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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

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IMPORTANT INFORMATION REGARDING

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ABSTRACT

This report provides the results for an evaluation for the Dresden containment response during a design basis loss-of-coolant accident (DBA-LOCA) to update the analytical design basis of the Dresden LPCI/Containment Cooling System. The results of the containment pressure and temperature response analyses described in this report can be used to update the long-term containment cooling analyses in Section 6.2 of the UFSAR and the evaluation of available NPSH for pumps taking suction from the suppression pool in Section 6.3 of the UFSAR.

In addition, this report : 1) describes an analysis which was used to benchmark the GE SHEX code to the Dresden UFSAR containment analysis for the limiting DBA-LOCA, and 2) includes a study of the effect on the peak suppression pool temperature of changing key containment parameters to the values used to update the analytical design basis for the LPCI/Containment Cooling System from the values used in the original UFSAR analysis.

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1.0 INTRODUCTION

The purpose of the analyses in this report is to provide an updated analytical design basis for the LPCI/Containment Cooling System for Dresden Units 2 and 3. The results of these analyses can be used to support a licensing amendment and can be used to update the licensing basis documents, including the UFSAR, for the LPCI/Containment Cooling System.

GENE previously performed long-term containment analyses for Dresden which were provided to Commonwealth Edison Company (CECo) in GENE-770-26-1092 (Reference 1). These analyses used the same containment cooling configurations assumed for Cases 3 and 4 of Section 6.2 the Dresden UFSAR. Cases 3 and 3a of GENE-770-26-1092 , which correspond to UFSAR Case 3, assumed operation with 2 LPCI/Containment Cooling pumps and 2 Containment Cooling Service Water (CCSW) pumps. Cases 4 and 4a of GENE-770-26-1092, which correspond to UFSAR Case 4, assumed operation with 1 LPCI/Containment Cooling pump and 1 CCSW pump.

CECo plans to use the results for Case 4 of GENE-770-26-1092 to update the basis for long-term containment cooling in UFSAR Section 6.2 for a configuration of 1 LPCI/Containment Cooling pump and 1 CCSW pump. CECo also plans to update the UFSAR basis for long-term containment cooling for a configuration of 2 LPCI/Containment Cooling pumps and 2 CCSW pumps. However, CECo plans to update the results of Case 3 of GENE-770-26-1092 with a revised CCSW flow rate and with a corresponding revised heat exchanger heat removal rate. The analyses described in this report supplement the analyses of GENE-770-26-1092 in updating the design basis for the LPCI/Containment Cooling System.

1.1 SCOPE OF WORK

The workscope of this report involves analysis of the containment long-term pressure and temperature response following a DBA-LOCA for Dresden. Long-term is defined here as beginning at 600 seconds into the event, which is when containment cooling is initiated, and extending through the time of the peak suppression pool temperature. This analysis uses the GE SHEX computer code and current standard assumptions for containment cooling analysis, including the use of the ANS 5.1 decay heat model.

Four tasks are documented in this report. Task 1 benchmarks the SHEX code to the analysis in Section 6.2 of the Dresden UFSAR for the limiting, DBA-LOCA event. Task 2 consists of sensitivity studies to assess the effect of using the ANS 5.1 versus the May-Witt decay heat model and to demonstrate the effect of other key containment parameters on the design basis analysis. Task 3 consists of an analysis to calculate the long-term DBA-LOCA containment pressure and temperature response with 2 LPCI/Containment Cooling pumps and 2 CCSW pumps. The analysis of Task 3 uses revised values of the CCSW pump flow rate and heat exchanger heat removal K-value which were provided by CECo in Reference 2. The results of Task 3 can be used with the results of Case 4 of GENE-770-26-1092 (1 LPCI/Containment Cooling pump and 1 CCSW pump) to update the long-term containment cooling analysis in UFSAR Section 6.2. Task 4 consists of analysis with the updated basis configurations with inputs which minimize containment pressure. The results of the analysis of Task 4 can be used in the evaluation of NPSH margins for the Core Spray and the LPCI/Containment Cooling pumps for the DBA-LOCA. These results can then be used to update the NPSH evaluation for the LPCI/Containment Cooling pumps and Core Spray pumps in UFSAR Section 6.3.

2.0 RESULTS

The results for each of the four tasks described in Section 1.0 are summarized in the following paragraphs:

Task 1 SHEX Benchmark Analysis (Case 1)

The benchmark analysis of Case 1 is performed to determine the difference in the calculated peak suppression pool temperature relative to the UFSAR value of 180°F due to the use of the GE SHEX-04 code. The benchmark analysis uses key input assumptions which are consistent with the input used in the analysis for Case 4 in UFSAR Section 6.2. This includes the use of May-Witt decay heat (Reference 3), an initial suppression pool temperature of 90°F, no feedwater addition, no pump heat addition and a configuration of 1 Containment Cooling loop with 1 heat exchanger, 1 LPCI/Containment Cooling pump and 1 CCSW pump, with a heat exchanger heat removal rate of 84.5 million Btu/hr (referenced to a suppression pool-to-service water temperature difference of 85°F). The basis for the inputs used for the benchmark analysis is discussed in Section 3.1 of this report.

The suppression pool temperature response obtained with Case 1 to benchmark SHEX with the UFSAR analysis is shown in Figure 1. The peak suppression pool temperature obtained with the SHEX benchmark analysis (Case 1) is 180°F, which is the same as the UFSAR value of 180°F. These results confirm that the SHEX code predicts a peak suppression pool temperature for Dresden which is the same as the original UFSAR value for the same input conditions.

Task 2 Sensitivity Studies (Cases 2.1 to 2.5)

The sensitivity studies in Cases 2.1 to 2.5 are performed to quantify the effect on the peak suppression pool temperature of each key containment parameter which was changed from the original UFSAR value to the value used in the current analyses. For each of Cases 2.1 to 2.5, one of the parameters described above for Task 1 is changed from the value used in the original UFSAR analysis to the value used in the current analysis (Case 4 of GENE-770-26-1092) to update the LPCI/Containment Cooling basis for a configuration of 1 LPCI/Containment Cooling pump and 1 CCSW pump.

Table 1 summarizes the peak suppression pool temperatures obtained for Case 1 of Task 1 and Cases 2.1 to 2.5 of Task 2, and also shows the incremental effect on the UFSAR peak suppression pool temperature of changing each parameter. The peak suppression pool temperature obtained for Case 4 of GENE-770-26-1092 is also included in Table 1 to show the net effect of all parameter changes.

The results of the sensitivity analyses (Cases 2.1 to 2.5 of Task 2) showed that the incremental effect on peak suppression pool for each of the current input assumptions is: 2°F for feedwater, 2°F for pump heat, 1°F for initial suppression pool temperature and 5°F for the current heat exchanger heat removal K-value. When added, the total effect of using the current input assumptions is equal the effect of using the ANS 5.1 decay heat instead of the May-Witt decay heat (10°F).

Task 3 Design Basis Analysis for a 2 LPCI/Containment Cooling Pumps and 2 CCSW Pumps Configuration (Case 3)

Case 3 provides an analysis to update the UFSAR long-term containment cooling basis for a configuration of 2 LPCI/Containment Cooling pumps and 2 CCSW pumps. The heat exchanger heat removal K-value for Case 3 of Task 3 is 365.2 Btu/sec-°F, corresponding to a total CCSW pump flow rate of 6000 gpm (Reference 2). The results of Task 3 can be used with the results of Case 4 of GENE-770-26-1092 (1 LPCI/Containment Cooling pump and 1 CCSW pump) to update the long-term containment cooling analysis basis in UFSAR Section 6.2.

Figures 2, 3 and 4 show the long-term containment pressure and temperature response for Case 3 of Task 3. The peak suppression pool temperature obtained for Case 3 of Task 3 is 167°F. This temperature is slightly less (1°F less) than the value of 168°F obtained previously for the same containment cooling configuration (but with a total CCSW pump flow rate of 5600 gpm) for Case 3 of GENE-770-26-1092. The lower peak suppression pool temperature obtained for Case 3 of Task 3 is attributed to the increase in the heat exchanger heat removal K-value to 365.2 Btu/sec-°F from the value of 356.1 Btu/sec-°F used for Case 3 of GENE-770-26-1092.

Table 2 provides a case summary for Case 3 of Task 3, including the peak suppression pool temperature and peak long-term suppression chamber pressure. Table 2 also provides a case summary for Case 4 of GENE-770-26-1092, corresponding to a configuration of 1 LPCI/Containment Cooling pump and 1 CCSW pump. The results shown in Table 2 can be used to update the basis in UFSAR Section 6.2 for long-term containment cooling.

Task 4 Design Basis Analyses for NPSH Evaluation (Cases 4.1 & 4.2)

Cases 4.1 and 4.2 determine the suppression pool temperature and suppression chamber pressure response which can be used to evaluate available NPSH for the LPCI/Containment Cooling pumps and Core Spray pumps during a DBA-LOCA. The results for Case 4.1 are for a configuration of 1 LPCI/Containment Cooling pump and 1 CCSW pump. The results for Case 4.2 are for a configuration of 2 LPCI/Containment Cooling pumps and 2 CCSW pumps. Cases 4.1 and 4.2 used the same input assumptions as used for Case 3 of Task 3 and Case 4 of GENE-770-26-1092, respectively, except that the suppression chamber pressure response was minimized to minimize the available NPSH.

The long-term drywell and suppression chamber pressure and suppression chamber airspace and suppression pool temperature responses obtained for Cases 4.1 and 4.2 are shown in Figures 5 through 10. The peak suppression pool temperature and the suppression chamber pressure at the time of the peak suppression pool temperature for Cases 4.1 and 4.2 are shown in Table 3.

