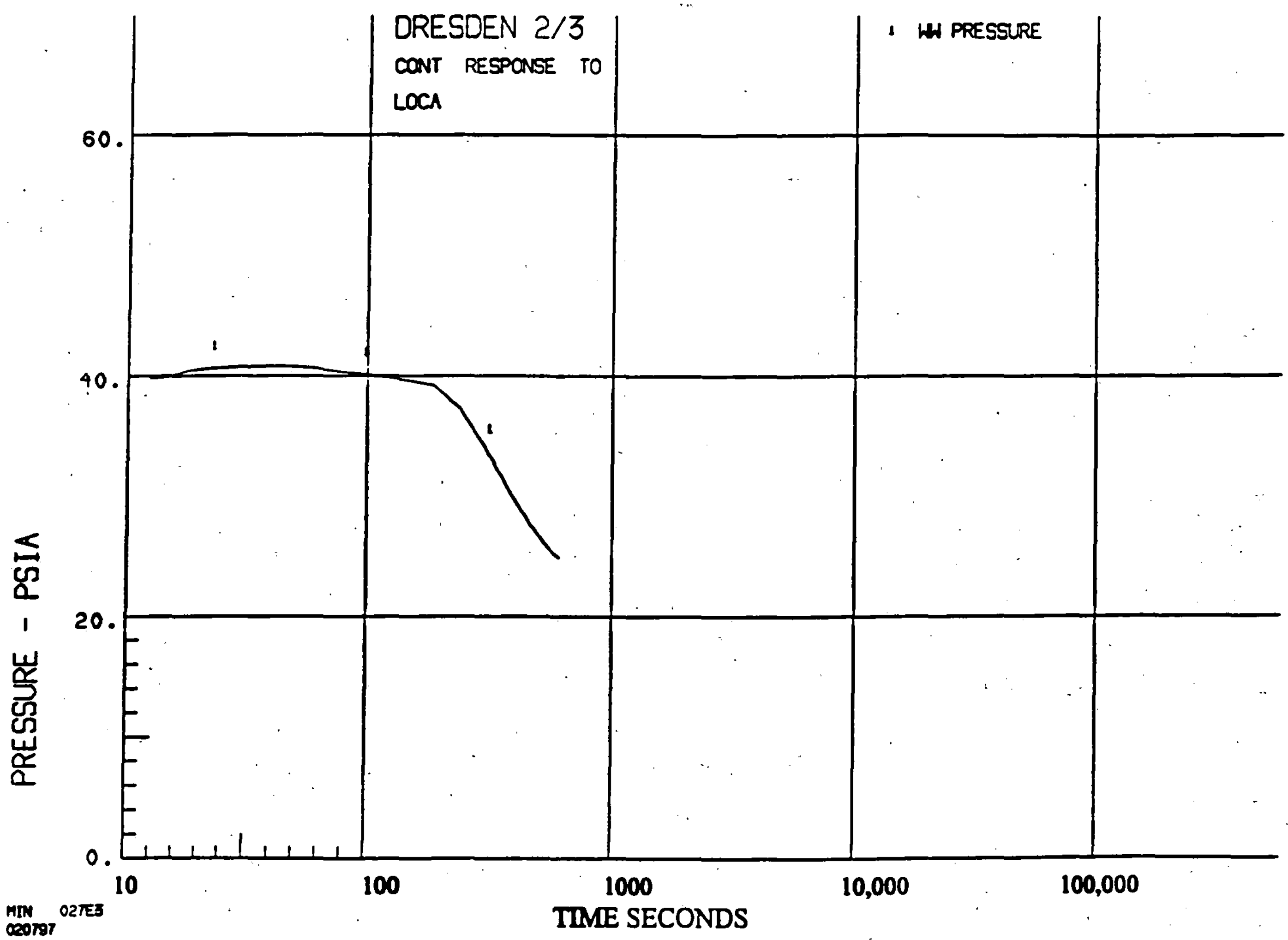

Figure 4 - DBA-LOCA UFSAR CASE C Suppression Chamber Pressure Response.
SHEX Case 7a - Thermal Equilibrium in Suppression Chamber

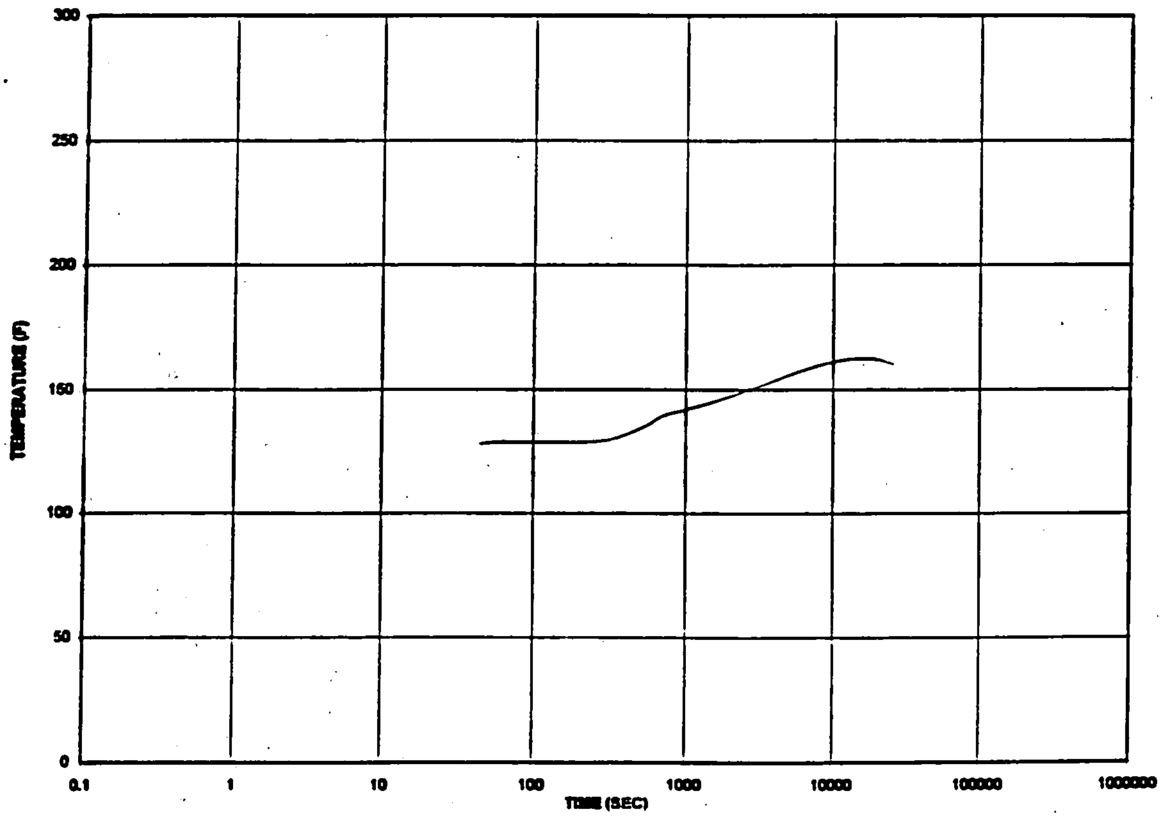

Figure 5 - DBA-LOCA Suppression Pool Temperature Response. SHEX Benchmark for UFSAR Case C

