ATTACHMENT 4

STRUCTURAL INTEGRITY ASSOCIATES, INC.

CALCULATION NO. 0800297.301, REVISION 1

REVISED PRESSURE-TEMPERATURE CURVES

Structural Integrity Associates, Inc.	File No.: 0800297.301
CALCULATION PACKAGE	**Project No.: 0800297** ☒ Q ☐ Non-Q

PROJECT NAME:

NMP Materials Update and Revised P-T Curves

CONTRACT NO.:

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CLIENT:	**PLANT:**
Constellation Energy	Nine Mile Point, Unit 1

CALCULATION TITLE:

Revised Pressure-Temperature Curves

Notes: This calculation supersedes all previous Pressure-Temperature curve calculations for the Nine Mile Point, Unit 1.

Document Revision	Affected Pages	Revision Description	Project Manager Approval Signature & Date	Preparer(s) & Checker(s) Signatures & Date
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1.0 INTRODUCTION

This calculation updates the Nine Mile Point, Unit 1 (NMP-1) pressure-temperature (P-T) curves for the beltline, bottom head, and non-beltline (feedwater nozzle / upper vessel) regions. The P-T curves are created for 28, 36, and 46 effective full power years (EFPY) of operation, and are developed using the methodology of the 2001 Edition, 2003 Addenda of ASME Code, Section XI, Appendix G [1], and 10CFR50 Appendix G [2]. This calculation has been developed in accordance with the methodology of the Boiling Water Reactor Owner's Group (BWROG) Licensing Topical Report, "Pressure-Temperature Limits Report Methodology for Boiling Water Reactors" [3].

2.0 METHODOLOGY

A full set of P-T curves are computed, including the following plant conditions: Operating Pressure (Leak) Test (Curve A), Normal Operation – Core Not Critical (Curve B), and Normal Operation – Core Critical (Curve C). The curves are consolidated into three bounding evaluation regions of the reactor pressure vessel (RPV): (1) the beltline, (2) the bottom head, and (3) the feedwater nozzle / upper vessel.

The primary methodology for calculating P-T curves is described in Reference [3]. Therefore, all methodology in this section is obtained from Reference [3] unless otherwise noted. The P-T curves are calculated by means of an iterative procedure, in which the following steps are completed:

Step 1: A fluid temperature, T, is assumed. The P-T curves are calculated under the premise of an assumed flaw that has extended ¼ of the way through the vessel wall. According to Reference [3], the temperature at the assumed flaw tip, $T_{1/4}$, is conservatively treated as equal to the assumed fluid temperature.

Step 2: The static fracture toughness factor, K_{Ic}, is computed using the following equation:

$$K_{Ic} = 20.734 \cdot e^{0.02(T-ART)} + 33.2 \qquad (1)$$

Where:
- K_{Ic} = the lower-bound static fracture toughness factor (ksi√in).
- T = the metal temperature at the tip of the postulated ¼ through-wall flaw (°F), as described above.
- ART = the Adjusted Reference Temperature (ART) for the limiting material in the RPV region under consideration (°F).

Step 3: The allowable stress intensity factor due to pressure, K_{Ip}, is calculated as:

$$K_{Ip} = \frac{K_{Ic} - K_{It}}{SF} \tag{2}$$

Where:
- K_{Ip} = the allowable stress intensity factor due to membrane (pressure) stress (ksi√in).
- K_{Ic} = the lower-bound static fracture toughness factor calculated in Equation 1 (ksi√in).
- K_{It} = the thermal stress intensity factor (ksi√in).
- SF = the safety factor, based on the reactor condition.

Note: For hydrostatic and leak test conditions (i.e., P-T Curve A), the SF = 1.5. For normal operation, for both a non-critical and a critical reactor (i.e., P-T Curves B and C), the SF = 2.0. When calculating values for Curve A, the thermal stress intensity factor is neglected (K_{It} = 0), since the hydrostatic leak test is performed at or near isothermal conditions (typically, the rate of temperature change is 25°F/hr or less) [3].

For Curve B and Curve C calculations, K_{It} is computed in different ways based on the evaluation region. For the beltline and bottom head regions, K_{It} is determined using the following equation based on the ASME Section XI, Nonmandatory Appendix G method:

$$K_{It} = 0.953 \times 10^{-3} \cdot CR \cdot t^{2.5} \tag{3}$$

Where:
- CR = the cooldown rate of the vessel (°F/hr).
- t = the RPV wall thickness, unique for each region (in).

For the feedwater nozzle / upper vessel region, K_{It} is obtained from the stress distribution output of a finite element model (FEM) of the feedwater nozzle, which is the limiting non-beltline component from a stress point-of-view (neglecting the flange, which is separately covered by application of 10 CFR 50 Appendix G limits). A thermal transient finite element analysis (FEA) is performed for the feedwater nozzle, and a polynomial curve-fit is applied to the through-wall stress distribution in the limiting nozzle corner location at each time point of the thermal transient. The subsequent method to evaluate K_{It} is given as:

$$K_{It} = \sqrt{\pi a}\left[0.706C_{0t} + \frac{2a}{\pi} \cdot 0.537C_{1t} + \frac{a^2}{2} \cdot 0.448C_{2t} + \frac{4a^3}{3\pi} \cdot 0.393C_{3t}\right] \tag{4}$$

Where:
- a = ¼ through-wall postulated flaw depth, a = ¼ t (in).
- t = thickness of the cross-section through the limiting nozzle inner blend radius corner (in).
- $C_{0t}, C_{1t}, C_{2t}, C_{3t}$ = thermal stress third order polynomial coefficients, obtained from a curve-fit of the extracted stresses from an FEM transient analysis.

The thermal stress polynomial coefficients are based on the polynomial form of $\sigma(x) = C_0 + C_1 \cdot \left(a/a_{max} \right) + C_2 \cdot \left(a/a_{max} \right)^2 + C_3 \cdot \left(a/a_{max} \right)^3$. In this equation, "a" represents the radial distance in inches from the inside surface to any point on the crack front, and "a_{max}" is the maximum crack depth, in inches.

Step 4: The allowable internal pressure of the RPV is calculated differently for each evaluation region. For the beltline region, the allowable pressure is determined as follows:

$$P_{allow} = \frac{K_{Ip} \cdot t}{M_m \cdot R_i} \tag{5}$$

Where:
- P_{allow} = the allowable RPV internal pressure (psig).
- K_{Ip} = the allowable stress intensity factor due to membrane (pressure) stress, as defined in Equation 2 (ksi√in).
- t = the RPV wall thickness, unique for each region (in).
- M_m = the membrane correction factor for an inside surface axial flaw:
  - $M_m = 1.85$ for $\sqrt{t} < 2$
  - $M_m = 0.926\sqrt{t}$ for $2 \leq \sqrt{t} \leq 3.464$
  - $M_m = 3.21$ for $\sqrt{t} > 3.464$
- R_i = the inner radius of the RPV (in).

For the bottom head region, the allowable pressure is calculated with the following equation:

$$P_{allow} = \frac{2 \cdot K_{Ip} \cdot t}{SCF \cdot M_m \cdot R_i} \tag{6}$$

Where:
- SCF = conservative stress concentration factor to account for bottom head penetration discontinuities; SCF = 3.0 per Reference [3].

P_{allow}, K_{Ip}, t, M_m and R_i are defined in the footnotes of Equation 5.