3.0 DESIGN ASSUMPTIONS AND ENGINEERING JUDGMENTS

Input assumptions are used which maintain the overall conservatism in the evaluation by maximizing the suppression pool temperature. Additionally, the input assumptions for the analysis in Task 4 are chosen to conservatively minimize the suppression chamber pressure and, therefore, minimize the available NPSH. The key input assumptions which are used in performing the Dresden containment DBA-LOCA pressure and temperature response analysis are described below. Table 4 provides values of key containment parameters common to all cases, while Table 5 and Table 6 provide case-specific inputs.

1. The reactor is assumed to be operating at 102% of the rated thermal power.

2. Vessel blowdown flow rates are based on the Homogeneous Equilibrium Model (Reference 4).

3. The core decay heat is based on ANSI/ANS-5.1-1979 decay heat (Reference 5).

   [For the benchmark analysis in Task 1 and for the parametric studies in Task 2 (except for Case 2.1) the core decay heat used was based on the May-Witt decay heat model (Reference 3)].

4. Feedwater flow into the RPV continues until all the feedwater above 180°F is injected into the vessel.

   [For the benchmark analysis in Task 1 and for the parametric studies in Task 2 (except for Case 2.3) feedwater is not added.]

5. Thermodynamic equilibrium exists between the liquids and gases in the drywell. Mechanistic heat and mass transfer between the suppression pool and the suppression chamber airspace are modeled.

6. To minimize the containment pressure for the analyses in Task 4 it is assumed that there is only partial heat transfer to the fluids in the drywell from the liquid flow from the break which does not flash. To model partial heat transfer in the analysis, a fraction of the non-flashing liquid break flow is assumed to be held up in the drywell and to be fully mixed with the drywell fluids before flowing to the suppression pool. Thermal equilibrium conditions are imposed between this held-up liquid and the fluids in the drywell as described in Assumption No. 5 above. The liquid not held up is assumed to flow directly to the suppression pool without heat transfer to the drywell fluids. For the analysis it is assumed that only 20% of the non-flashing liquid flow from the break is held up in the drywell airspace. Because the liquid flow from the break is at a higher temperature than the drywell fluid, this minimizes the drywell temperature and consequently minimizes the drywell and suppression chamber pressure.

7. The vent system flow to the suppression pool consists of a homogeneous mixture of the fluid in the drywell.

8. The initial suppression pool volume is at the minimum Technical Specification (T/S) limit to maximize the calculated suppression pool temperature.

9. For the analyses of Task 4 the initial drywell and suppression chamber pressure are at the minimum expected operating values to minimize the containment pressure.

10. For the analyses in Task 4, the maximum operating value of the drywell temperature of 150°F and a relative humidity of 100% are used to minimize the initial non-condensible gas mass and minimize the long-term containment pressure for the NPSH evaluation.

11. The initial suppression pool temperature is at the maximum T/S value (95°F) to maximize the calculated suppression pool temperature.

[For the benchmark analysis in Task 1 and for the parametric studies in Task 2 (except for Case 2.3) an initial suppression pool temperature of 90°F is used.]

12. Consistent with the UFSAR analyses, containment sprays are available to cool the containment. Once initiated at 600 seconds, it is assumed that containment sprays are operated continuously with no throttling of the LPCI/Containment Cooling pumps.

13. Passive heat sinks in the drywell, suppression chamber airspace and suppression pool are conservatively neglected to maximize the suppression pool temperature.

14. All Core Spray and LPCI/Containment Cooling system pumps have 100% of their horsepower rating converted to a pump heat input which is added either to the RPV liquid or suppression pool water.

[For the benchmark analysis in Task 1 and for the parametric studies in Task 2 (except for Case 2.4) pump heat was not added.]

15. Heat transfer from the primary containment to the reactor building is conservatively neglected.

16. Although a containment atmospheric leakage rate of 5% per day is used to determine the available NPSH in UFSAR Section 6.3, containment leakage is not included in the analyses in Task 4. Including containment leakage has no impact on the peak suppression pool temperature, but will slightly reduce the calculated containment pressure. A leakage rate of 5% per day is considered to be unrealistically large since the Dresden T/S limits the allowable leakage to 1.6 % per day. Use of the leakage rate of 1.6 % per day would result in less than a 0.1 psi reduction in the pressures calculated in the analysis. This effect is negligible considering all other input conditions have been chosen at their limiting values to minimize containment pressure and the assumption of only 20% holdup of the non-flashing liquid flow from the break in the drywell (see assumption no. 6). Therefore containment atmospheric leakage was not included in the analysis.

3.1 Input Assumptions for Benchmark Case

For the Benchmark case (Case 1 of Task 1), assumptions which are consistent with those used in the original UFSAR analysis are used. This includes the use of May-Witt decay heat (Reference 3), an initial suppression pool temperature of 90°F, no feedwater addition, no pump heat and heat exchanger heat removal rate of 84.5 million Btu/hr (referenced to a suppression pool-to-service water temperature difference of 85°F). The basis for using these inputs in the benchmark analysis is given in the following:

May-Witt Decay Heat

The UFSAR does not identify the decay heat model used in the original analyses. However, the May-Witt decay heat model was used by GENE for containment analyses in the time frame when the original UFSAR analyses were performed. In addition a review of available files provided strong evidence that the May-Witt decay heat was used in the original containment UFSAR analyses. Therefore, it is expected that the May-Witt decay heat model was used.

An Initial Suppression Pool Temperature of 90°F

The requirements for the containment cooling system given in the Dresden Auxiliary Systems Data Book (Reference 6 for Unit 2 and Reference 7 for Unit 3) include a requirement that the maximum pool temperature during normal operation be limited to 90°F. Since References 6 and 7 were issued during the time frame of the original UFSAR analyses it is expected that an initial pool temperature of 90°F was used.

No Feedwater Addition

The UFSAR states in Section 6.2. that feedwater addition was terminated at the time of the DBA-LOCA initiation. The purpose of this assumption, as reported in the UFSAR, was to maximize the short-term containment pressure response. There is no mention in UFSAR Section 6.2 that feedwater was included in the long-term containment response analysis. Additionally, during the time frame of the original UFSAR analyses it was not common practice to include feedwater in the containment analyses. It is therefore considered most likely that feedwater was not included in the original UFSAR analysis.

No Pump Heat

It is stated in Section 6.2 of the UFSAR that pump heat for the LPCI/Containment Cooling system pumps was included in the analysis. However, no mention is made of the pump heat contribution from the Core Spray pumps. Since it is not certain how much pump heat was included in the original analysis, it was assumed that none was included.

LPCI/Containment Cooling System Heat Exchanger Heat Removal Rate of 276.1 Btu/°F-sec

The heat exchanger heat removal K-value used in the original analysis is not identified in the UFSAR. However, Mode C of the LPCI/Containment Cooling System Process Diagram (Reference 8) for the Dresden LPCI/Containment Cooling System gives a heat exchanger heat removal rate of 84.5 million Btu/sec with a suppression pool water inlet-to-service water inlet temperature difference of 85°F. This is equivalent to a heat exchanger heat removal K-value of 276.1 Btu/sec-°F. Mode C of the Process Diagram includes 1 LPCI/Containment Cooling pump and 1 CCSW pump and is shown as the limiting containment cooling configuration with respect to maximum post-LOCA suppression pool temperature (180°F).

In addition, the containment cooling equipment specification given in UFSAR Table 6.2-7 shows a heat load of 105 x 10^6 Btu/hr with a suppression pool water inlet-to-service water inlet temperature difference of 70°F for a LPCI/Containment Cooling Pump flow rate of 10,700 gpm and a CCSW pump flow rate of 7000 gpm. This heat load is consistent with the heat load shown for Mode B of the LPCI/Containment Cooling System Process Diagram for these pump flow rates. This shows consistency between the values of the heat exchanger heat load specified in the UFSAR and the values specified in the LPCI/Containment Cooling System Process Diagram.

It is therefore expected that a heat exchanger heat removal K-value of 276.1 Btu/sec-°F, specified for Mode C of the Process Diagram, was used in the original UFSAR analysis for containment cooling configuration of 1 LPCI/Containment Cooling pump and 1 CCSW pump.

4.0 INPUT DOCUMENTATION

4.1 Inputs

The initial conditions and key input parameters used in the long-term containment pressure and temperature analysis are provided in Tables 4, 5 and 6. These are based on the current Dresden containment data which was confirmed by CECo in Reference 9.

Appendix A provides the core decay heat used in the analysis based on the May-Witt and ANSI/ANS-5.1-1979 models.

Reference 2 provided by CECo, contains the LPCI/Containment Cooling pump and CCSW pump flow rates and heat exchanger heat removal rates used for the analyses performed with a configuration of 2 LPCI/Containment Cooling pumps and 2 CCSW pumps for this report.

4.2 Industry Codes and Standards

The core decay heat used for the containment analysis to update the Dresden UFSAR (Cases 3, 4.1 and 4.2) is based on the ANSI/ANS-5.1-1979 decay heat model (Reference 5).

5.0 REGULATORY REQUIREMENTS

The analysis are performed with an initial reactor thermal power level of 102% of the rated reactor thermal power, per Regulatory Guide 1.49.

Pertinent sections of the UFSAR which are identified in this report are UFSAR Sections 6.2 and 6.3.

6.0 LIMITATIONS OF APPLICABILITY

The results of the analysis described in this report are based on the inputs described in Section 4.0. Any changes to these inputs should be reviewed to determine the impact on the results and conclusions reported here.

7.0 CALCULATIONS AND COMPUTER CODES

7.1 Calculation Record

The calculations used for this report are documented in the GE Design Record File DRF T23-00717.

7.2 Model Description

The GE computer code SHEX is used to perform the analysis of the containment pressure and temperature response. The SHEX code has been validated in conformance with the requirements of the GE Engineering Operating Procedures (EOPs). In addition, a benchmark analysis to validate the code for a plant-specific application to Dresden was performed, which is included in this report (see Task 1).