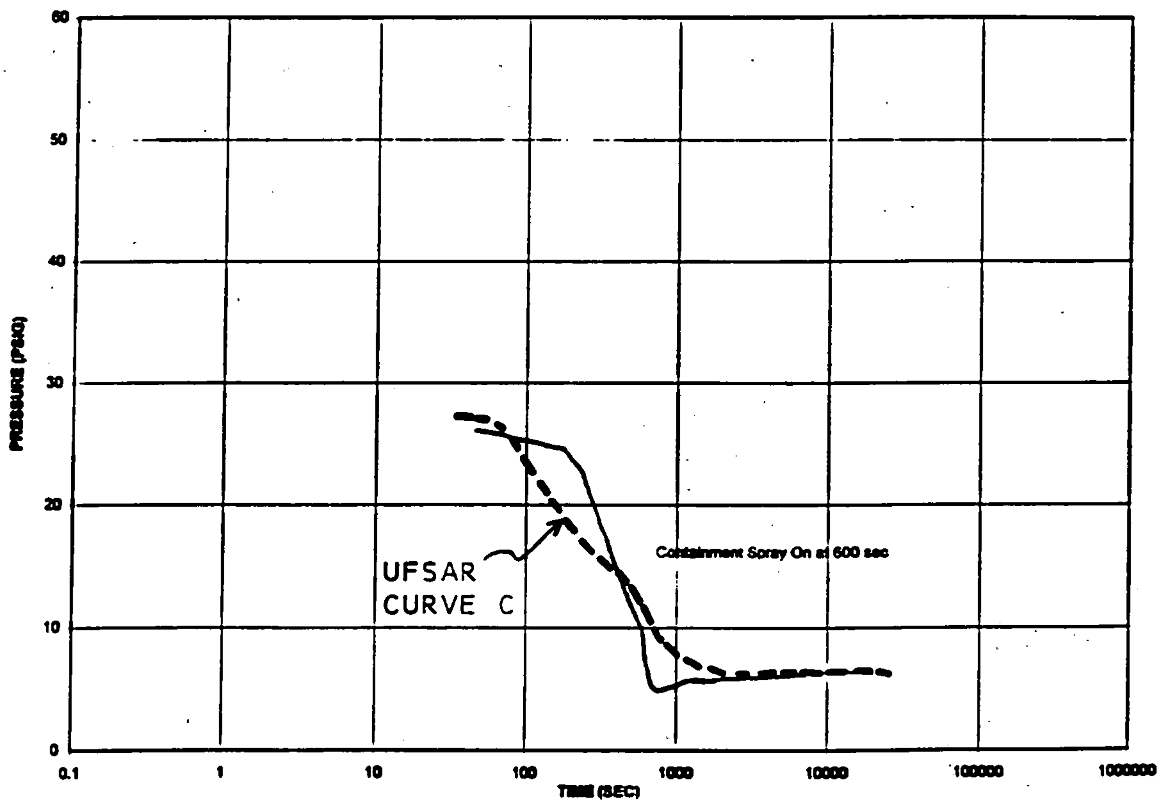

Figure 6 - DBA-LOCA Suppression Chamber Pressure Response. SHEX Benchmark for UFSAR Case C

Appendix 1 to Attachment A

Estimate of Drywell Temperature at Time of Peak Suppression Pool Temperature

The drywell temperature can be estimated by the suppression pool temperature (within 1°F) at the time of the peak suppression pool temperature. This is demonstrated below.

During the long-term phase of the event steady state conditions exist with respect to mass transfer in and out of the suppression pool.

Mass Balance on Suppression Pool

$m_{in} = m_v + m_{wws} = m_{out} = m_{cs} + m_L$ (1)

where:

m_{in} = mass flow into suppression pool
m_{out} = mass flow out of suppression pool

m_v = mass flow from dw to suppression pool through vent
$= m_b + m_{dws}$

m_{cs} = core spray pump suction from the suppression pool

m_L = LPCI/Containment Cooling pump suction from the suppression pool
$= m_{dws} + m_{wws}$

m_b = break flow = m_{cs}

m_{dws} = drywell spray flow

m_{wws} = wetwell spray flow

At the time of the peak suppression pool temperature the energy going into the pool is equal to the energy going out.

Heat Balance on Suppression Pool

$E_{out} = m_L h_p + m_{cs} h_p = E_{in} = m_v h_v + m_{wws} h_{wws}$ (2)

or

$h_v = [(m_L + m_{cs}) h_p - m_{wws} h_{wws}]/m_v$ (3)

Where

h_p = pool enthalpy
h_v = enthalpy of vent flow to pool
h_{wws} = enthalpy of wetwell spray = $h_p - K(T_p-T_{sw})/m_L$
K = heat exchanger heat transfer rate in Btu/°F-sec
T_p = pool temperature at time of peak suppression pool temperature
T_{sw} = service water temperature

From (3) and the definition of h_{wws}

$$h_v = (m_L+ m_{cs}) h_p- m_{wws} [h_p- \{K(T_p-T_{sw})/m_L\}]/m_v \qquad (4)$$

or

$$h_v = h_p + \{K(T_p-T_{sw})/m_L\}(m_{wws}/ m_v) \qquad (5)$$

According to the UFSAR the drywell temperature is defined as

$$T_{dw} = T_v + 5°F$$

Where:

T_{dw} = drywell temperature
T_v = temperature of exiting drywell fluid

This is equivalent to:

$$h_{dw} = h_v+5 \text{ btu/lbm} \qquad (6)$$

Where

h_{dw} = drywell enthalpy

Therefore from (5) and (6)

$$h_{dw} = h_p +5 + \{K(T_p-T_{sw})/m_L\}(m_{wws}/ m_v) \quad (7)$$

The numerical value of ($h_{dw}-h_p$) in Btu/lbm will be equal to the numerical value of $T_{dw}-T_p$ in degrees F. Therefore Eq. (7) can be written as:

$$T_{dw}-T_p = 5 + \{K(T_p-T_{sw})/m_L\}(m_{wws}/ m_v) \ (8)$$

or

$$T_p = \frac{T_{dw}-5 +(K(T_{sw}))(m_{wws}/ m_L*m_v)}{[1+K(m_{wws}/m_L\, m_v)]} \quad (9)$$

To determine the pool temperature at the time of peak suppression pool temperature, based on the drywell temperature, numerical values from the Dresden UFSAR analysis for Case C are inserted into (9).