For the feedwater nozzle / upper vessel region, the allowable pressure is determined from a ratio of the allowable and applied stress intensity factors. The applied factor can be determined from an FEM that outputs the stresses due to the internal pressure on the nozzle / RPV. The methodology for this approach is as follows:

$$P_{allow} = \frac{K_{Ip} \cdot P_{ref}}{K_{Ip-app}} \tag{7}$$

Where:
- P_{ref} = RPV internal pressure at which the FEA stress coefficients (Equation 8) are valid (psig).
- K_{Ip-app} = the applied pressure stress intensity factor (ksi√in).

P_{allow} and K_{Ip} are defined in the footnotes of Equation 5.

The applied pressure stress intensity factor is determined using a polynomial curve-fit approximation for the through-wall pressure stress distribution from an FEA, similar to the methodology of Equation 4:

$$K_{Ip-app} = \sqrt{\pi a}\left[0.706C_{0p} + \frac{2a}{\pi}\cdot 0.537C_{1p} + \frac{a^2}{2}\cdot 0.448C_{2p} + \frac{4a^3}{3\pi}\cdot 0.393C_{3p}\right] \quad (8)$$

Where:
- a = ¼ through-wall postulated flaw depth, a = ¼ t (in).
- t = thickness of the cross-section through the limiting nozzle inner blend radius corner (in).
- $C_{0p}, C_{1p}, C_{2p}, C_{3p}$ = pressure stress polynomial coefficients, obtained from a curve-fit from the extracted stresses from an FEM unit pressure analysis.

Step 5: Steps 1 through 4 are repeated in order to generate a series of P-T points; the fluid temperature is incremented with each repetition. Calculations proceed in this iterative manner until the allowable reactor pressure (P_{P-T}) exceeds the maximum possible pressure. The maximum pressure limit is set to 1900 psig, since this value bounds the pre-service hydrostatic test pressure of 1,875 psig (see Section 3.0).

Step 6: The final P-T limits are calculated using the following equations:

$$T_{P-T} = T + U_T \quad (9)$$

$$P_{P-T} = P_{allow} - P_H - U_P \quad (10)$$

Where:
- T_{P-T} = the allowable coolant (metal) temperature (°F).
- U_T = the coolant temperature instrument uncertainty (°F).
- P_{P-T} = the allowable reactor pressure (psig).
- P_H = the pressure head to account for the water in the RPV (psig). Can be calculated from the following expression: $P_H = \rho \cdot \Delta h$.
- ρ = Water density at ambient temperature (lb/in^3).
- Δh = elevation of full height water level in RPV (in.).
- U_P = the pressure instrument uncertainty (psig).

Step 7: The following additional minimum temperature requirements apply to the feedwater nozzle / upper vessel region, according to Table 1 of 10CFR50, Appendix G [2]:

- If the pressure is greater than 20% of the pre-service hydro-test pressure, the temperature must be greater than the RT_{NDT} of the limiting flange material plus a temperature adjustment. For Curve A calculations, the temperature adjustment is 90°F; for Curve B, the temperature adjustment is 120°F.
- If the pressure is less than or equal to 20% of the pre-service hydro-test pressure, the minimum temperature must be greater than or equal to the RT_{NDT} of the limiting flange material.

The P-T Curves for the hydrostatic leak test (Curve A) and normal operation – core not critical (Curve B) can be computed by following Steps 1 through 7. Values for Curve C, the core-critical operating curve, are generated from the requirements of 10CFR50 Appendix G [2] and the Curve A and Curve B limits. Table 1 of Reference [2] requires that core critical P-T limits be 40°F above any Curve A or Curve B limits at all pressures. 10CFR50 Appendix G [2] also stipulates that, above the 20% pressure transition point, the Curve C temperatures must be either the reference temperature (RT_{NDT}) of the closure flange region plus 160°F, or the temperature required for the operating pressure (leak) test from Curve A, whichever is greater.

For P-T Curves A and B, the initial fluid temperature assumed in Step 1 is typically taken at the bolt-up temperature of the closure flange. According to Reference [2], the minimum bolt-up temperature is equal to the limiting material RT_{NDT} of the regions affected by bolt-up stresses. Consistent with Reference [3], the minimum bolt-up temperature shall not be lower than 60°F. Thus, the minimum bolt-up temperature shall be 60°F or the material RT_{NDT}, whichever is higher.

For P-T Curve C, when the reactor is critical, the initial fluid temperature is equal to the calculated minimum criticality temperature in this region. Table 1 of Reference [2] indicates that, for a BWR with normal operating water levels, the allowable temperature for initial criticality at the closure flange region is equal to the reference temperature (RT_{NDT}) at the flange region plus 60°F.

3.0 DESIGN INPUTS / ASSUMPTIONS

All design inputs and assumptions used to perform the NMP-1 P-T curve calculations are summarized in the input listings in Appendix A.

ART values in the NMP-1 beltline region are obtained from a previous Structural Integrity Associates (SI) calculation [4]. The calculations were performed in accordance with Nuclear Regulatory Commission (NRC) Regulatory Guide 1.99, Revision 2 (RG1.99) [5]. Based on Table 4 through Table 6 of Reference [4], the limiting beltline material is the P2112 lower shell plate. The limiting plate has ART values of 151.4°F, 159.0°F, and 167.4°F for 28, 36, and 46 EFPY, respectively.

NMP-1 has no large or small diameter nozzles (e.g. instrument nozzles) in the RPV beltline where the fluence exceeds 1.0×10^{17} n/cm^2(E>1MeV).

Non-beltline regions are not subjected to significant fluence; therefore, initial reference temperature (RT_{NDT}) values do not change, and are valid substitutions for corresponding ART values for these regions. Limiting RT_{NDT} values for the upper vessel and flange region are taken from Reference [12c] as 40°F. A complete list of RT_{NDT} values is not available for the bottom head [13]. Of the available data, a value of 40°F is bounding [13]. Since this value is also bounding for the upper vessel and flange region, the limiting bottom head RT_{NDT} is taken as 40°F. This is consistent with References [12.d] and [11, Section 10.3.1.1] which indicate the initial RT_{NDT} for areas of reactor vessel material away from the high flux density region of the core is 40°F.

The inner radius of the RPV, per Reference [6, Table 4-5], is 106.5 inches. The vessel shell thickness is taken as 7.125 inches from the same source. Dimensions for the bottom head radius and thickness are obtained from Reference [10, Appendix A] as 106.719 inches and 8.75 inches, respectively.

The GE design hydro-test is defined as 1,250 psig [14] while the operating pressure test maximum is defined as 1,055 psig [16]. As described by IWB-5220 [15], the system leakage test (Curve A) pressure is taken as the operating pressure. The pre-service system hydrostatic test pressure was taken as 1.5 times the GE design pressure, resulting in a value of 1,875 psig, as confirmed in Reference [12a]. The instrument uncertainties for the Curve A hydrotest are 4°F and 10 psig [17]. For Curves B and C, the instrument uncertainties are 12.2°F and 52.2 psig [17].

The total internal height of the RPV is 766 inches, as shown in Table V-1 of Reference [12b]. The density of the water is assumed to be 62.4 lb/ft^3 = 0.0361 lb/in^3. Thus, the static pressure adjustment due to the pressure head of the water in the RPV is conservatively calculated as 766·0.0361 = 27.66 psig for all evaluation regions, which addresses pressure test conditions when the RPV is fully flooded. The maximum cool-down rate of the vessel is 100°F/Hr per Reference [14]. Appendix B presents a bounding curve for a maximum heat-up / cool-down rate of 200°F/Hr.