SHEX uses a coupled reactor pressure vessel and containment model, based on the Reference 10 and Reference 11 models which have been reviewed and approved by the NRC, to calculate the transient response of the containment during the LOCA. This model performs fluid mass and energy balances on the reactor primary system and the suppression pool, and calculates the reactor vessel water level, the reactor vessel pressure, the pressure and temperature in the drywell and suppression chamber airspace and the bulk suppression pool temperature. The various modes of operation of all important auxiliary systems, such as SRVs, the MSIVs, the ECCS, the RHR system (the LPCI/Containment Cooling System when applied to Dresden) and feedwater, are modeled. The model can simulate actions based on system setpoints, automatic actions and operator-initiated actions.

7.3 Analysis Approach

The long-term containment pressure and temperature response is analyzed with the SHEX code for the DBA-LOCA which is identified in the UFSAR as an instantaneous double-ended break of a recirculation suction line. Several cases are performed to benchmark the SHEX code to the UFSAR and to provide a basis for an update to the Dresden LPCI/Containment Cooling system.

The following describes the GE analysis and the purpose of each case. Table 4 provides values of the key containment parameters common to all cases in this report. Case-specific containment input parameters for the different cases are summarized in Tables 5 and 6. Except as identified below and in Tables 5 and 6, the input values used in the analyses for this report are the same as previously used in the analysis described in GENE-770-26-1092 (Reference 1).

Task 1 SHEX Benchmark Analysis (Case 1)

<u>Case 1</u>

Purpose:

Task 1 consists of a single case (Case 1) which is used to benchmark the SHEX code to the UFSAR analysis for a 1 LPCI/Containment Cooling System pump and 1 Containment Cooling Service Water (CCSW) pump configuration.

Case Description:

The benchmark analysis in Case 1 uses the same inputs and assumptions as those used originally to analyze the 1 LPCI/Containment Cooling System pump and 1 Containment Cooling Service Water (CCSW) pump configuration for Case 4 in Section 6.2 of the UFSAR. The key inputs include: an initial suppression pool temperature of 90°F, no feedwater addition, no pump heat for pumps taking suction from the suppression pool, May-Witt decay heat and a LPCI/Containment Cooling heat exchanger heat removal K-value of 276.1 Btu/sec-°F.

Task 2 Sensitivity Studies (Cases 2.1 to 2.5)

The analyses in Task 2 quantified the sensitivity of the peak suppression pool temperature to key analysis parameters which are different for Case 4 of GENE-770-26-1092 and the original UFSAR analysis.

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Case 2.1

Purpose:

Case 2.1 determines the effect of using ANS 5.1 decay heat instead of May-Witt decay heat on the UFSAR DBA-LOCA peak suppression pool temperature.

Case Description:

Case 2.1 is performed with the inputs used for the UFSAR benchmark analysis of Case 1 except that ANS 5.1 is used instead of May-Witt decay heat.

Case 2.2

Purpose:

Case 2.2 determines the effect of using an initial suppression pool temperature of 95°F instead of 90°F on the UFSAR DBA-LOCA peak suppression pool temperature.

Case Description:

Case 2.2 is performed with the inputs used for the UFSAR benchmark analysis of Case 1 except that an initial suppression pool temperature of 95°F is used.

Case 2.3

Purpose:

Case 2.3 is performed to determine the effect of including feedwater mass and energy on the UFSAR DBA-LOCA peak suppression pool temperature.

Case Description:

Case 2.3 is performed with the inputs used for the UFSAR benchmark analysis of

Case 1 except that feedwater mass and energy are included.

Case 2.4

Purpose:

Case 2.4 determines the effect of including pump heat on the UFSAR DBA-LOCA peak suppression pool temperature.

Case Description:

Case 2.4 is performed with the inputs used for the UFSAR benchmark analysis of Case 1 except that the full rated pump heat for one LPCI/Containment Cooling pump and one Core Spray pump is added to the vessel-containment system.

Case 2.5

Purpose:

Case 2.5 determines the effect of using a different LPCI/Containment Cooling System heat exchanger heat removal K-value on the UFSAR DBA-LOCA peak suppression pool temperature.

Case Description:

Case 2.5 is performed with the inputs used for the UFSAR benchmark analysis of Case 1 except that a LPCI/Containment Cooling System heat exchanger heat removal K-value of 249.6 Btu/sec-°F is used instead of the value of 276.1 Btu/sec-°F used for Case 4 of UFSAR Section 6.2.

Task 3 Design Basis Analysis for 2 LPCI/ Containment Cooling pumps and 2 CCSW pumps Configuration (Case 3)

Case 3

Purpose:

Task 3 consists of a single case (Case 3) which can be used to establish the design basis long-term post-LOCA containment pressure and temperature response for a containment cooling configuration of 2 LPCI/Containment Cooling pumps and 2 CCSW pumps. For this case updated values of the CCSW flow rate and heat removal K-value are used which were provided by CECo (Reference 2).

Case Description:

The analysis of Case 3 of Task 3 uses the same inputs as used for Case 3 of GENE-770-26-1092 except that the CCSW flow rate and the corresponding heat removal K-value are updated with revised values provided by CECo in Reference 2.

Task 4 Design Basis Analyses for NPSH Evaluation (Cases 4.1 & 4.2)

The analyses in Task 4 determines the peak suppression pool temperature and suppression chamber pressure response which can be used for evaluating available NPSH margins for the LPCI/Containment Cooling pumps and Core Spray pumps, which take suction from the suppression pool during a DBA-LOCA. These results can be used in an update of the Dresden NPSH evaluation in UFSAR Section 6.3

Case 4.1

Purpose:

The purpose of Case 4.1 is to obtain the suppression pool temperature and suppression chamber pressure which can be used to evaluate the available NPSH margins for a 1 LPCI/Containment Cooling pump - 1 CCSW pump configuration.

Case Description:

Case 4.1 is a re-analysis of Case 4 of GENE-770-26-1092 with the exception that initial conditions are used which minimize the containment pressure. Table 1 shows these initial conditions. Additionally, it is conservatively assumed that only 20% of the break flow which does not flash achieves thermal equilibrium with the fluids in the drywell. The rest flows directly to the suppression pool without any heat transferred to the drywell fluids. Because the liquid break flow is at a higher temperature than the drywell fluid, this minimizes the drywell temperature and, consequently, the drywell and suppression chamber pressure.

<u>Case 4.2</u>

Purpose:

The purpose of Case 4.2 is to obtain the suppression pool temperature and suppression chamber pressure which can be used to evaluate the available NPSH margins for a 2 LPCI/Containment Cooling pump - 2 CCSW pump configuration.

Case Description:

Case 4.2 is a re-analysis of Case 3 of Task 3, except that the initial conditions used for Case 4.1 and the assumption of partial heat transfer used for Case 4.1 are also used for Case 4.2, to minimize containment pressure (see Table 1).

8.0 Q/A RECORDS

All work performed to produce this document and supporting background information is contained in the GE Design Record File DRF T23-00717.

9.0 REFERENCES

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

2) Letter, T. A. Rieck (Nuclear Fuel Services Manager - CECo) to H. L. Massin (CECo), "Calculation of LPCI HX Performance at 2/2 Flow Conditions," December 13, 1993.

3) NEDO-10625, "Power Generation in a BWR Following Normal Shutdown or Loss-of-Coolant Accident Conditions," March 1973.

4) NEDO-21052, "Maximum Discharge Rate of Liquid-Vapor Mixtures from Vessels," General Electric Company, September 1975.

5) "Decay Heat Power in Light Water Reactors," ANSI/ANS - 5.1 - 1979, Approved by American National Standards Institute, August 29, 1979.

6) GE Report 257HA654, Dresden 2, "Auxiliary Systems Data Book," Rev. 3, April 15, 1969.

7) GE Report 257HA749, Dresden 3, "Auxiliary Systems Data Book," Rev. 3, April 15, 1969.

8) LPCI Containment Cooling System Process Diagram, GE Dwg. 729E583, Rev. 1, February 24, 1969.

9) Letter, S. Mintz to S. Eldridge (CECo), "Updated Basis for LPCI/Containment Cooling System Input Parameters for the LOCA Long-Term Containment Response Analyses. Dresden Nuclear Power Station, Units 2 & 3," November 23, 1993.

10) NEDM-10320, "The GE Pressure Suppression Containment System Analytical Model," March 1971.

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

TABLE 1 - RESULTS OF BENCHMARK CASE AND PARAMETRIC STUDIES

Case	Description	Peak Pool Temperature (°F)	Incremental Change in Peak Pool Temperature Relative to Case 1 (°F)
1	SHEX-04 BENCHMARK MAY-WITT DECAY HEAT INITIAL POOL TEMP = 90°F NO FEEDWATER ADDED NO PUMP HEAT ADDED K=276.1 BTU/SEC-°F	180	N/A
2.1	ANS 5.1 DECAY HEAT	170	-10
2.2	INITIAL POOL TEMP = 95°F	181	+1
2.3	FEEDWATER ADDED	182	+2
2.4	PUMP HEAT ADDED	182	+2
2.5	K=249.6 BTU/SEC-°F	185	+5

GENE-770-26-1092 CASE 4	1 LPCI/CONTAINMENT COOLING PUMP, 1 CCSW PUMP ANS 5.1 DECAY HEAT INITIAL POOL TEMP = 95°F FEEDWATER ADDED PUMP HEAT ADDED K=249.6 BTU/SEC-°F	180	0

TABLE 2 - UPDATED CONTAINMENT RESPONSE FOR DRESDEN LPCI/CONTAINMENT COOLING SYSTEM

Case *	No. of Cont. Cooling Loops**	LPCI/ Containment Cooling Pumps Per Loop	Total LPCI/ Cont. Cooling Pump Flow (gpm)	No. of CCSW Pumps Per Loop	HX CCSW Pump Flow (gpm)	Peak Suppression Pool Temp. (°F)	Peak Long-Term Suppression Chamber Pressure (psig)
3	1	2	10000	2	6000	167 (@ 13350 s)	7.3
4 (of GENE-770-26-1092)	1	1	5000	1	3500	180 (@ 26380 s)	8.7

* 1 Core Spray Pump assumed for all Cases.
** 1 Heat Exchanger per loop.