$K = 416.7$ Btu/sec-°F
$m_L = 1484$ lbm/sec
$m_{wws} = 74$ lbm/sec
$T_{dw} = 168$°F (From UFSAR Figure 6.2-20)
$T_{sw} = 95$°F

$m_v = m_{dws} + m_b = m_{dws} + m_{cs} = 1410$ lbm/sec + 624 lbm/sec = 2034 lbm/sec

Therefore from (9):

$T_p = 162.3$ °F

This temperature is approximately 6°F lower than the drywell temperature in UFSAR Figure 6.2-20.

This temperature is also approximately 1°F lower than the mixture temperature of the fluid exiting the drywell since the mixture temperature is 5°F lower than the drywell temperature reported in Figure 6.2-20 according to the UFSAR.

ATTACHMENT B

DIGITIZED SUPPRESSION POOL TEMPERATURE AND SUPPRESSION CHAMBER PRESSURE
SHEX BENCHMARK ANALYSIS FOR CASE C OF UFSAR SECTION 6.2

TIME PERIOD > 600 SECONDS FROM CASE 7

TIME PERIOD ≤ 600 SECONDS FROM CASE 7A

TIME (SECONDS)	SUPPRESSION CHAMBER PRESSURE (PSIG)	SUPPRESSION POOL TEMPERATURE (°F)
0.0	1.0	90.0
0.6	4.3	90.2
3.9	21.4	94.6
13.9	25.2	110.6
20.2	25.8	119.3
28.7	26.0	124.4
33.8	26.1	126.1
37.4	26.1	126.9
40.1	26.1	127.4
43.5	26.1	127.9
45.6	26.1	128.1
47.4	26.0	128.3
48.9	26.0	128.4
50.5	26.0	128.5
52.1	26.0	128.6
53.6	26.0	128.6
55.2	26.0	128.7
56.7	25.9	128.8
58.3	25.9	128.8
64.7	25.8	128.8
96.0	25.4	128.7
127.2	25.0	128.7
158.5	24.7	128.7
182.4	24.5	128.7
234.0	22.6	128.9
301.8	19.0	129.5
366.8	16.0	130.8
431.9	13.7	132.4
491.2	12.1	134.0
504.1	11.8	134.3
511.1	11.6	134.4
518.2	11.5	134.6
525.8	11.4	134.8
532.9	11.2	135.0
541.7	11.0	135.2
552.6	10.9	135.4
563.8	10.7	135.7
573.9	10.5	136.0
585.5	10.4	136.2
597.1	10.2	136.5
600.2	10.2	136.5
606.7	8.3	136.8

TIME (SECONDS)	SUPPRESSION CHAMBER PRESSURE (PSIG)	SUPPRESSION POOL TEMPERATURE (°F)
614.4	7.7	137.1
623.5	7.2	137.5
631.7	6.8	137.7
642.8	6.4	138.0
652.3	6.0	138.3
663.0	5.7	138.6
674.8	5.4	138.8
688.4	5.2	139.1
700.9	5.1	139.3
716.2	5.0	139.5
730.0	4.9	139.8
746.8	4.9	140.0
762.3	4.8	140.2
776.3	4.8	140.3
792.2	4.9	140.5
808.0	4.9	140.6
824.8	4.9	140.8
838.8	4.9	140.9
856.7	5.0	141.0
872.9	5.0	141.1
891.5	5.1	141.3
907.8	5.1	141.4
926.0	5.2	141.5
942.5	5.2	141.6
959.0	5.3	141.7
975.5	5.3	141.8
991.0	5.4	142.0
1140.0	5.8	143.0
1398.5	5.7	144.6
1666.8	5.8	146.0
1928.0	5.8	147.2
2179.2	5.8	148.2
2428.5	5.8	149.1
2675.9	5.8	149.9
2924.9	5.9	150.7
3178.2	5.9	151.5
3423.0	5.8	152.2
3670.5	5.9	152.8
3916.3	5.9	153.5
4156.0	6.0	154.0
4407.8	6.0	154.6

TIME (SECONDS)	SUPPRESSION CHAMBER PRESSURE (PSIG)	SUPPRESSION POOL TEMPERATURE (°F)
4667.5	6.1	155.2
4923.0	6.1	155.7
5173.0	6.1	156.1
5426.0	6.2	156.6
5681.7	6.2	157.0
5939.4	6.2	157.4
6185.8	6.2	157.7
6433.3	6.2	158.0
6685.0	6.3	158.4
6929.8	6.3	158.6
7174.8	6.3	158.9
7427.9	6.3	159.2
7675.7	6.3	159.4
7930.2	6.3	159.7
8179.3	6.3	159.9
8439.0	6.3	160.1
8691.8	6.3	160.3
8937.8	6.4	160.5
9184.8	6.4	160.7
9430.8	6.4	160.8
9685.3	6.4	161.0
9933.8	6.4	161.1
10181.8	6.4	161.2
10436.6	6.4	161.4
10688.3	6.4	161.5
10947.8	6.4	161.6
11196.1	6.4	161.7
11440.1	6.4	161.8
11694.1	6.4	161.9
11940.1	6.4	161.9
12186.0	6.4	162.0
12440.2	6.4	162.1
12696.2	6.4	162.1
12950.7	6.4	162.2
13212.2	6.4	162.2
13467.5	6.4	162.3
13715.5	6.4	162.3
13966.2	6.4	162.4
14216.8	6.4	162.4
14470.1	6.4	162.4