According to Section 2.8 of Reference [3], the minimum bolt-up temperature for the RPV shall be no lower than 60°F. Since the RT_{NDT} values for all regions highly stressed by bolt preload are all less than 60°F, the initial assumed fluid temperature in the iterative P-T curve calculation process is set equal to 60°F. A temperature increment of 2°F between subsequent iterations is assumed.

The 60°F initial temperature of Reference [3] replaces the previous lower limit of 60°F plus the limiting RT_{NDT} for Curves A and B, which was applied to the previous NMP-1 P-T curves [7a, 7b]. This additional conservatism was required in pre-1971 ASME Section III Code, but is no longer required in ASME Section XI, Appendix G [1] or 10CFR50, Appendix G [2]. When the Pressure-Temperature Limits Report (PTLR) [3] was developed, SI consciously recognized the additional 60°F margin and chose to exclude it, as it is not technically required.

Post processing was performed for a previously developed finite element analyses to extract the necessary polynomial coefficients describing the hoop stress distribution through the feedwater nozzle's limiting corner location (Equations 4 and 8). The thermal and pressure stresses were extracted using ANSYS [8].

Based upon a previous axisymmetric analysis, the limiting nozzle corner location was chosen based upon the highest total stress intensity due to pressure loading [9]. This path (Nodes 584 to 570) is utilized to extract thermal and pressure hoop stresses from the results databases [9]. For thermal stresses, the feedwater nozzle FEM was run with a thermal shock from 550°F to 100°F applied to the nozzle flow path with 100% flow [9]. This represents the thermal shock during the transient "Increase to Rated Power" [14]. It can be seen from Reference [14] that this is the highest thermal shock for the feedwater nozzle. The thermal stresses are taken as function of time during the transient. Each stress distribution is fit with a third-order polynomial as a function of distance into the nozzle. The thermal stress intensity factor (Equation 4) is calculated for all time steps. The most limiting (highest) value is chosen, corresponding to a time of 5,000 seconds. Since operation is along the saturation curve, the

thermal stress intensity factor is scaled to reflect the worst-case step change due to available temperature difference. The pressure stresses are taken at steady state. The pressure stress analysis was performed for a 1,000 psig RPV pressure and the results scaled to reflect the operating pressure of 1,055 psig. The supporting *.out files of Reference [9] show that the path selected defines the nozzle corner thickness to be 7.8427 inches. Thus, the postulated flaw location at 1/4t is 1.9607 inches. Appendix C lists the ANSYS files included in the electronic supporting files. Note that only the finite element model developed in Reference [9] is used in this calculation; the Green's Function was not utilized.

The analyzed transient "Increase to Rated Power" is associated with the startup/shutdown event for the feedwater nozzle [14]. The evaluated shock is from 550°F to 100°F, which represents the design basis definition for this event. Figure 3-3 of Reference [18] shows a plant specific Turbine Roll transient for Unit 1 to be a shock from 485°F to 161°F. Even considering a potential 35°F feedwater temperature, page 4 of Appendix G states that the 161°F temperature would drop to 123°F [18]. Both of these are bounded by the analyzed 550°F to 100°F shock.

4.0 CALCULATIONS

The P-T curves in this calculation were developed using an Excel spreadsheet, which is independently verified for use on a project-specific basis in accordance with SI's QA Program.

The polynomial stress coefficients in Table 1 were applied to Equations 4 and 8. The resulting pressure stress intensity ($K_{Ip\text{-}applied}$) and thermal stress intensity (K_{It}) factors are 86.72 ksi√in and 45.60 ksi√in, respectively.

4.1 Pressure Test (Curve A)

The minimum bolt-up temperature of 60°F is applied to all regions as the initial temperature in the iterative calculation process. The static fracture toughness (K_{Ic}) is calculated for all regions using Equation 1. The resulting value of K_{Ic}, along with a safety factor of 1.5, is used in Equation 2 to calculate the pressure stress intensity (K_{Ip}). The allowable RPV pressure is calculated for the beltline, bottom head, and upper vessel regions using Equations 5, 6, and 7, respectively. For the feedwater nozzle / upper vessel region, the additional constraints specified in Step 7 of Section 2.0 are applied. Final P-T limits for temperature and pressure are obtained from Equations 9 and 10, respectively.

The data resulting from each P-T curve calculation was tabulated. Values for the beltline region at 28, 36, and 46 EFPY are given in Table 2, Table 3, and Table 4, respectively. Data for the bottom head region is listed in Table 5, and data for the feedwater nozzle / upper vessel region is presented in Table 6. The data for each region was graphed, and the resulting P-T curves for 28, 36, and 46 EFPY are provided in Figure 1, Figure 2, and Figure 3, respectively.

4.2 Normal Operation – Core Not Critical (Curve B)

The minimum bolt-up temperature of 60°F is applied to all regions as the initial temperature in the iterative calculation process. The static fracture toughness (K_{Ic}) is calculated for all regions using Equation 1. The thermal stress intensity factor (K_{It}) is calculated for the beltline and bottom head regions using Equation 3, and for the feedwater nozzle using Equation 4.

The resulting values of K_{Ic} and K_{It}, along with a safety factor of 2.0, are used in Equation 2 to calculate the pressure stress intensity (K_{Ip}). The allowable RPV pressure was calculated for the beltline, bottom head, and upper vessel regions using Equations 5, 6, and 7, respectively. For the feedwater nozzle / upper vessel region, the additional constraints specified in Step 7 of Section 2.0 are applied. Final P-T limits for temperature and pressure are obtained from Equations 9 and 10, respectively.

The data resulting from each P-T curve calculation was tabulated. Values for the beltline region at 28, 36, and 46 EFPY are given in Table 7, Table 8, and Table 9, respectively. Data for the bottom head region is listed in Table 10, and data for the feedwater nozzle / upper vessel region is presented in Table 11. The data for each region was graphed, and the resulting P-T curves for 28, 36, and 46 EFPY are provided in Figure 4, Figure 5, and Figure 6, respectively.

4.3 Normal Operation – Core Critical (Curve C)

The pressure and temperature values for Curve C are calculated in a similar manner as Curve B, with several exceptions. The initial evaluation temperature is calculated as the limiting closure flange region RT_{NDT} that is highly stressed by the bolt preload (in this case, that of the closure flange region: 40°F per Section 3.0) plus 60°F, resulting in a minimum critical temperature of 100°F. When the pressure exceeds 20% of the pre-service system hydro-test pressure (20% of 1,875 psig = 375 psig), the P-T limits are specified as 40°F higher than the Curve B values. The minimum temperature above the 20% pressure transition point is always greater than the reference temperature (RT_{NDT}) of the closure region plus 160°F, or the temperature required for the hydrostatic pressure test. The final Curve C values are taken as the absolute maximum between the three regions of Curve B P-T curves.

Tabulated overall values for Curve C are provided at 28, 36, and 46 EFPY in Table 12, Table 13, and Table 14, respectively. The corresponding P-T curves for 28, 36, and 46 EFPY are provided in Figure 7, Figure 8, and Figure 9, respectively.