TABLE 3 - RESULTS OF CONTAINMENT ANALYSIS FOR NPSH EVALUATIONS

Case	Description	Peak Pool Temperature (°F)	Suppression Chamber Pressure at Time of Peak Pool Temperature (psig)
4.1	1 LPCI/CONTAINMENT COOLING PUMP & 1 CCSW PUMP (UFSAR CASE 4)	180	4.3
4.2	2 LPCI/CONTAINMENT COOLING PUMPS & 2 CCSW PUMPS (UFSAR CASE 3)	167	3.7

Table 4- Input Parameters for Containment Analysis

Parameter	Units	Value Used In Analysis
Core Thermal Power	MWt	2578
Vessel Dome Pressure	psia	1020
Drywell Free (Airspace) Volume (including vent system)	ft^3	158236
Initial Suppression Chamber Free (Airspace) Volume		
Low Water Level (LWL)	ft^3	120097
Initial Suppression Pool Volume		
Min. Water Level	ft^3	112000
No. of Downcomers		96
Total Downcomer Flow Area	ft^2	301.6
Initial Downcomer Submergence	ft	3.67
Downcomer I.D.	ft	2.00
Vent System Flow Path Loss Coefficient (includes exit loss)		5.17
Supp. Chamber (Torus) Major Radius	ft	54.50
Supp. Chamber (Torus) Minor Radius	ft	15.00
Suppression Pool Surface Area (in contact with suppression chamber airspace)	ft^2	9971.4

Table 4 - Input Parameters for Containment Analysis (continued)

Parameter	Units	Value Used in Analysis
Suppression Chamber-to-Drywell Vacuum Breaker Opening Diff. Press.		
- start	psid	0.15
- full open	psid	0.5
Supp. Chamber-to-Drywell Vacuum Breaker Valve Opening Time	sec	1.0
Supp. Chamber-to-Drywell Vacuum Breaker Flow Area (per valve assembly)	ft^2	3.14
Supp. Chamber-to-Drywell Vacuum Breaker Flow Loss Coefficient (including exit loss)		3.47
No. of Supp. Chamber-to-Drywell Vacuum Breaker Valve Assemblies (2 valves per assembly)		6
LPCI/Containment Cooling Heat Exchanger K in Containment Cooling Mode	Btu/sec-°F	See Table 5
LPCI/Containment Cooling Service Water Temperature	°F	95
LPCI/Containment Cooling Pump Heat (per pump)	hp	700
Core Spray Pump Heat (per pump)	hp	800
Time for Operator to Turn On LPCI/Containment Cooling System in Containment Cooling Mode (after LOCA signal)	sec	600

Table 4 - Input Parameters for Containment Analysis (continued)

Feedwater Addition (to RPV after start of event; mass and energy)

Feedwater Node **	Mass (lbm)	Enthalpy * (Btu/lbm)
1	34658	308.0
2	96419	289.2
3	145651	268.7
4	91600	219.8
5	65072	188.4

* Includes sensible heat from the feedwater system piping metal.
** Feedwater mass and energy data combined to fit into 5 nodes for use in the analysis.

Table 5- LPCI/Containment Cooling System Parameters for Containment Analysis

Case	No. of Loops*	LPCI/ Containment Cooling Pumps Per Loop	Total LPCI/ Containment Cooling Flow (gpm)	No. of CCSW Pumps	Total CCSW Pump Flow (gpm)	HX K (Btu/s-°F)
1	1	1	5,000	1	3,500	276.1
2.1	1	1	5,000	1	3,500	276.1
2.2	1	1	5,000	1	3,500	276.1
2.3	1	1	5,000	1	3,500	276.1
2.4	1	1	5,000	1	3,500	276.1
2.5	1	1	5,000	1	3,500	249.6
3	1	2	10,000	2	6,000	365.2**
4.1	1	1	5,000	1	3,500	249.6
4.2	1	2	10,000	2	6,000	365.2**

* one heat exchanger per loop

** (Reference 2)

TABLE 6

KEY PARAMETERS FOR CONTAINMENT ANALYSIS

	CASE 1	CASE 2.1	CASE 2.2	CASE 2.3	CASE 2.4	CASE 2.5
DECAY HEAT MODEL	May-Witt	ANS 5.1	May-Witt	May-Witt	May-Witt	May-Witt
INITIAL SUPPRESSION POOL TEMPERATURE (°F)	90	90	95	90	90	90
FEEDWATER ADDED	No	No	No	Yes	No	No
PUMP HEAT ADDED	No	No	No	No	Yes	No
HEAT EXCHANGER K-VALUE (BTU/SEC-°F)	276.1	276.1	276.1	276.1	276.1	249.6
INITIAL DRYWELL PRESSURE (PSIA)	15.95	15.95	15.95	15.95	15.95	15.95
INITIAL SUPPRESSION CHAMBER PRESSURE (PSIA)	14.85	14.85	14.85	14.85	14.85	14.85
INITIAL DRYWELL TEMPERATURE	135	135	135	135	135	135
INITIAL DRYWELL RELATIVE HUMIDITY (%)	20	20	20	20	20	20
INITIAL SUPPRESSION CHAMBER RELATIVE HUMIDITY (%)	100	100	100	100	100	100
HEAT TRANSFER BETWEEN NON-FLASHING BREAK LIQUID AND DRYWELL FLUID (%)	100	100	100	100	100	100

* Changes to the Benchmark case (Case 1) for the sensitivity studies are underlined.

TABLE 6 (CONTINUED)

KEY PARAMETERS FOR CONTAINMENT ANALYSIS

	CASE 3	CASE 4.1	CASE 4.2
DECAY HEAT MODEL	ANS 5.1	ANS 5.1	ANS 5.1
INITIAL SUPPRESSION POOL TEMPERATURE (°F)	95	95	95
FEEDWATER ADDED	Yes	Yes	Yes
PUMP HEAT ADDED	Yes	Yes	Yes
HEAT EXCHANGER K-VALUE (BTU/SEC-°F)	365.2**	249.6	365.2**
INITIAL DRYWELL PRESSURE (PSIA)	15.95	15.7*	15.7*
INITIAL SUPPRESSION CHAMBER PRESSURE (PSIA)	14.85	14.7*	14.7*
INITIAL DRYWELL TEMPERATURE	135	150	150
INITIAL DRYWELL RELATIVE HUMIDITY (%)	20	100	100
INITIAL SUPPRESSION CHAMBER RELATIVE HUMIDITY (%)	100	100	100
HEAT TRANSFER BETWEEN NON-FLASHING BREAK LIQUID AND DRYWELL FLUID (%)	100	20	20

*Minimum operating pressure reported in Table B.1 of GENE-770-26-1092, which was previously provided by CECo.
** Reference 2

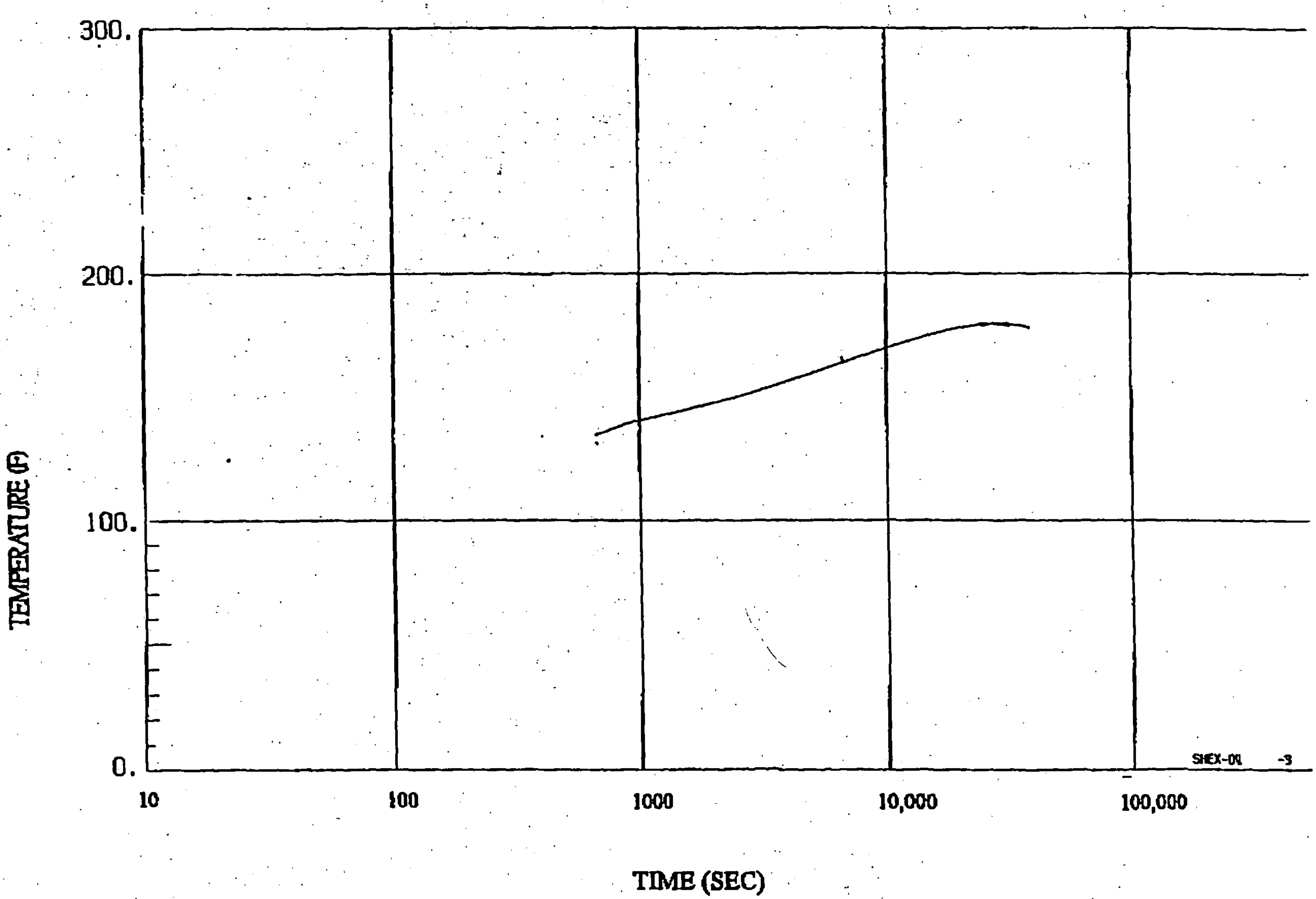

Figure 1 - Long-Term DBA-LOCA Suppression Pool Temperature Response for UFSAR Case 4 Bench Mark. (Case 1 of Task 1)