TIME (SECONDS)	SUPPRESSION CHAMBER PRESSURE (PSIG)	SUPPRESSION POOL TEMPERATURE (°F)
14726.1	6.4	162.4
14980.3	6.4	162.5
15240.6	6.4	162.5
15489.3	6.4	162.5
15742.8	6.4	162.5
15995.0	6.4	162.5
16247.0	6.4	162.5
16494.0	6.4	162.5
16745.2	6.3	162.4
16995.4	6.3	162.4
17249.2	6.3	162.4
17500.7	6.3	162.4
17755.9	6.3	162.3
18009.2	6.3	162.3
18268.5	6.3	162.3
18522.3	6.3	162.2
18774.8	6.3	162.2
19022.0	6.3	162.1
19266.0	6.3	162.1
19521.4	6.2	162.0
19764.7	6.2	161.9
20011.7	6.2	161.9
20258.4	6.2	161.8
20468.3	6.2	161.8
20637.0	6.2	161.7
20805.8	6.2	161.7
21000.4	6.1	161.6
21191.9	6.1	161.5
21360.7	6.1	161.5
21529.4	6.1	161.4
21700.0	6.1	161.4
21868.8	6.1	161.3
22037.5	6.1	161.3
22206.3	6.1	161.2
22381.8	6.1	161.2
22570.9	6.1	161.1
22821.3	6.1	161.0
23072.5	6.1	160.9
23332.2	6.1	160.8
23595.8	6.1	160.8
23861.2	6.1	160.7

TIME (SECONDS)	SUPPRESSION CHAMBER PRESSURE (PSIG)	SUPPRESSION POOL TEMPERATURE (°F)
24113.9	6.1	160.6
24366.7	6.1	160.5
24625.9	6.1	160.4
24877.9	6.1	160.3
25131.7	6.0	160.2
25385.2	6.0	160.1
25637.0	6.0	160.0
25677.8	6.0	160.0

Commonwealth Edison Company
Dresden Generating Station
6500 North Dresden Road
Morris, IL 60450
Tel 815-942-2920

ComEd

February 27, 1997

JSPLTR: 97-0042

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-0001

SUBJECT: Dresden Nuclear Power Station Units 2 and 3
Additional Information Regarding Application for Amendment to Facility Operating Licenses DPR-19 and DPR-25, Appendix A, Technical Specifications, **Section 3/4.7.K, "Suppression Chamber," and Section 3/4.8.C, "Ultimate Heat Sink."**
Docket Nos. 50-237 and 50-249

Reference: J. Stephen Perry Letter to U.S. NRC, dated February 17, 1997; Dresden Nuclear Power Station Units 2 and 3, Application for Amendment to Facility Operating Licenses DPR-19 and DPR-25, Appendix A, Technical Specifications, Section 3/4.7.K, "Suppression Chamber," and Section 3/4.8.C, "Ultimate Heat Sink."

Pursuant to 10 CFR 50.90, ComEd has requested your approval of changes to Facility Operating Licenses DPR-19 and DPR-25 through the above reference. The purpose of this letter is to 1) provide the Staff with an additional set of benchmark calculations to validate the pressure response, both short and long term, of the SHEX containment analysis model used to support the License Amendment, 2) provide information regarding the status of activities which were incomplete at the time of submittal of the above reference, 3) clarify which attachments to the above reference were considered proprietary in nature, and 4) provide the Staff with the mass and energy release rates for the short and long term accident scenarios.

Benchmark Analysis

Previously, report GENE-770-26-1092 (reference 11 to the above February 17, 1997 Application for License Amendment) provided the suppression pool temperature response to benchmark the General Electric SHEX code against the Dresden UFSAR analysis. Based on our discussion with the NRC Staff at the January 30, 1997 meeting, ComEd has now completed an additional benchmark analysis for suppression pool temperature and suppression chamber pressure using a combination of two Low Pressure Coolant Injection (LPCI) Pumps and two Containment Cooling Service Water Pumps. The results of this analysis are provided as attachment A to this letter.

The SHEX benchmark analysis provides excellent comparison of the long term pressure response, and the short term analysis also compares favorably. In the short term pressure response, minor differences exist over a nominal period which is attributable to uncertainties associated with the actual ECCS vessel injection modeled in the original analysis.

Supporting Calculations

Environmental Qualification-This item has changed due to the higher suppression pool temperature of 176 degrees F. The increased temperature parameter affects the following areas:

Reactor Building Corner Rooms-The calculation to determine the environment has been completed and all environmentally qualified equipment is qualified to the postulated environmental conditions.

Torus Area-The environment was conservatively chosen to equal the suppression pool water temperature and all environmentally qualified equipment is qualified to this postulated temperature.

Reactor Building General Areas-The temperature will increase by 6 degrees F due to the higher Suppression Pool Temperature. The calculation for this temperature rise will be finalized by March 7, 1997. The temperature increase of 6 degrees F will bring the temperature in the reactor building general areas to 110 degrees F, which is still below 120 degrees F that is considered the upper limit for a mild environment.

Electrical Loading-The impact of the higher than rated pump flow on the brake horsepower requirements for the motors has been reviewed and the conclusion in the UFSAR is not changed. The brake-horsepower varies slightly at runout conditions and the electrical load monitoring project evaluation will be updated by March 7, 1997.

Torus Attached Piping-Currently, 40 % margin exists in the current piping design and 20 % margin exists on pipe supports. Due to the suppression pool temperature increase to 176 degrees F, the increased thermal loading will effect the available margin, however, the piping including pipe supports and torus penetrations remain within UFSAR allowables. The only remaining item is update of the calculation to represent this fact. This will be completed by April 1, 1997.

The final results of the Environmental Qualification Temperatures, Electrical Loading and Torus Attached Piping loads will be supplied by April 1, 1997.

Proprietary Information

Proprietary information was provided in reference (a), however some attachments were erroneously mis-identified as proprietary. The actual proprietary attachments are as follows:

NEDE-30911, SHEX-04 User's Manual, Class II (GE Company Proprietary Information), dated August 1985,
NEDE-30911-1, SHEX-04V User's Manual (Addendum to SHEX-04 User's Manual), Class II (GE Company Proprietary Information), dated June 1994, and
384HA497, Heat Exchanger (RHR), Heat Transfer Calculation Computer Program, Revision 2, (GE Company Proprietary Information), dated October 3, 1979.

The proprietary references described above are reference 15 and 25 to the February 17, 1997 Application for License Amendment. This is the only proprietary information provided to you through the reference submittal; other references are non-proprietary. An affidavit was provided for these documents.

Mass and Energy Release Rates

The available containment pressure is a combination of accident scenarios case 6A2 (less than 600 seconds) and case 2A1 (greater than 600 seconds). The results of these accident scenarios were provided to you in reference 4 and 19 to the February 17, 1997 Application for License Amendment. The mass and energy release rates for these cases are provided in attachment B to this letter.

If there are any questions regarding this issue, please contact Frank Spangenberg of my staff at (815) 942-2920, extension 3800.