5.0 CONCLUSIONS

P-T curves were calculated for NMP-1 for 28, 36, and 46 EFPY using the methodology in Section 2.0 and the design inputs and assumptions defined in Section 3.0. A full set of P-T curves were computed, including the following plant conditions: Operating Pressure (Leak) Test (Curve A), Normal Operation – Core Not Critical (Curve B), and Normal Operation – Core Critical (Curve C). Calculations were performed for the beltline, bottom head, and feedwater nozzle / upper vessel regions. Values for the

beltline regions were computed at 28, 36, and 46 EFPY. The calculations were performed in accordance with the PTLR methodology approved by the NRC in Reference [3].

Tabulated pressure and temperature values are provided for all regions in Table 2 through Table 14. The accompanying P-T curve plots are provided in Figure 1 through Figure 9.

6.0 REFERENCES

1. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, Rules for In-Service Inspection of Nuclear Power Plant Components, 2001 Edition including the 2003 Addenda.
2. Part 50 U.S. Code of Federal Regulations, Title 10, Energy, Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix G, "Fracture Toughness Requirements," (60 FR 65474, Dec. 19, 1995; 73 FR 5723, Jan. 31, 2008).
3. Structural Integrity Associates Report No. SIR-05-044A, Revision 0, "Pressure-Temperature Limits Report Methodology for Boiling Water Reactors," April 2007, SI File No. GE-10Q-401.
4. Structural Integrity Associates Calculation No. 0800297.300, Revision 1, "Evaluation of Adjusted Reference Temperatures and Reference Temperature Shifts."
5. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials," May 1988.
6. MPM Report No. MPM-59838, "Pressure-Temperature Operating Curves for Nine Mile Point Unit 1," May 1998, SI File No. NMP-05Q-207.
7. Previous Structural Integrity Associates P-T Curve Calculations for NMP-1:
    a. NMP-05Q-301, Revision 0, "Benchmark Analysis."
    b. NMP-05Q-302, Revision 0, "NMP-1 P-T Curves Generated Using Code Case N-640."
8. ANSYS/Mechanical Release 6.1 (w/Service Packs 2 and 3), ANSYS, Inc., April 2002.
9. Structural Integrity Associates Calculation No. NMP-09Q-302, Revision 0, "Feedwater Nozzle Green's Functions for Nine Mile Point Unit 1."
10. Combustion Engineering, Inc. Report No. CENC-1142, "Analytical Report for Niagara Mohawk Reactor Vessel," SI File No. NMP-09Q-246.
11. GE Specification 21A1104, Revision 0, "Reactor Pressure Vessel," SI File No. NMP-09Q-292.
12. Nine Mile Point Unit 1 Updated Final Safety Analysis Report:
    a. Section V, "Reactor Coolant System," Revision 16, Table V-1, p. 3 of 3, November 1999, SI File No. NMP-09Q-231.
    b. Section V, "Reactor Coolant System," Revision 17, Table V-1, p. 1 of 3, October 2001, SI File No. NMP-09Q-231.
    c. Section V, "Reactor Coolant System," Revision 16, p. V-12, November 1999, SI File No. NMP-09Q-231.
    d. Section I, Revision 17, p. I-10, October 2001, SI File No. 0800297.215.
13. Westinghouse Report No. DNS-03-001, "Document Transmittal," January 20, 2003, SI File No. 0800297.213.

14. G.E. Drawing No. 237E434, "Loadings Reactor Vessel," Note: Revision and Sheet Number not legible, SI File No. NMP-09Q-225.

15. ASME Boiler and Pressure Vessel Code, Section XI, 2001 Edition w/ Addenda through 2003.

16. Email from G. Inch (NMP) to T. Griesbach (SI), "FW: NMP1 Pressure Test Pressure," October 10, 2008 11:58AM, SI File No. 0800297.214.

17. Niagara Mohawk letter M97-080 to Dr. Michael P. Manahan, Sr., "Re: Instrument Uncertainty for PT Curves," December 18, 1997, SI File No. NMP-05Q-201.

18. MPR Associates Inc. Report No. MPR-1484, Revision 1, "Nine Mile Point Unit 1 Feedwater Nozzle Fatigue Evaluation," March 1999, SI File No. 0800297.216.

Table 1: NMP-1 Polynomial Coefficients for Feedwater Nozzle Stress Intensity Distributions

Feedwater Nozzle Pressure Stress Coefficients					$K_{Ip\text{-}applied}$
c0	c1	c2	c3		(psi√in)
57668.48	-10039.72	1229.09	-79.59		86,723
Feedwater Nozzle Thermal Stress Coefficients					K_{It}
c0	c1	c2	c3		(psi√in)
29382.12	-3688.32	150.32	-23.48		45,595

Table 2: NMP-1 Beltline Region, Curve A, for 28 EFPY

Plant =	NMP-1	
Component =	Beltline	
Vessel thickness, t =	7.125	inches
Vessel Radius, R =	106.5	inches
ART =	151.4	°F =====> 28 EFPY
K_{It} =	0	(no thermal effects)
Safety Factor =	1.5	
M_m =	2.472	
Temperature Adjustment =	4.0	°F (instrument uncertainty)
Pressure Adjustment =	27.7	psig (hydrostatic pressure head for a full vessel at 70°F)
Pressure Adjustment =	10.0	psig (instrument uncertainty)

Guage Fluid Temperature (°F)	K_{Ic} (ksi·√in)	K_{Im} (ksi·√in)	Guage Pressure (psig)	Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
56	36.28	24.18	0	60	0
56	36.28	24.18	655	60	617
58	36.40	24.27	657	62	619
60	36.53	24.36	659	64	622
62	36.67	24.45	662	66	624
64	36.81	24.54	664	68	627
66	36.96	24.64	667	70	629
68	37.11	24.74	670	72	632
70	37.27	24.85	673	74	635
72	37.44	24.96	676	76	638
74	37.61	25.07	679	78	641
76	37.79	25.19	682	80	644
78	37.98	25.32	685	82	648
80	38.17	25.45	689	84	651
82	38.37	25.58	692	86	655
84	38.59	25.72	696	88	659
86	38.81	25.87	700	90	663
88	39.03	26.02	704	92	667
90	39.27	26.18	709	94	671
92	39.52	26.35	713	96	675
94	39.78	26.52	718	98	680
96	40.05	26.70	723	100	685
98	40.33	26.88	728	102	690
100	40.62	27.08	733	104	695
102	40.92	27.28	738	106	701
104	41.23	27.49	744	108	706
106	41.56	27.71	750	110	712
108	41.90	27.94	756	112	718
110	42.26	28.17	763	114	725
112	42.63	28.42	769	116	732
114	43.01	28.68	776	118	738
116	43.41	28.94	783	120	746
118	43.83	29.22	791	122	753
120	44.26	29.51	799	124	761
122	44.72	29.81	807	126	769
124	45.19	30.12	815	128	778
126	45.68	30.45	824	130	787
128	46.18	30.79	833	132	796
130	46.71	31.14	843	134	805
132	47.27	31.51	853	136	815
134	47.84	31.89	863	138	826
136	48.44	32.29	874	140	836
138	49.06	32.71	885	142	848
140	49.71	33.14	897	144	859