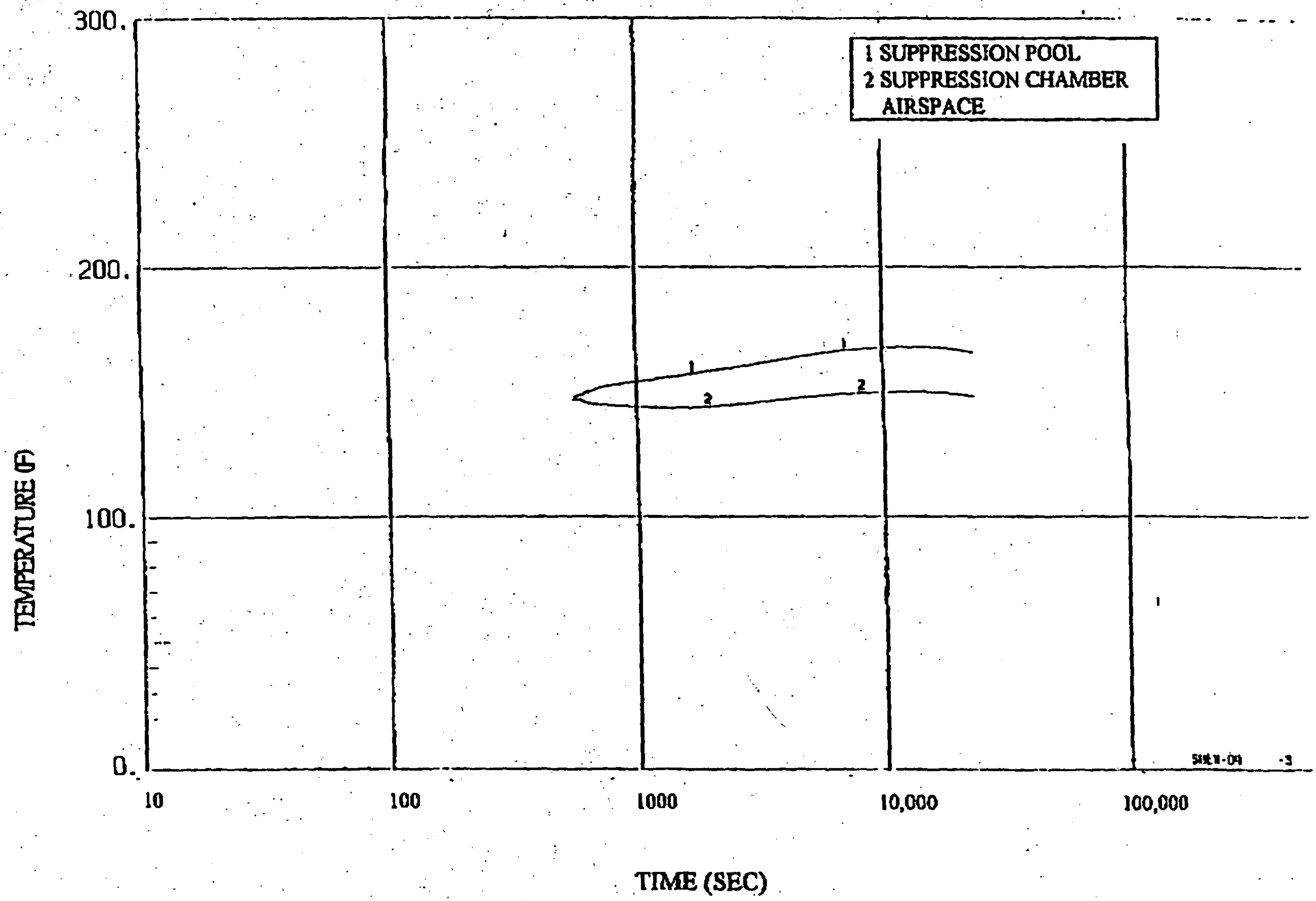

Figure 2 - Long-Term DBA-LOCA Suppression Pool and Suppression Chamber Airspace Temperature Response (Case 3 of Task 3)

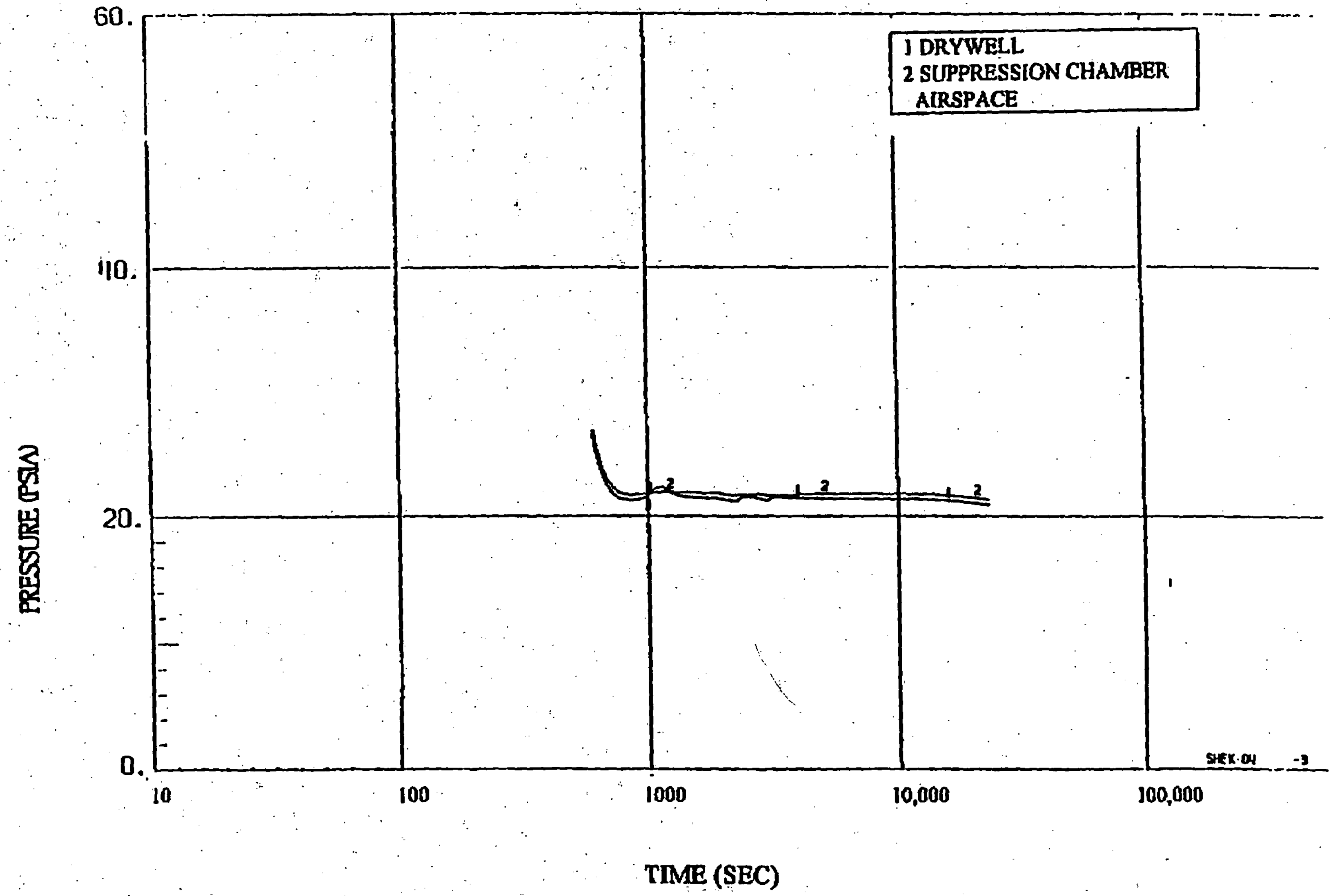

Figure 3 - Long-Term DBA-LOCA Drywell and Suppression Chamber Airspace Pressure Response.
(Case 3 of Task 3)