Sincerely,

J. Stephen Perry
Site Vice President
Dresden Station

Attachment: a) Letter to J. Nash from S. Mintz, Dresden Containment Analyses for Limiting DBA-LOCA, dated February 17, 1997.

b) Letter to J. Nash from S. Mintz, Dresden Containment Analyses for ComEd NPSH Evaluations. Transmittal of Mass and Energy Release Rates, dated February 25, 1997.

cc: A. Bill Beach, Regional Administrator - RIII
Senior Resident Inspector -Dresden
J. F. Stang, Dresden Project Manager, NRR
Office of Nuclear Facility Safety - IDNS

GE Nuclear Energy

General Electric Company
175 Curtner Avenue, San Jose, CA 95125

February 25, 1997

cc: N. Shirley
DRF T23-00740

To: J. Nash

From: S. Mintz

Subject: Dresden Containment Analyses for ComEd NPSH Evaluations. Transmittal of Mass and Energy Release Rates.

References:

1. GE-NE-T2300740-1, "Dresden Nuclear Power Station, Units 2 and 3, Containment Analyses of the DBA-LOCA Base on Long-Term LPCI/Containment Cooling System Configuration of One LPCI/Containment Cooling System Pump and 2 CCSW Pumps, "Class II, December 1996.
2. Letter, S. Mintz to J. Nash, "Dresden Containment Analyses for Limiting Short-Term LOCA Event, " January 28, 1997.
3. Proposal for Supplying Containment Analysis Data to Support NRC Review and Approval of Dresden Licensing Submittal on Hx Performance and Suppression Pool Temperature and Chamber Pressure and Request for Sixth Change Order to Purchase Order 118064, (GE Proposal No. 523-1GY5D-EB0)," Letter K. Dias to S. Konrad (ComEd). February 24, 1997.

Attachment A to this letter provides the rates of mass and energy release into the drywell for Case 2A1 (with 20% thermal mixing) of Reference 1 and 6A2 of Reference 2 as requested by ComEd (Reference 3). The containment spray flow rate and enthalpy are also provided for Case 2A1. Electronic copies of the attached data in Microsoft EXCEL format are also being provided to you via E-mail.

It should be noted that energy release data is provided for the entire event duration to obtain the correct integrated mass and energy release for these cases. However, the initial blowdown history (first 30 seconds) should not be used as a basis for a detailed calculation of the initial drywell pressure history for the DBA-LOCA. Other models and assumptions are used to evaluate the containment response during this time period.

Please note that the data provided is coupled to the heat exchanger performance and the Core Spray (CS) and LPCI/Containment Cooling pump flow rates assumed for the analyses. Therefore, this data should be applied with the same heat exchanger performance and CS and LPCI/Containment Cooling pump flow rates as used in Cases 2A1 and Case 6A2.

The results in Attachment A are verified and can be used by ComEd.

If you have any questions, please, contact me.

Performer

S. Mintz
Plant Upgrade Projects
M/C 172 Ext. 1791

Verifier

S. K. Rhow
Plant Upgrade Projects
M/C 172 Ext 1356

ATTACHMENT A
CONTAINMENT PRESSURE AND TEMPERATURE ANALYSIS FOR DRESDEN NPSH EVALUATIONS.

MASS AND ENERGY RELEASE RATES

This attachment provides the following data. Mass and energy release time histories for Case 6A2 of Reference 1 and Case 2A1 (20% thermal mixing) of Reference 2. The data includes mass flow in lbm/sec and flow enthalpy in BTU/lbm. The data is provided in tabular form for these two cases.

Case 6A2 -

Mass flow (lbm/sec) and flow enthalpy (BTU/lbm) as a function of time corresponding to the break flow from the vessel.

Mass flow (lbm/sec) and flow enthalpy (BTU/lbm) as a function of time corresponding the LPCI/Containment Cooling pump flow being injected directly into the drywell.

Case 2A1 (20% thermal mixing)

Mass flow (lbm/sec) and flow enthalpy (BTU/lbm) as a function of time corresponding to the break flow from the vessel.

Mass flow (lbm/sec) and flow enthalpy (BTU/lbm) as a function of time corresponding to the drywell spray.

Mass flow (lbm/sec) and flow enthalpy (BTU/lbm) as a function of time corresponding to the suppression chamber spray.

COMMENTS REGARDING USE OF MASS AND ENERGY RELEASE DATA

It should be noted that energy release data is provided for the entire event duration to obtain the correct integrated mass and energy release for these cases. However, the initial blowdown history (first 30 seconds) should not be used as a basis for a detailed calculation of the initial drywell pressure history for the DBA-LOCA. Other models and assumptions are used to evaluate the containment response during this time period.

Please note that the data provided is coupled to the heat exchanger performance and the Core Spray (CS) and LPCI/Containment Cooling pump flow rates assumed for the analyses. Therefore, this data should be applied with the same heat exchanger performance and CS and LPCI/Containment Cooling pump flow rates as used in Cases 2A1 and Case 6A2.

REFERENCES

1. Letter, S. Mintz to J. Nash, "Dresden Containment Analyses for Limiting Short-Term LOCA Event, " January 28, 1997.

2. GE-NE-T2300740-1, "Dresden Nuclear Power Station, Units 2 and 3, Containment Analyses of the DBA-LOCA Base on Long-Term LPCI/Containment Cooling System Configuration of One LPCI/Containment Cooling System Pump and 2 CCSW Pumps, "Class II, December 1996.