Table 2 Continued: NMP-1 Beltline Region, Curve A, for 28 EFPY

Guage Fluid Temperature (°F)	K_{Ic} (ksi√in)	K_{Im} (ksi√in)	Guage Pressure (psig)	Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
142	50.38	33.59	909	146	871
144	51.08	34.05	922	148	884
146	51.81	34.54	935	150	897
148	52.57	35.05	949	152	911
150	53.36	35.57	963	154	925
152	54.18	36.12	978	156	940
154	55.04	36.69	993	158	956
156	55.93	37.29	1009	160	972
158	56.86	37.91	1026	162	988
160	57.83	38.55	1043	164	1006
162	58.83	39.22	1062	166	1024
164	59.88	39.92	1080	168	1043
166	60.96	40.64	1100	170	1062
168	62.10	41.40	1121	172	1083
170	63.28	42.18	1142	174	1104
172	64.50	43.00	1164	176	1126
174	65.78	43.85	1187	178	1149
176	67.11	44.74	1211	180	1173
178	68.50	45.66	1236	182	1198
180	69.94	46.62	1262	184	1224
182	71.44	47.62	1289	186	1251
184	73.00	48.66	1317	188	1280
186	74.62	49.75	1346	190	1309
188	76.31	50.87	1377	192	1339
190	78.07	52.05	1409	194	1371
192	79.90	53.27	1442	196	1404
194	81.81	54.54	1476	198	1438
196	83.79	55.86	1512	200	1474
198	85.86	57.24	1549	202	1512
200	88.00	58.67	1588	204	1550
202	90.24	60.16	1628	206	1591
204	92.57	61.71	1670	208	1633
206	94.99	63.33	1714	210	1676
208	97.51	65.01	1760	212	1722
210	100.14	66.76	1807	214	1769
212	102.87	68.58	1856	216	1819
214	105.71	70.48	1908	218	1870
216	108.67	72.45	1961	220	1923

Table 3: NMP-1 Beltline Region, Curve A, for 36 EFPY

Plant =	NMP-1	
Component =	Beltline	
Vessel thickness, t =	7.125	inches
Vessel Radius, R =	106.5	inches
ART =	159.0	°F =====> 36 EFPY
K_{It} =	0	(no thermal effects)
Safety Factor =	1.5	
M_m =	2.472	
Temperature Adjustment =	4.0	°F (instrument uncertainty)
Pressure Adjustment =	27.7	psig (hydrostatic pressure head for a full vessel at 70°F)
Pressure Adjustment =	10.0	psig (instrument uncertainty)

Guage Fluid Temperature (°F)	K_{Ic} (ksi√in)	K_{Im} (ksi√in)	Guage Pressure (psig)	Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
56	35.84	23.90	0	60	0
56	35.84	23.90	647	60	609
58	35.95	23.97	649	62	611
60	36.06	24.04	651	64	613
62	36.18	24.12	653	66	615
64	36.30	24.20	655	68	617
66	36.43	24.29	657	70	620
68	36.56	24.37	660	72	622
70	36.70	24.46	662	74	625
72	36.84	24.56	665	76	627
74	36.99	24.66	667	78	630
76	37.14	24.76	670	80	633
78	37.30	24.87	673	82	635
80	37.47	24.98	676	84	638
82	37.64	25.10	679	86	642
84	37.83	25.22	683	88	645
86	38.02	25.34	686	90	648
88	38.21	25.47	690	92	652
90	38.42	25.61	693	94	656
92	38.63	25.75	697	96	659
94	38.85	25.90	701	98	663
96	39.08	26.05	705	100	668
98	39.32	26.21	710	102	672
100	39.57	26.38	714	104	676
102	39.83	26.55	719	106	681
104	40.10	26.73	724	108	686
106	40.38	26.92	729	110	691
108	40.68	27.12	734	112	696
110	40.98	27.32	739	114	702
112	41.30	27.53	745	116	708
114	41.63	27.75	751	118	714
116	41.97	27.98	757	120	720
118	42.33	28.22	764	122	726
120	42.70	28.47	771	124	733
122	43.09	28.73	778	126	740
124	43.50	29.00	785	128	747
126	43.92	29.28	792	130	755
128	44.35	29.57	800	132	763
130	44.81	29.87	809	134	771
132	45.28	30.19	817	136	779
134	45.78	30.52	826	138	788
136	46.29	30.86	835	140	798
138	46.82	31.22	845	142	807
140	47.38	31.59	855	144	817

Table 3 Continued: NMP-1 Beltline Region, Curve A, for 36 EFPY

Guage Fluid Temperature (°F)	K_{Ic} (ksi-√in)	K_{Im} (ksi-√in)	Guage Pressure (psig)	Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
142	47.96	31.97	865	146	828
144	48.56	32.37	876	148	839
146	49.19	32.79	888	150	850
148	49.84	33.23	899	152	862
150	50.52	33.68	912	154	874
152	51.23	34.15	924	156	887
154	51.96	34.64	938	158	900
156	52.73	35.15	951	160	914
158	53.52	35.68	966	162	928
160	54.35	36.24	981	164	943
162	55.22	36.81	996	166	959
164	56.11	37.41	1013	168	975
166	57.05	38.03	1029	170	992
168	58.02	38.68	1047	172	1009
170	59.04	39.36	1065	174	1028
172	60.09	40.06	1084	176	1047
174	61.19	40.79	1104	178	1066
176	62.33	41.55	1125	180	1087
178	63.52	42.35	1146	182	1108
180	64.76	43.17	1168	184	1131
182	66.04	44.03	1192	186	1154
184	67.38	44.92	1216	188	1178
186	68.78	45.85	1241	190	1203
188	70.23	46.82	1267	192	1230
190	71.74	47.83	1295	194	1257
192	73.32	48.88	1323	196	1285
194	74.95	49.97	1352	198	1315
196	76.66	51.10	1383	200	1346
198	78.43	52.29	1415	202	1378
200	80.28	53.52	1449	204	1411
202	82.20	54.80	1483	206	1446
204	84.20	56.13	1519	208	1482
206	86.28	57.52	1557	210	1519
208	88.44	58.96	1596	212	1558
210	90.70	60.47	1637	214	1599
212	93.05	62.03	1679	216	1641
214	95.49	63.66	1723	218	1685
216	98.03	65.35	1769	220	1731
218	100.68	67.12	1817	222	1779
220	103.43	68.95	1866	224	1829
222	106.30	70.86	1918	226	1880
224	109.28	72.85	1972	228	1934

Table 4: NMP-1 Beltline Region, Curve A, for 46 EFPY

Plant =	NMP-1	
Component =	Beltline	
Vessel thickness, t =	7.125	inches
Vessel Radius, R =	106.5	inches
ART =	167.4	°F =====> 46 EFPY
K_{It} =	0	(no thermal effects)
Safety Factor =	1.5	
M_m =	2.472	
Temperature Adjustment =	4.0	°F (instrument uncertainty)
Pressure Adjustment =	27.7	psig (hydrostatic pressure head for a full vessel at 70°F)
Pressure Adjustment =	10.0	psig (instrument uncertainty)