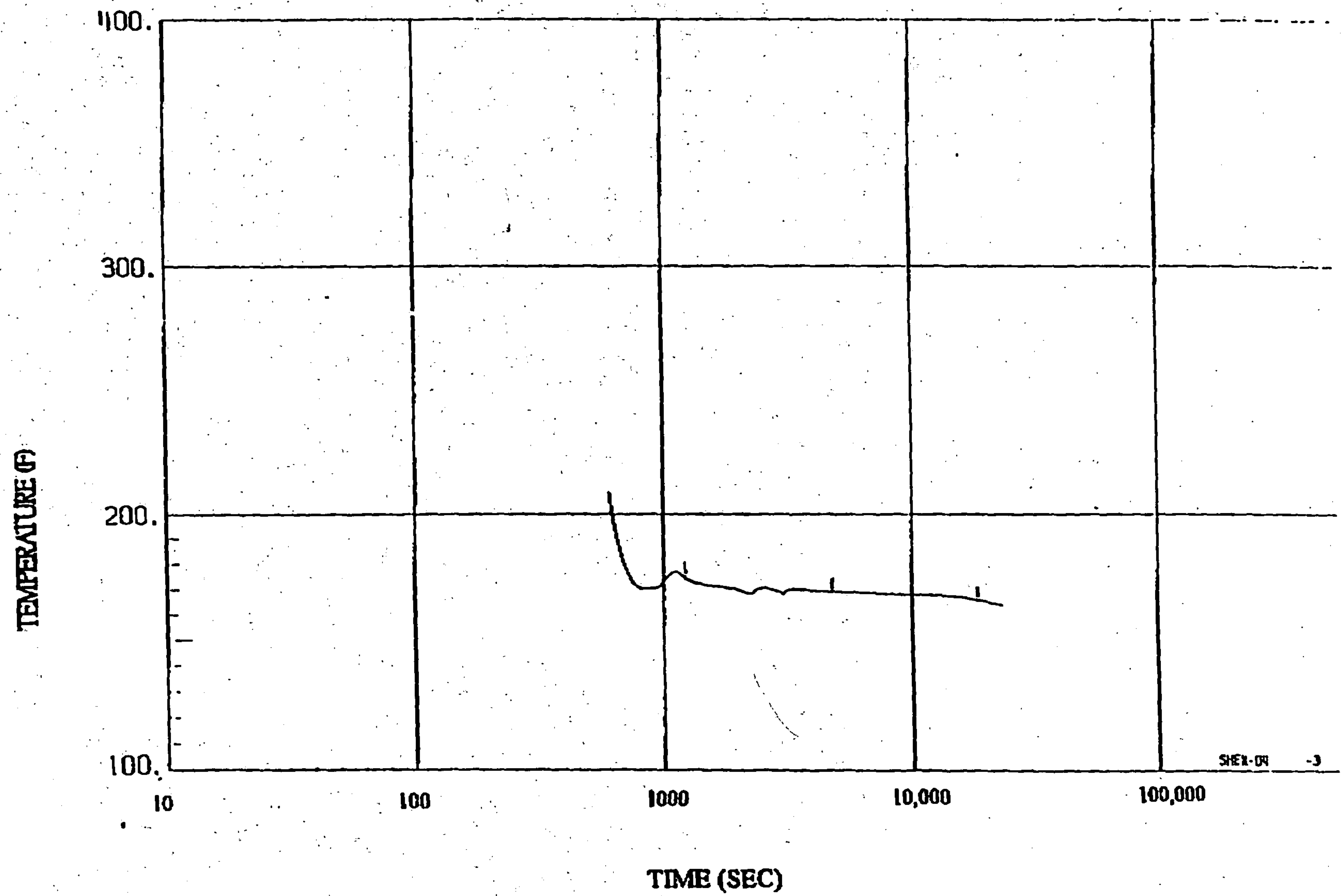

**Figure 4 - Long-Term DBA-LOCA Drywell Temperature Response.
(Case 3 of Task 3)**

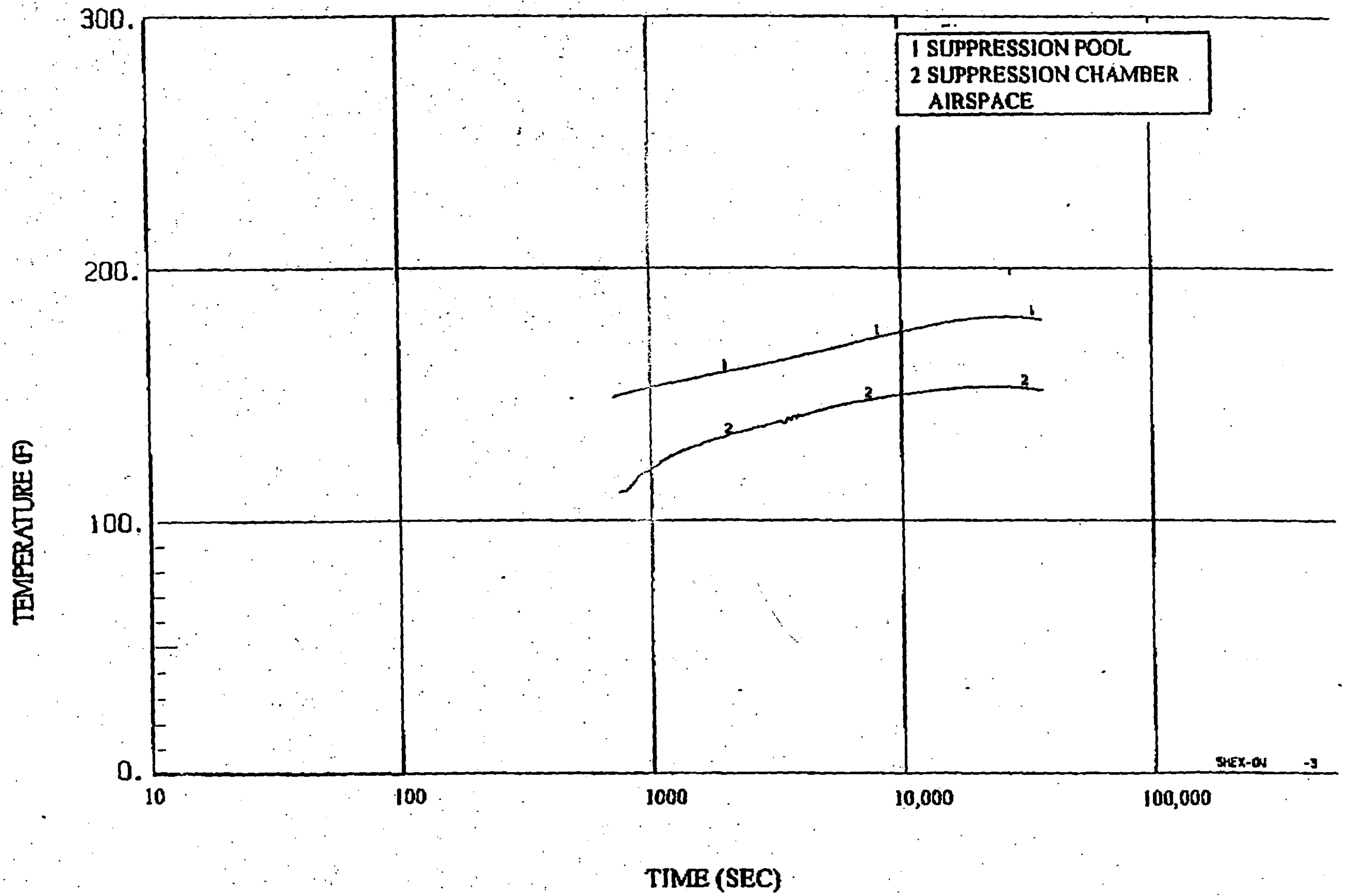

Figure 5 - Long-Term DBA-LOCA Suppression Pool and Suppression Chamber Airspace Temperature Response (Case 4.1 of Task 4)

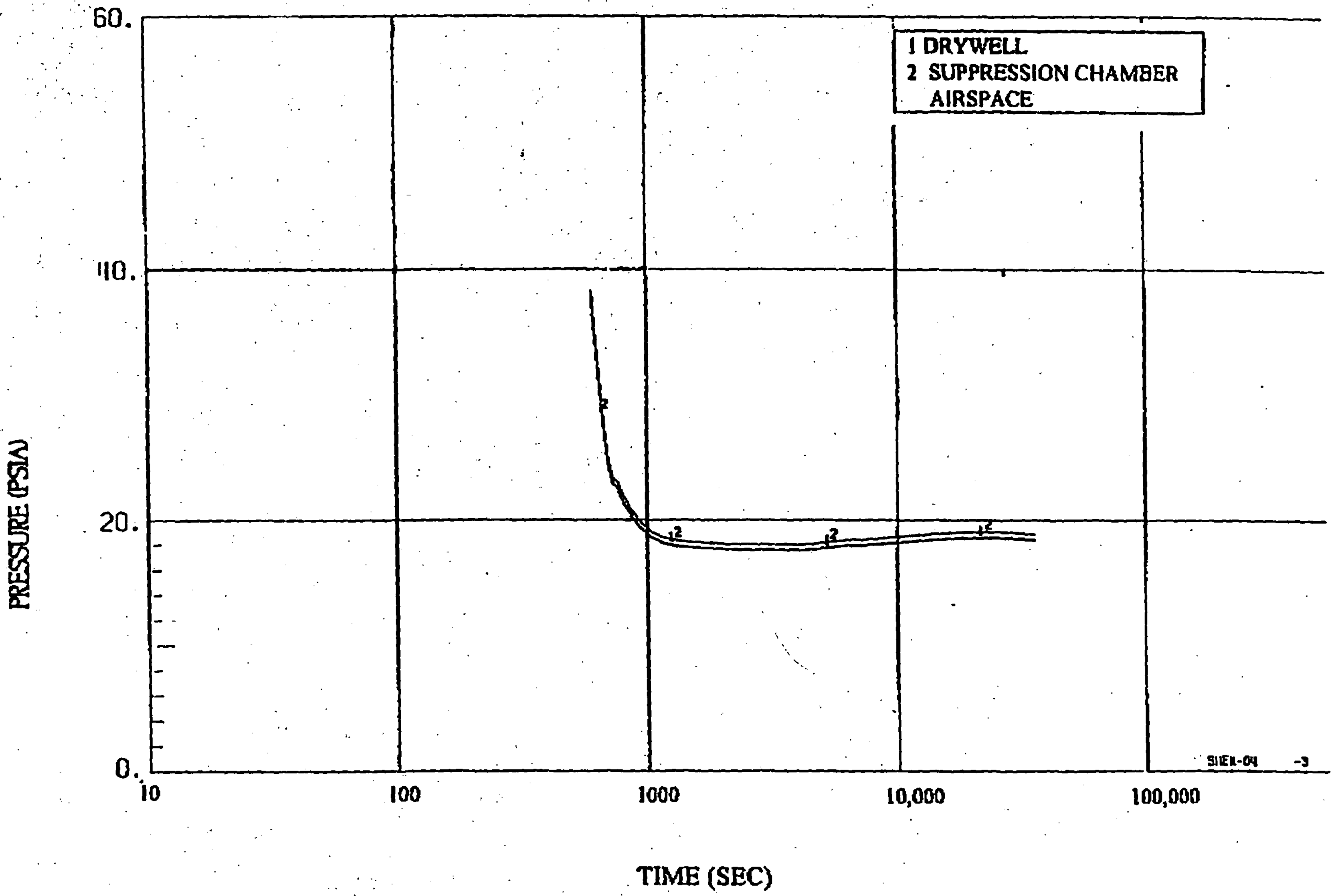

Figure 6 - Long-Term DBA-LOCA Drywell and Suppression Chamber Airspace Pressure Response. (Case 4.1 of Task 4)