CASE 6A2 OF REFERENCE 1

CASE 6A2 MASS & ENERGY

Time (seconds)	Vessel Liq. BRK Flow (lbm/sec)	Ves. Liq. BRK Flow Enthalpy. (BTU/lbm)	Vessel Vapor BRK Flow (lbm/sec)	Vessel Vapor BRK Flow Enth. (BTU/lbm)	LPCI Liq. BRK Flow to Drywell (lbm/sec)	LPCI Liq. BRK Flow Enthalpy. (BTU/lbm)
0.0	12730.0	546.0	0.0	0.0	0.0	0.0
0.9	12663.2	544.0	0.0	0.0	0.0	0.0
2.5	12615.4	543.2	0.0	0.0	0.0	0.0
5.0	12607.5	544.1	0.0	0.0	0.0	0.0
15.7	12052.4	538.1	0.0	0.0	0.0	0.0
30.7	10736.3	521.6	0.0	0.0	0.0	0.0
44.0	7273.2	503.0	579.5	1204.5	2863.0	92.5
51.2	2744.2	471.2	1493.0	1203.7	2863.0	95.5
54.7	2413.1	429.3	1097.7	1204.3	2863.0	96.4
58.8	3083.3	387.8	460.0	1204.7	2863.0	97.3
78.7	3266.6	369.6	146.9	1203.2	2863.0	99.9
105.4	3129.9	322.8	0.0	0.0	2863.0	101.0
134.3	3467.3	285.0	0.0	0.0	2863.0	102.4
161.2	3153.3	264.7	0.0	0.0	2863.0	104.4
187.9	2060.4	246.9	0.0	0.0	2863.0	106.3
223.3	1774.6	236.1	0.0	0.0	2863.0	108.1
253.8	1637.2	226.4	0.0	0.0	2863.0	109.4
290.5	1598.8	217.3	0.0	0.0	2863.0	110.8
337.0	1611.7	208.6	0.0	0.0	2863.0	112.3
384.8	1635.2	200.6	0.0	0.0	2863.0	113.6
442.2	1467.6	194.5	0.0	0.0	2863.0	114.9
496.5	1245.8	190.4	0.0	0.0	2863.0	116.0
508.8	1072.2	188.5	0.0	0.0	2863.0	116.2
520.8	1160.6	182.1	0.0	0.0	2863.0	116.3
532.9	1299.5	184.4	0.0	0.0	2863.0	116.5
545.4	1400.0	185.7	0.0	0.0	2863.0	116.7
557.9	1423.1	186.5	0.0	0.0	2863.0	116.9
571.4	1423.1	186.5	0.0	0.0	2863.0	117.1
583.9	1465.3	181.1	0.0	0.0	2863.0	117.2
596.7	1476.9	179.2	0.0	0.0	2863.0	117.4
600.2	1428.6	180.0	0.0	0.0	2863.0	117.4

CASE 2A1 OF REFERENCE 2

CASE 2A1 (20%) MASS & ENERGY

Time (seconds)	Vessel Liq. BRK Flow (lbm/sec)	Ves. Liq. BRK Flow Enthalpy. (BTU/lbm)	Vessel Vapor BRK Flow (lbm/sec)	Vessel Vapor BRK Flow Enth. (BTU/lbm)	DW Spray Flow (lbm/sec)	DW Spray Flow Enthalpy. (BTU/lbm)	WW Spray Flow (lbm/sec)	WW Spray Flow Enthalpy. (BTU/lbm)
0.0	37700.0	546.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	37028.9	544.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2	27165.0	541.2	0.0	0.0	0.0	0.0	0.0	0.0
4.4	24429.6	539.5	0.0	0.0	0.0	0.0	0.0	0.0
11.4	22000.0	536.1	367.8	1197.4	0.0	0.0	0.0	0.0
18.9	8865.2	532.8	2850.4	1202.5	0.0	0.0	0.0	0.0
28.2	0.0	0.0	3688.4	1202.9	0.0	0.0	0.0	0.0
34.0	0.0	0.0	2008.6	1200.2	0.0	0.0	0.0	0.0
37.5	0.0	0.0	1462.2	1195.0	0.0	0.0	0.0	0.0
40.3	0.0	0.0	1211.9	1192.4	0.0	0.0	0.0	0.0
43.4	0.0	0.0	1057.8	1189.9	0.0	0.0	0.0	0.0
45.9	0.0	0.0	935.8	1189.1	0.0	0.0	0.0	0.0
47.5	2133.3	293.5	401.2	1185.0	0.0	0.0	0.0	0.0
50.2	3620.0	292.8	74.0	1162.2	0.0	0.0	0.0	0.0
52.5	3922.6	289.5	0.0	0.0	0.0	0.0	0.0	0.0
54.1	3851.9	284.6	0.0	0.0	0.0	0.0	0.0	0.0
55.9	3840.0	284.7	0.0	0.0	0.0	0.0	0.0	0.0
57.9	3834.5	287.8	0.0	0.0	0.0	0.0	0.0	0.0
59.5	3921.5	272.8	0.0	0.0	0.0	0.0	0.0	0.0
78.2	4187.6	262.8	0.0	0.0	0.0	0.0	0.0	0.0
102.9	3941.3	248.6	0.0	0.0	0.0	0.0	0.0	0.0
132.7	3643.4	232.7	0.0	0.0	0.0	0.0	0.0	0.0
162.0	2878.2	223.6	0.0	0.0	0.0	0.0	0.0	0.0
193.0	1704.8	212.2	0.0	0.0	0.0	0.0	0.0	0.0
257.4	1830.3	196.8	0.0	0.0	0.0	0.0	0.0	0.0
322.4	2212.8	187.2	0.0	0.0	0.0	0.0	0.0	0.0
363.2	2396.1	179.0	0.0	0.0	0.0	0.0	0.0	0.0
400.0	2484.0	173.7	0.0	0.0	0.0	0.0	0.0	0.0
435.2	2530.8	170.1	0.0	0.0	0.0	0.0	0.0	0.0
470.0	2555.8	166.9	0.0	0.0	0.0	0.0	0.0	0.0
501.3	2559.0	165.7	0.0	0.0	0.0	0.0	0.0	0.0
508.7	2583.0	163.9	0.0	0.0	0.0	0.0	0.0	0.0
515.3	2583.0	161.1	0.0	0.0	0.0	0.0	0.0	0.0
522.6	2571.4	161.1	0.0	0.0	0.0	0.0	0.0	0.0
529.3	2583.0	163.9	0.0	0.0	0.0	0.0	0.0	0.0
536.5	2548.7	163.9	0.0	0.0	0.0	0.0	0.0	0.0
543.4	2511.2	165.7	0.0	0.0	0.0	0.0	0.0	0.0
550.5	2573.9	162.2	0.0	0.0	0.0	0.0	0.0	0.0
557.8	2632.0	155.3	0.0	0.0	0.0	0.0	0.0	0.0
564.9	2606.1	158.1	0.0	0.0	0.0	0.0	0.0	0.0
574.3	2566.6	161.7	0.0	0.0	0.0	0.0	0.0	0.0
583.2	2580.6	160.0	0.0	0.0	0.0	0.0	0.0	0.0
591.7	2520.5	160.9	0.0	0.0	0.0	0.0	0.0	0.0