Guage Fluid Temperature (°F)	K_{Ic} (ksi·√in)	K_{Im} (ksi·√in)	Guage Pressure (psig)	Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
56	35.43	23.62	0	60	0
56	35.43	23.62	639	60	602
58	35.53	23.68	641	62	603
60	35.62	23.75	643	64	605
62	35.72	23.81	645	66	607
64	35.82	23.88	646	68	609
66	35.93	23.95	648	70	611
68	36.04	24.03	650	72	613
70	36.16	24.10	652	74	615
72	36.28	24.18	655	76	617
74	36.40	24.27	657	78	619
76	36.53	24.36	659	80	622
78	36.67	24.45	662	82	624
80	36.81	24.54	664	84	627
82	36.96	24.64	667	86	629
84	37.11	24.74	670	88	632
86	37.27	24.85	673	90	635
88	37.44	24.96	676	92	638
90	37.61	25.07	679	94	641
92	37.79	25.19	682	96	644
94	37.98	25.32	685	98	648
96	38.17	25.45	689	100	651
98	38.37	25.58	692	102	655
100	38.59	25.72	696	104	659
102	38.81	25.87	700	106	663
104	39.03	26.02	704	108	667
106	39.27	26.18	709	110	671
108	39.52	26.35	713	112	675
110	39.78	26.52	718	114	680
112	40.05	26.70	723	116	685
114	40.33	26.88	728	118	690
116	40.62	27.08	733	120	695
118	40.92	27.28	738	122	701
120	41.23	27.49	744	124	706
122	41.56	27.71	750	126	712
124	41.90	27.94	756	128	718
126	42.26	28.17	763	130	725
128	42.63	28.42	769	132	732
130	43.01	28.68	776	134	738
132	43.41	28.94	783	136	746
134	43.83	29.22	791	138	753
136	44.26	29.51	799	140	761
138	44.72	29.81	807	142	769
140	45.19	30.12	815	144	778

Table 4 Continued: NMP-1 Beltline Region, Curve A, for 46 EFPY

Guage Fluid Temperature (°F)	K_{Ic} (ksi√in)	K_{Im} (ksi√in)	Guage Pressure (psig)	Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
142	45.68	30.45	824	146	787
144	46.18	30.79	833	148	796
146	46.71	31.14	843	150	805
148	47.27	31.51	853	152	815
150	47.84	31.89	863	154	826
152	48.44	32.29	874	156	836
154	49.06	32.71	885	158	848
156	49.71	33.14	897	160	859
158	50.38	33.59	909	162	871
160	51.08	34.05	922	164	884
162	51.81	34.54	935	166	897
164	52.57	35.05	949	168	911
166	53.36	35.57	963	170	925
168	54.18	36.12	978	172	940
170	55.04	36.69	993	174	956
172	55.93	37.29	1009	176	972
174	56.86	37.91	1026	178	988
176	57.83	38.55	1043	180	1006
178	58.83	39.22	1062	182	1024
180	59.88	39.92	1080	184	1043
182	60.96	40.64	1100	186	1062
184	62.10	41.40	1121	188	1083
186	63.28	42.18	1142	190	1104
188	64.50	43.00	1164	192	1126
190	65.78	43.85	1187	194	1149
192	67.11	44.74	1211	196	1173
194	68.50	45.66	1236	198	1198
196	69.94	46.62	1262	200	1224
198	71.44	47.62	1289	202	1251
200	73.00	48.66	1317	204	1280
202	74.62	49.75	1346	206	1309
204	76.31	50.87	1377	208	1339
206	78.07	52.05	1409	210	1371
208	79.90	53.27	1442	212	1404
210	81.81	54.54	1476	214	1438
212	83.79	55.86	1512	216	1474
214	85.86	57.24	1549	218	1512
216	88.00	58.67	1588	220	1550
218	90.24	60.16	1628	222	1591
220	92.57	61.71	1670	224	1633
222	94.99	63.33	1714	226	1676
224	97.51	65.01	1760	228	1722
226	100.14	66.76	1807	230	1769
228	102.87	68.58	1856	232	1819
230	105.71	70.48	1908	234	1870
232	108.67	72.45	1961	236	1923

Table 5: NMP-1 Bottom Head Region, Curve A, for all EFPY

Plant =	NMP-1	
Component =	Bottom Head	(penetrations portion)
Bottom Head thickness, t =	8.75	inches
Bottom Head Radius, R =	106.719	inches
ART =	40	°F =====> All EFPY
K_{It} =	0	(no thermal effects)
Safety Factor =	1.5	
Stress Concetration Factor =	3.0	(bottom head penetrations)
M_m =	2.739	
Temperature Adjustment =	4.0	°F (instrument uncertainty)
Pressure Adjustment =	27.7	psig (hydrostatic pressure head for a full vessel at 70°F)
Pressure Adjustment =	10.0	psig (instrument uncertainty)

Guage Fluid Temperature (°F)	K_{Ic} (ksi·√in)	K_{Im} (ksi·√in)	Guage Pressure (psig)	Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
56	61.75	41.17	0	60	0
56	61.75	41.17	822	60	784
58	62.92	41.95	837	62	799
60	64.13	42.75	853	64	816
62	65.39	43.60	870	66	832
64	66.71	44.47	887	68	850
66	68.08	45.38	906	70	868
68	69.50	46.33	925	72	887
70	70.98	47.32	944	74	907
72	72.52	48.35	965	76	927
74	74.13	49.42	986	78	948
76	75.80	50.53	1008	80	971
78	77.54	51.69	1031	82	994
80	79.34	52.90	1056	84	1018
82	81.23	54.15	1081	86	1043
84	83.19	55.46	1107	88	1069
86	85.23	56.82	1134	90	1096
88	87.35	58.23	1162	92	1124
90	89.56	59.71	1191	94	1154
92	91.86	61.24	1222	96	1184
94	94.25	62.84	1254	98	1216
96	96.75	64.50	1287	100	1249
98	99.34	66.23	1322	102	1284
100	102.04	68.03	1357	104	1320
102	104.85	69.90	1395	106	1357
104	107.77	71.85	1434	108	1396
106	110.82	73.88	1474	110	1437
108	113.98	75.99	1516	112	1479
110	117.28	78.19	1560	114	1523
112	120.71	80.47	1606	116	1568
114	124.28	82.86	1653	118	1616
116	128.00	85.33	1703	120	1665
118	131.87	87.91	1754	122	1717
120	135.90	90.60	1808	124	1770
122	140.09	93.39	1864	126	1826
124	144.45	96.30	1922	128	1884
126	148.99	99.33	1982	130	1944

Table 6: NMP-1 Upper Vessel Region, Curve A, for all EFPY

Plant =	NMP-1		
Component =	Upper Vessel		
ART =	40.0	°F =====>	All EFPY
Vessel Radius =	106.5	inches	
Nozzle corner thickness, t =	7.843	inches	
Nozzle K_{It} =	0	(no thermal effects)	
Nozzle $K_{Ip\text{-}applied}$ =	86.72	ksi√in	
Crack Depth, a =	1.961	inches	
Safety Factor =	1.5		
Temperature Adjustment =	4.0	°F (instrument uncertainty)	
Pressure Adjustment =	27.7	psig (hydrostatic pressure head for a full vessel at 70°F)	
Pressure Adjustment =	10.0	psig (instrument uncertainty)	
Reference Pressure =	1,000	psig (pressure at which FEA stress coefficients are valid) (GREEN)	
Unit Pressure =	1,875	*psig (hydrostatic pressure)*	
Flange RT_{NDT} =	40.0	°F =====>	All EFPY