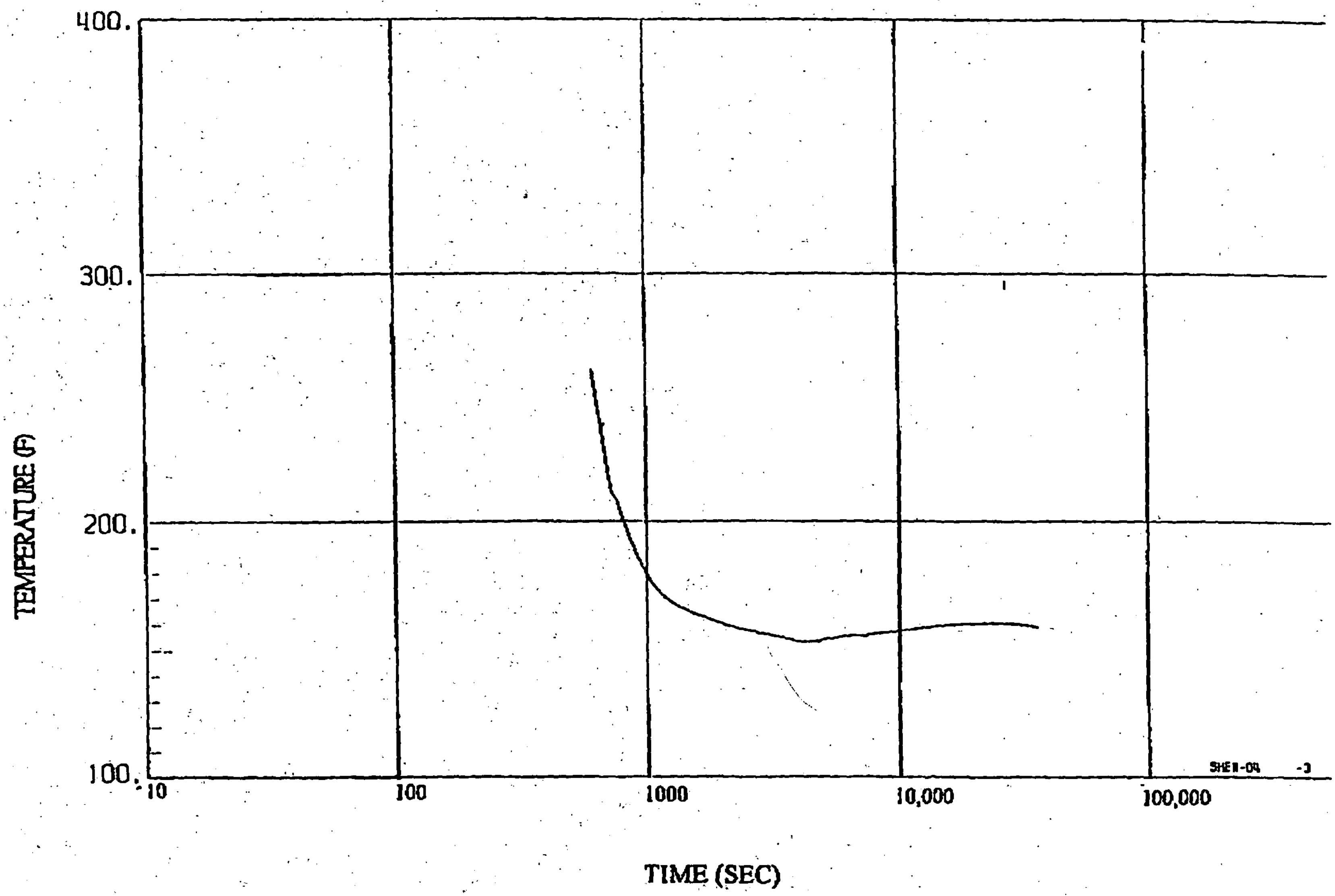

Figure 7 - Long-Term DBA-LOCA Drywell Temperature Response.
(Case 4.1 of Task 4)

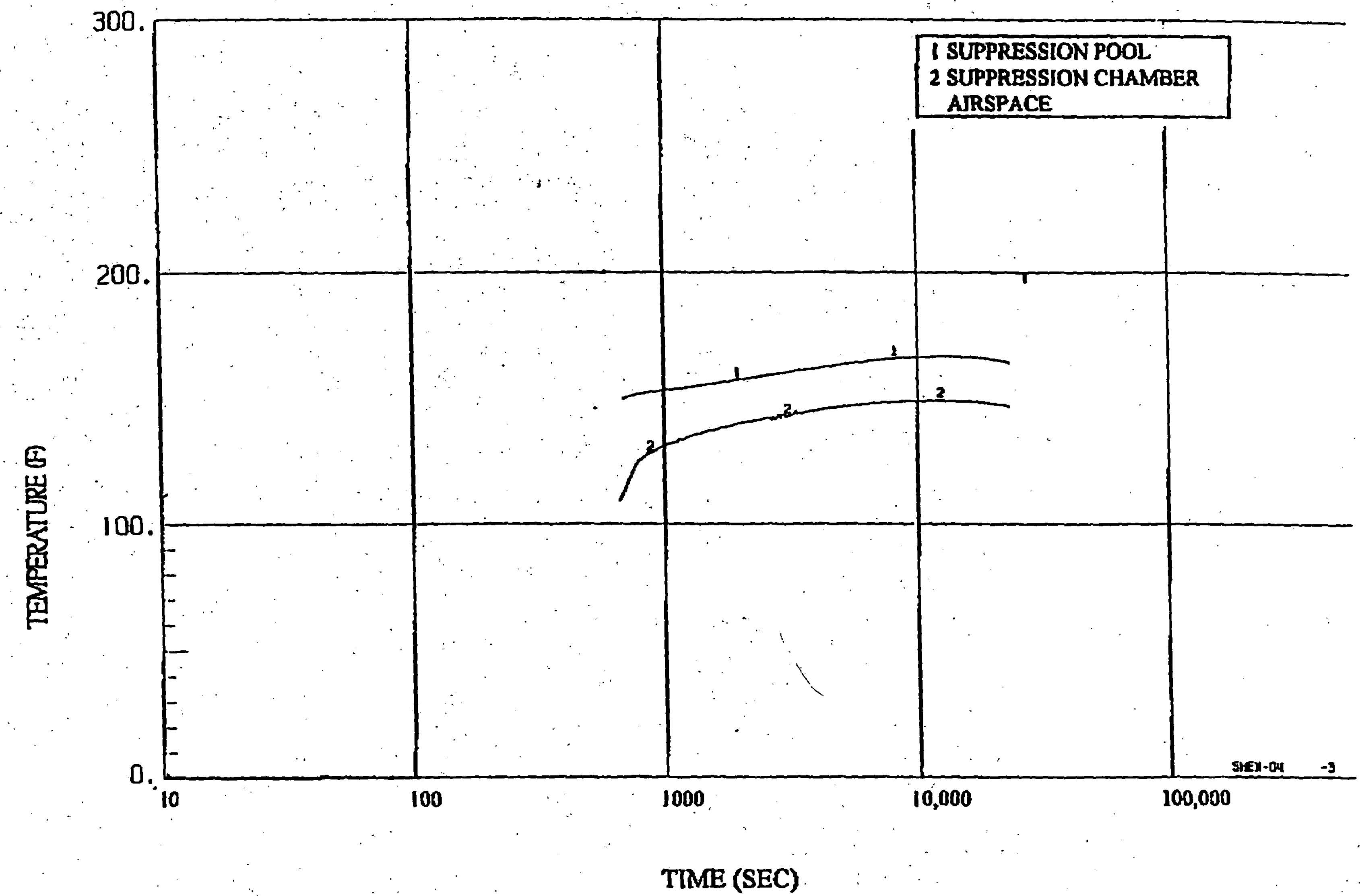

Figure 8 - Long-Term DBA-LOCA Suppression Pool and Suppression Chamber Airspace Temperature Response (Case 4.2 of Task 4)