CASE 2A1 (20%) MASS & ENERGY

Time (seconds)	Vessel Liq. BRK Flow (lbm/sec)	Ves. Liq. BRK Flow Enthalpy. (BTU/lbm)	Vessel Vapor BRK Flow (lbm/sec)	Vessel Vapor BRK Flow Enth. (BTU/lbm)	DW Spray Flow (lbm/sec)	DW Spray Flow Enthalpy. (BTU/lbm)	WW Spray Flow (lbm/sec)	WW Spray Flow Enthalpy. (BTU/lbm)
601.5	2010.1	160.0	0.0	0.0	660.2	93.1	34.8	93.1
616.6	1679.0	160.8	0.0	0.0	660.2	93.3	34.8	93.3
631.8	1532.6	164.0	0.0	0.0	660.2	93.5	34.8	93.5
649.2	1393.6	163.5	0.0	0.0	660.2	93.7	34.8	93.6
669.2	1353.6	164.0	0.0	0.0	660.2	93.8	34.8	93.8
686.2	1300.0	166.7	0.0	0.0	660.2	93.9	34.8	93.9
699.2	1201.0	171.0	0.0	0.0	660.2	94.0	34.8	94.0
712.0	1139.8	170.4	0.0	0.0	660.2	94.1	34.8	94.1
722.8	1087.0	172.0	0.0	0.0	660.2	94.2	34.8	94.2
735.0	1037.0	178.6	0.0	0.0	660.2	94.3	34.8	94.2
749.8	1012.7	173.3	0.0	0.0	660.2	94.3	34.8	94.3
764.6	992.0	174.2	0.0	0.0	660.2	94.4	34.8	94.4
781.1	946.4	181.3	0.0	0.0	660.2	94.5	34.8	94.5
798.4	921.3	180.0	0.0	0.0	660.2	94.6	34.8	94.6
813.7	1056.6	182.9	0.0	0.0	660.2	94.7	34.8	94.6
831.5	1347.7	185.1	0.0	0.0	660.2	94.8	34.8	94.8
848.5	1540.7	182.7	0.0	0.0	660.2	94.8	34.8	94.8
865.3	1390.0	186.7	1.5	1200.0	660.2	94.9	34.8	94.9
880.9	945.1	189.3	7.4	1227.3	660.2	95.0	34.8	95.0
894.9	641.5	176.5	12.8	1176.5	660.2	95.1	34.8	95.1
907.4	607.1	188.2	13.2	1108.1	660.2	95.1	34.8	95.1
922.9	601.8	194.1	12.7	1166.7	660.2	95.2	34.8	95.2
935.7	609.5	187.5	13.0	1176.5	660.2	95.2	34.8	95.2
949.2	618.2	188.2	13.1	1138.9	660.2	95.3	34.8	95.3
963.2	642.9	183.3	12.9	1166.7	660.2	95.3	34.8	95.3
977.2	637.2	183.3	13.1	1135.1	660.2	95.4	34.8	95.4
991.4	607.9	189.9	13.3	1152.3	660.2	95.4	34.8	95.4
1090.7	612.5	188.1	13.1	1166.3	660.2	95.7	34.8	95.7
1308.2	613.3	188.2	12.3	1157.5	660.2	96.3	34.8	96.3
1574.9	613.1	188.7	10.6	1149.2	660.2	97.0	34.8	97.0
1857.8	616.6	187.8	8.4	1156.2	660.2	97.7	34.8	97.7
2158.8	618.6	187.3	6.7	1147.1	660.2	98.4	34.8	98.3
2454.3	620.7	187.1	5.4	1138.5	660.2	98.9	34.8	98.9
2756.5	621.8	186.9	4.4	1145.0	660.2	99.5	34.8	99.5
3055.8	622.6	186.8	3.3	1144.3	660.2	100.0	34.8	99.9
3366.9	622.5	187.0	2.3	1197.2	660.2	100.4	34.8	100.4
3675.9	623.6	187.0	1.2	1153.8	660.2	100.8	34.8	100.8
4009.9	622.2	186.5	0.4	800.0	660.2	101.2	34.8	101.2
4354.2	613.5	187.0	0.0	0.0	660.2	101.6	34.8	101.6
4697.8	605.4	184.8	0.0	0.0	660.2	101.9	34.8	101.9
5026.4	610.1	184.3	0.0	0.0	660.2	102.2	34.8	102.2
5346.9	622.2	185.9	0.0	0.0	660.2	102.5	34.8	102.5
5666.0	626.0	186.6	0.0	0.0	660.2	102.8	34.8	102.8

CASE 2A1 (20%) MASS & ENERGY

Time (seconds)	Vessel Liq. BRK Flow (lbm/sec)	Ves. Liq. BRK Flow Enthalpy. (BTU/lbm)	Vessel Vapor BRK Flow (lbm/sec)	Vessel Vapor BRK Flow Enth. (BTU/lbm)	DW Spray Flow (lbm/sec)	DW Spray Flow Enthalpy. (BTU/lbm)	WW Spray Flow (lbm/sec)	WW Spray Flow Enthalpy. (BTU/lbm)
5989.0	623.7	187.2	0.0	0.0	660.2	103.0	34.8	103.0
6317.0	613.6	186.9	0.0	0.0	660.2	103.3	34.8	103.3
6634.4	594.2	186.0	0.0	0.0	660.2	103.5	34.8	103.5
6968.3	586.6	184.5	0.0	0.0	660.2	103.7	34.8	103.7
7272.0	603.4	182.4	0.0	0.0	660.2	103.9	34.8	103.9
7513.5	618.8	181.8	0.0	0.0	660.2	104.0	34.8	104.0
7752.0	617.9	181.2	0.0	0.0	660.2	104.2	34.8	104.1
7995.8	621.2	180.3	0.0	0.0	660.2	104.3	34.8	104.3
8243.0	621.4	184.5	0.0	0.0	660.2	104.4	34.8	104.4
8493.0	622.5	181.8	0.0	0.0	660.2	104.5	34.8	104.5
8737.8	624.8	180.6	0.0	0.0	660.2	104.6	34.8	104.6
8989.2	624.7	181.5	0.0	0.0	660.2	104.7	34.8	104.7
9240.4	623.9	180.4	0.0	0.0	660.2	104.8	34.8	104.8
9495.7	615.7	182.4	0.0	0.0	660.2	104.9	34.8	104.9
9739.0	616.5	180.9	0.0	0.0	660.2	105.0	34.8	105.0
9988.8	627.9	180.4	0.0	0.0	660.2	105.1	34.8	105.1
10242.3	630.7	180.4	0.0	0.0	660.2	105.2	34.8	105.2
10489.8	628.5	178.9	0.0	0.0	660.2	105.4	34.8	105.3
10740.3	627.3	180.4	0.0	0.0	660.2	105.5	34.8	105.4
10993.5	626.2	180.4	0.0	0.0	660.2	105.5	34.8	105.5
11244.9	626.0	181.5	0.0	0.0	660.2	105.6	34.8	105.6
11495.2	625.7	182.7	0.0	0.0	660.2	105.7	34.8	105.7
11743.5	624.0	180.1	0.0	0.0	660.2	105.7	34.8	105.7
11993.5	625.6	179.5	0.0	0.0	660.2	105.8	34.8	105.8
12242.3	623.9	180.1	0.0	0.0	660.2	105.8	34.8	105.8
12492.0	624.3	179.5	0.0	0.0	660.2	105.9	34.8	105.9
12742.0	625.4	182.1	0.0	0.0	660.2	105.9	34.8	105.9
12992.5	622.8	181.0	0.0	0.0	660.2	106.0	34.8	106.0
13247.8	624.2	179.8	0.0	0.0	660.2	106.0	34.8	106.0
13500.4	626.8	179.2	0.0	0.0	660.2	106.1	34.8	106.1
13755.2	628.1	178.1	0.0	0.0	660.2	106.1	34.8	106.1
14009.9	614.8	183.9	0.0	0.0	660.2	106.1	34.8	106.1
14259.4	617.5	180.6	0.0	0.0	660.2	106.2	34.8	106.2
14511.9	632.6	178.1	0.0	0.0	660.2	106.2	34.8	106.2
14765.3	630.1	178.1	0.0	0.0	660.2	106.2	34.8	106.2
15019.8	627.1	178.1	0.0	0.0	660.2	106.3	34.8	106.2
15275.5	625.6	178.1	0.0	0.0	660.2	106.3	34.8	106.3
15531.3	628.7	178.1	0.0	0.0	660.2	106.3	34.8	106.3
15784.5	613.9	183.9	0.0	0.0	660.2	106.3	34.8	106.3
16036.3	609.9	183.9	0.0	0.0	660.2	106.4	34.8	106.3
16292.8	630.4	178.1	0.0	0.0	660.2	106.4	34.8	106.3
16543.9	637.6	171.9	0.0	0.0	660.2	106.4	34.8	106.4
16794.7	618.5	177.4	0.0	0.0	660.2	106.4	34.8	106.4