Guage Fluid Temperature (°F)	K_{Ic} (ksi√in)	K_{Im} (ksi√in)	Guage Pressure (psig)	P-T Curve Temperature (°F)	P-T Curve 10CFR50 Adjustments (psig)
56	61.75	41.17	0	60	0
56	61.75	41.17	475	60	375
58	62.92	41.95	484	130	375
60	64.13	42.75	493	130	455
62	65.39	43.60	503	130	465
64	66.71	44.47	513	130	475
66	68.08	45.38	523	130	486
68	69.50	46.33	534	130	497
70	70.98	47.32	546	130	508
72	72.52	48.35	557	130	520
74	74.13	49.42	570	130	532
76	75.80	50.53	583	130	545
78	77.54	51.69	596	130	558
80	79.34	52.90	610	130	572
82	81.23	54.15	624	130	587
84	83.19	55.46	639	130	602
86	85.23	56.82	655	130	618
88	87.35	58.23	671	130	634
90	89.56	59.71	688	130	651
92	91.86	61.24	706	130	669
94	94.25	62.84	725	130	687
96	96.75	64.50	744	130	706
98	99.34	66.23	764	130	726
100	102.04	68.03	784	130	747
102	104.85	69.90	806	130	768
104	107.77	71.85	828	130	791
106	110.82	73.88	852	130	814
108	113.98	75.99	876	130	839
110	117.28	78.19	902	130	864
112	120.71	80.47	928	130	890
114	124.28	82.86	955	130	918
116	128.00	85.33	984	130	946
118	131.87	87.91	1014	130	976
120	135.90	90.60	1045	130	1007
122	140.09	93.39	1077	130	1039
124	144.45	96.30	1110	130	1073
126	148.99	99.33	1145	130	1108
128	153.72	102.48	1182	132	1144
130	158.63	105.76	1219	134	1182
132	163.75	109.17	1259	136	1221
134	169.08	112.72	1300	138	1262
136	174.63	116.42	1342	140	1305
138	180.40	120.26	1387	142	1349
140	186.40	124.27	1433	144	1395
142	192.66	128.44	1481	146	1443
144	199.16	132.78	1531	148	1493
146	205.94	137.29	1583	150	1545
148	212.99	141.99	1637	152	1600
150	220.32	146.88	1694	154	1656
152	227.96	151.97	1752	156	1715
154	235.91	157.27	1814	158	1776
156	244.18	162.79	1877	160	1839
158	252.79	168.53	1943	162	1906

Table 7: NMP-1 Beltline Region, Curve B, for 28 EFPY

Component =	Beltline	
Vessel thickness, t =	7.125	inches
Vessel Radius, R =	106.5	inches
ART =	151.4	°F =====> 28 EFPY
K_{It} =	12.91	ksi·√in
Safety Factor =	2.0	
M_m =	2.472	
Temperature Adjustment =	12.2	°F (instrument uncertainty)
Pressure Adjustment =	27.7	psig (hydrostatic pressure head for a full vessel at 70°F)
Pressure Adjustment =	52.2	psig (instrument uncertainty)
Heat Up and Cool Down Rate =	100	°F/Hr

Guage Fluid Temperature (°F)	K_{Ic} (ksi·√in)	K_{Im} (ksi·√in)	Guage Pressure (psig)	Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
48	35.82	11.45	310	60	0
48	35.82	11.45	310	60	230
50	35.93	11.51	311	62	232
52	36.04	11.56	313	64	233
54	36.16	11.62	315	66	235
56	36.28	11.68	316	68	236
58	36.40	11.74	318	70	238
60	36.53	11.81	320	72	240
62	36.67	11.88	321	74	242
64	36.81	11.95	323	76	244
66	36.96	12.02	325	78	246
68	37.11	12.10	327	80	248
70	37.27	12.18	330	82	250
72	37.44	12.26	332	84	252
74	37.61	12.35	334	86	254
76	37.79	12.44	337	88	257
78	37.98	12.53	339	90	259
80	38.17	12.63	342	92	262
82	38.37	12.73	345	94	265
84	38.59	12.84	347	96	268
86	38.81	12.95	350	98	271
88	39.03	13.06	353	100	274
90	39.27	13.18	357	102	277
92	39.52	13.30	360	104	280
94	39.78	13.43	364	106	284
96	40.05	13.57	367	108	287
98	40.33	13.71	371	110	291
100	40.62	13.85	375	112	295
102	40.92	14.00	379	114	299
104	41.23	14.16	383	116	303
106	41.56	14.32	388	118	308
108	41.90	14.50	392	120	312
110	42.26	14.67	397	122	317
112	42.63	14.86	402	124	322
114	43.01	15.05	407	126	327
116	43.41	15.25	413	128	333
118	43.83	15.46	418	130	339
120	44.26	15.68	424	132	344
122	44.72	15.90	430	134	351
124	45.19	16.14	437	136	357
126	45.68	16.38	443	138	364
128	46.18	16.64	450	140	370
130	46.71	16.90	457	142	378
132	47.27	17.18	465	144	385
134	47.84	17.46	473	146	393
136	48.44	17.76	481	148	401
138	49.06	18.07	489	150	409
140	49.71	18.40	498	152	418

Table 7 Continued: NMP-1 Beltline Region, Curve B, for 28 EFPY

Guage Fluid Temperature (°F)	K_{Ic} (ksi·√in)	K_{Im} (ksi·√in)	Guage Pressure (psig)	Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
142	50.38	18.73	507	154	427
144	51.08	19.08	517	156	437
146	51.81	19.45	526	158	447
148	52.57	19.83	537	160	457
150	53.36	20.22	547	162	468
152	54.18	20.64	559	164	479
154	55.04	21.06	570	166	490
156	55.93	21.51	582	168	502
158	56.86	21.97	595	170	515
160	57.83	22.46	608	172	528
162	58.83	22.96	621	174	542
164	59.88	23.48	636	176	556
166	60.96	24.03	650	178	570
168	62.10	24.59	666	180	586
170	63.28	25.18	682	182	602
172	64.50	25.80	698	184	618
174	65.78	26.43	715	186	636
176	67.11	27.10	733	188	654
178	68.50	27.79	752	190	672
180	69.94	28.51	772	192	692
182	71.44	29.26	792	194	712
184	73.00	30.04	813	196	733
186	74.62	30.85	835	198	755
188	76.31	31.70	858	200	778
190	78.07	32.58	882	202	802
192	79.90	33.49	907	204	827
194	81.81	34.45	932	206	852
196	83.79	35.44	959	208	879
198	85.86	36.47	987	210	907
200	88.00	37.55	1016	212	936
202	90.24	38.66	1046	214	967
204	92.57	39.83	1078	216	998
206	94.99	41.04	1111	218	1031
208	97.51	42.30	1145	220	1065
210	100.14	43.61	1180	222	1101
212	102.87	44.98	1217	224	1138
214	105.71	46.40	1256	226	1176
216	108.67	47.88	1296	228	1216
218	111.75	49.42	1338	230	1258
220	114.96	51.02	1381	232	1301
222	118.30	52.69	1426	234	1346
224	121.77	54.43	1473	236	1393
226	125.38	56.23	1522	238	1442
228	129.14	58.12	1573	240	1493
230	133.06	60.07	1626	242	1546
232	137.14	62.11	1681	244	1601
234	141.38	64.23	1739	246	1659
236	145.79	66.44	1798	248	1718
238	150.39	68.74	1860	250	1781
240	155.17	71.13	1925	252	1845
242	160.15	73.62	1993	254	1913

Table 8: NMP-1 Beltline Region, Curve B, for 36 EFPY

Plant =	NMP-1	
Component =	Beltline	
Vessel thickness, t =	7.125	inches
Vessel Radius, R =	106.5	inches
ART =	159.0	°F =====> 36 EFPY
K_{It} =	12.91	ksi·√in
Safety Factor =	2.0	
M_m =	2.472	
Temperature Adjustment =	12.2	°F (instrument uncertainty)
Pressure Adjustment =	27.7	psig (hydrostatic pressure head for a full vessel at 70°F)
Pressure Adjustment =	52.2	psig (instrument uncertainty)
Heat Up and Cool Down Rate =	100	°F/Hr