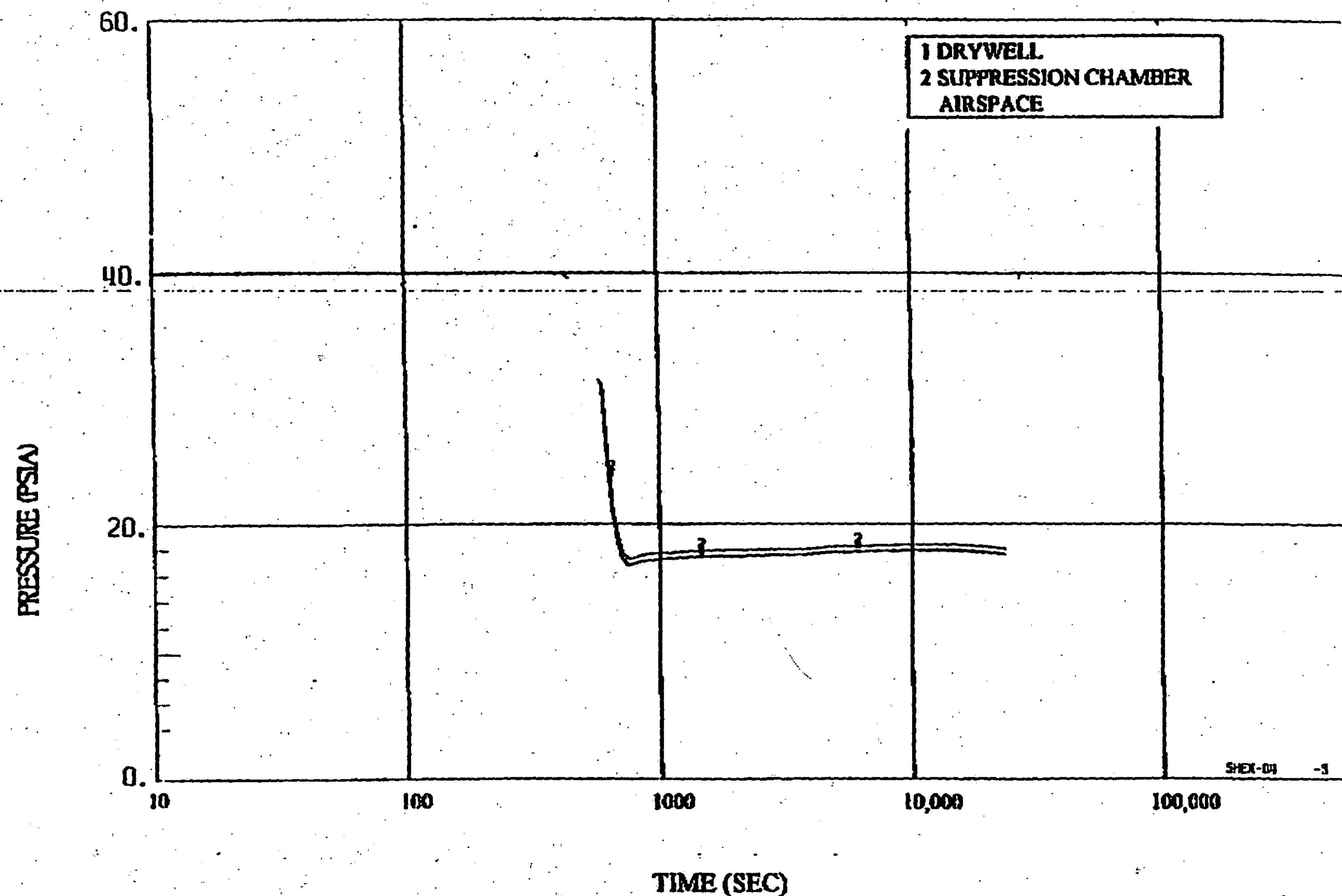

Figure 9 - Long Term DBA-LOCA Drywell and Suppression Chamber Airspace Pressure Response.
(Case 4.2 of Task 4)

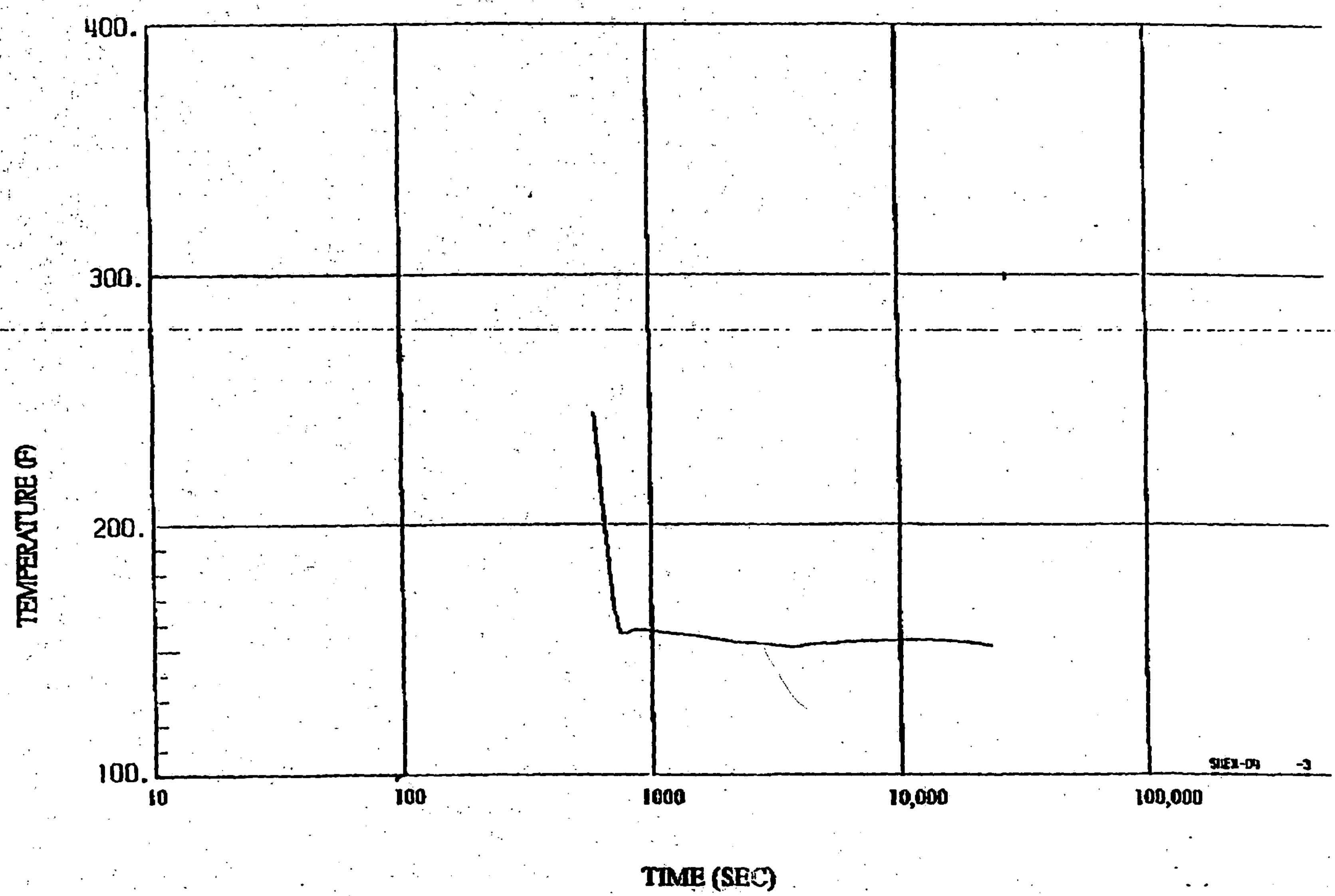

Figure 10 - Long-Term DBA-LOCA Drywell Temperature Response.
(Case 4.2 of Task 4)

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10.0 APPENDICES

A. CORE HEAT DATA

APPENDIX A
CORE DECAY HEAT DATA

Table A.1 provides the core heat (Btu/sec) based on the May-Witt (Reference A.2) decay heat model used for Cases 1, 2.2, 2.3, 2.4 and 2.5 of Section 7.0. The core heat includes decay heat (May-Witt), metal-water reaction energy, fission power and fuel relaxation energy. The core heat in Table A.1 is normalized to the initial core thermal power of 2578 MWt.

Table A.2 provides the core heat (Btu/sec) based on the ANS 5.1 (Reference A.1) decay heat model used for Cases 2.1, 3, 4.1 and 4.2 of Section 7.0. The core heat includes decay heat (ANS 5.1-1979), metal-water reaction energy, fission power and fuel relaxation energy. The core heat in Table A.2 is normalized to the initial core thermal power of 2578 MWt.

Appendix A References:

1) NEDO-10625, "Power Generation in a BWR Following Normal Shutdown or Loss-Of-Coolant Accident Conditions," March 1973.

2) "Decay Heat Power in Light Water Reactors," ANSI/ANS-5.1 - 1979, Approved by American National Standards Institute, August 29, 1979.

TABLE A.1 - CORE HEAT MAY-WITT

Time (sec)	Core Heat*
0.0	1.0232
0.1	1.0092
0.2	.9785
0.6	.7467
0.8	.6966
1.0	.5860
2.0	.5541
3.0	.5921
4.0	.5830
6.0	.5486
8.0	.4733
10.	.3859
20.	.08943
30.	.07161
40.	.05378
60.	.04937
80.	.04727
100.	.04588
120.	.04499
121.**	.03718
200.	.03365
600.	.02549
1000.	.02229
2000.	.01841
4000.	.01512
6000.	.01353
10000.	.01201
20000.	.01008
40000.	.008125
60000.	.007394

*Core Heat (normalized to the initial core thermal power of 2578 MWt)
= decay heat + fission power + fuel relaxation energy + metal-water reaction energy

** Metal-water reaction heat is assumed to end at 120 seconds.

TABLE A.2 - CORE HEAT ANS 5.1

Time (sec)	Core Heat*
0.0	1.0078
0.1	.9976
0.2	.9694
0.6	.7404
0.8	.6907
1.0	.5802
2.0	.5480
3.0	.5852
4.0	.5755
6.0	.5401
8.0	.4637
10.	.3771
20.	.08192
30.	.06405
40.	.04697
60.	.04271
80.	.04064
100.	.03925
120.	.03815
121.**	.03033
200.	.02752
600.	.02212
1000.	.01956
2000.	.01599
4000.	.01273
7800.	.01033
10200.	.01012
20400.	.008491
39600.	.007060
61200.	.006306

*Core Heat (normalized to the initial core thermal power of 2578 MWt)

= decay heat + fission power + fuel relaxation energy + metal-water reaction energy

** Metal-water reaction heat is assumed to end at 120 seconds.

Reference 13

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