CASE 2A1 (20%) MASS & ENERGY

Time (seconds)	Vessel Liq. BRK Flow (lbm/sec)	Ves. Liq. BRK Flow Enthalpy. (BTU/lbm)	Vessel Vapor BRK Flow (lbm/sec)	Vessel Vapor BRK Flow Enth. (BTU/lbm)	DW Spray Flow (lbm/sec)	DW Spray Flow Enthalpy. (BTU/lbm)	WW Spray Flow (lbm/sec)	WW Spray Flow Enthalpy. (BTU/lbm)
17045.2	619.1	180.6	0.0	0.0	660.2	106.4	34.8	106.4
17295.4	638.4	175.0	0.0	0.0	660.2	106.4	34.8	106.4
17546.4	617.2	180.6	0.0	0.0	660.2	106.4	34.8	106.4
17797.7	614.2	180.6	0.0	0.0	660.2	106.4	34.8	106.4
18051.2	628.1	175.0	0.0	0.0	660.2	106.4	34.8	106.4
18307.2	628.1	175.0	0.0	0.0	660.2	106.4	34.8	106.4
18560.7	633.2	175.0	0.0	0.0	660.2	106.4	34.8	106.4
18812.5	611.3	180.6	0.0	0.0	660.2	106.4	34.8	106.4
19067.8	608.1	183.9	0.0	0.0	660.2	106.4	34.8	106.4
19322.3	626.2	178.1	0.0	0.0	660.2	106.4	34.8	106.4
19578.8	629.3	175.0	0.0	0.0	660.2	106.4	34.8	106.4
19830.8	636.8	171.9	0.0	0.0	660.2	106.4	34.8	106.4
20081.3	617.2	177.4	0.0	0.0	660.2	106.4	34.8	106.4
20333.0	615.4	177.4	0.0	0.0	660.2	106.4	34.8	106.3
20585.0	624.7	175.0	0.0	0.0	660.2	106.3	34.8	106.3
20845.3	618.1	178.1	0.0	0.0	660.2	106.3	34.8	106.3
21102.8	640.2	172.7	0.0	0.0	660.2	106.3	34.8	106.3
21360.8	632.5	172.7	0.0	0.0	660.2	106.3	34.8	106.3
21624.5	624.7	172.7	0.0	0.0	660.2	106.3	34.8	106.3
21889.0	622.3	175.8	0.0	0.0	660.2	106.2	34.8	106.2
22154.8	623.5	175.8	0.0	0.0	660.2	106.2	34.8	106.2
22418.3	627.4	175.8	0.0	0.0	660.2	106.2	34.8	106.2
22680.8	619.7	175.8	0.0	0.0	660.2	106.2	34.8	106.2
22950.8	629.8	173.5	0.0	0.0	660.2	106.2	34.8	106.1
23220.7	629.8	173.5	0.0	0.0	660.2	106.1	34.8	106.1
23490.7	610.3	178.8	0.0	0.0	660.2	106.1	34.8	106.1
23761.4	612.0	178.8	0.0	0.0	660.2	106.1	34.8	106.1
24029.9	625.6	173.5	0.0	0.0	660.2	106.0	34.8	106.0
24304.9	624.7	173.5	0.0	0.0	660.2	106.0	34.8	106.0
24574.2	623.0	173.5	0.0	0.0	660.2	106.0	34.8	106.0
24850.7	630.9	171.4	0.0	0.0	660.2	106.0	34.8	105.9
25128.9	632.1	171.4	0.0	0.0	660.2	105.9	34.8	105.9
25404.4	613.7	176.5	0.0	0.0	660.2	105.9	34.8	105.9
25682.9	623.0	173.5	0.0	0.0	660.2	105.9	34.8	105.8
25950.2	625.9	173.5	0.0	0.0	660.2	105.8	34.8	105.8
26226.2	630.6	171.4	0.0	0.0	660.2	105.8	34.8	105.8
26505.2	623.1	171.4	0.0	0.0	660.2	105.7	34.8	105.7
26787.9	614.0	173.5	0.0	0.0	660.2	105.7	34.8	105.7
27058.9	631.6	171.4	0.0	0.0	660.2	105.7	34.8	105.7
27342.0	624.0	174.3	0.0	0.0	660.2	105.6	34.8	105.6
27619.8	631.2	168.6	0.0	0.0	660.2	105.6	34.8	105.6
27896.5	632.6	168.6	0.0	0.0	660.2	105.6	34.8	105.5
28173.0	614.8	176.5	0.0	0.0	660.2	105.5	34.8	105.5