Guage Fluid Temperature (°F)	K_{Ic} (ksi·√in)	K_{Im} (ksi·√in)	Guage Pressure (psig)	Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
48	35.45	11.27	305	60	0
48	35.45	11.27	305	60	225
50	35.54	11.31	306	62	226
52	35.64	11.36	308	64	228
54	35.74	11.41	309	66	229
56	35.84	11.46	310	68	230
58	35.95	11.52	312	70	232
60	36.06	11.57	313	72	233
62	36.18	11.63	315	74	235
64	36.30	11.69	317	76	237
66	36.43	11.76	318	78	238
68	36.56	11.82	320	80	240
70	36.70	11.89	322	82	242
72	36.84	11.96	324	84	244
74	36.99	12.04	326	86	246
76	37.14	12.11	328	88	248
78	37.30	12.19	330	90	250
80	37.47	12.28	332	92	252
82	37.64	12.37	335	94	255
84	37.83	12.46	337	96	257
86	38.02	12.55	340	98	260
88	38.21	12.65	342	100	263
90	38.42	12.75	345	102	265
92	38.63	12.86	348	104	268
94	38.85	12.97	351	106	271
96	39.08	13.08	354	108	274
98	39.32	13.20	357	110	278
100	39.57	13.33	361	112	281
102	39.83	13.46	364	114	284
104	40.10	13.59	368	116	288
106	40.38	13.73	372	118	292
108	40.68	13.88	376	120	296
110	40.98	14.03	380	122	300
112	41.30	14.19	384	124	304
114	41.63	14.36	389	126	309
116	41.97	14.53	393	128	313
118	42.33	14.71	398	130	318
120	42.70	14.90	403	132	323
122	43.09	15.09	408	134	329
124	43.50	15.29	414	136	334
126	43.92	15.50	420	138	340
128	44.35	15.72	425	140	346
130	44.81	15.95	432	142	352
132	45.28	16.18	438	144	358
134	45.78	16.43	445	146	365
136	46.29	16.69	452	148	372
138	46.82	16.95	459	150	379
140	47.38	17.23	466	152	387

Table 8 Continued: NMP-1 Beltline Region, Curve B, for 36 EFPY

Guage Fluid Temperature (°F)	K_{Ic} (ksi·√in)	K_{Im} (ksi·√in)	Guage Pressure (psig)	Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
142	47.96	17.52	474	154	394
144	48.56	17.82	482	156	403
146	49.19	18.14	491	158	411
148	49.84	18.46	500	160	420
150	50.52	18.80	509	162	429
152	51.23	19.16	518	164	439
154	51.96	19.52	528	166	449
156	52.73	19.91	539	168	459
158	53.52	20.30	550	170	470
160	54.35	20.72	561	172	481
162	55.22	21.15	572	174	493
164	56.11	21.60	585	176	505
166	57.05	22.07	597	178	517
168	58.02	22.55	610	180	531
170	59.04	23.06	624	182	544
172	60.09	23.59	638	184	559
174	61.19	24.14	653	186	573
176	62.33	24.71	669	188	589
178	63.52	25.30	685	190	605
180	64.76	25.92	702	192	622
182	66.04	26.57	719	194	639
184	67.38	27.24	737	196	657
186	68.78	27.93	756	198	676
188	70.23	28.66	776	200	696
190	71.74	29.41	796	202	716
192	73.32	30.20	817	204	738
194	74.95	31.02	840	206	760
196	76.66	31.87	863	208	783
198	78.43	32.76	887	210	807
200	80.28	33.68	912	212	832
202	82.20	34.64	938	214	858
204	84.20	35.64	965	216	885
206	86.28	36.68	993	218	913
208	88.44	37.77	1022	220	942
210	90.70	38.89	1053	222	973
212	93.05	40.07	1084	224	1005
214	95.49	41.29	1118	226	1038
216	98.03	42.56	1152	228	1072
218	100.68	43.88	1188	230	1108
220	103.43	45.26	1225	232	1145
222	106.30	46.69	1264	234	1184
224	109.28	48.18	1304	236	1224
226	112.38	49.74	1346	238	1266
228	115.62	51.35	1390	240	1310
230	118.98	53.03	1435	242	1356
232	122.48	54.78	1483	244	1403
234	126.12	56.60	1532	246	1452
236	129.92	58.50	1583	248	1504
238	133.86	60.47	1637	250	1557
240	137.97	62.53	1692	252	1613
242	142.25	64.67	1750	254	1670
244	146.70	66.89	1811	256	1731
246	151.33	69.21	1873	258	1793
248	156.15	71.62	1938	260	1859
250	161.17	74.13	2006	262	1926

Table 9: NMP-1 Beltline Region, Curve B, for 46 EFPY

Plant =	NMP-1	
Component =	Beltline	
Vessel thickness, t =	7.125	inches
Vessel Radius, R =	106.5	inches
ART =	167.4	°F =====> 46 EFPY
K_{It} =	12.91	ksi√in
Safety Factor =	2.0	
M_m =	2.472	
Temperature Adjustment =	12.2	°F (instrument uncertainty)
Pressure Adjustment =	27.7	psig (hydrostatic pressure head for a full vessel at 70°F)
Pressure Adjustment =	52.2	psig (instrument uncertainty)
Heat Up and Cool Down Rate =	100	°F/Hr

Guage Fluid Temperature (°F)	K_{Ic} (ksi√in)	K_{Im} (ksi√in)	Guage Pressure (psig)	Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
48	35.10	11.09	300	60	0
48	35.10	11.09	300	60	220
50	35.18	11.13	301	62	221
52	35.26	11.17	302	64	223
54	35.35	11.22	304	66	224
56	35.43	11.26	305	68	225
58	35.53	11.31	306	70	226
60	35.62	11.35	307	72	227
62	35.72	11.40	309	74	229
64	35.82	11.45	310	76	230
66	35.93	11.51	311	78	232
68	36.04	11.56	313	80	233
70	36.16	11.62	315	82	235
72	36.28	11.68	316	84	236
74	36.40	11.74	318	86	238
76	36.53	11.81	320	88	240
78	36.67	11.88	321	90	242
80	36.81	11.95	323	92	244
82	36.96	12.02	325	94	246
84	37.11	12.10	327	96	248
86	37.27	12.18	330	98	250
88	37.44	12.26	332	100	252
90	37.61	12.35	334	102	254
92	37.79	12.44	337	104	257
94	37.98	12.53	339	106	259
96	38.17	12.63	342	108	262
98	38.37	12.73	345	110	265
100	38.59	12.84	347	112	268
102	38.81	12.95	350	114	271
104	39.03	13.06	353	116	274
106	39.27	13.18	357	118	277
108	39.52	13.30	360	120	280
110	39.78	13.43	364	122	284
112	40.05	13.57	367	124	287
114	40.33	13.71	371	126	291
116	40.62	13.85	375	128	295
118	40.92	14.00	379	130	299
120	41.23	14.16	383	132	303
122	41.56	14.32	388	134	308
124	41.90	14.50	392	136	312
126	42.26	14.67	397	138	317
128	42.63	14.86	402	140	322
130	43.01	15.05	407	142	327
132	43.41	15.25	413	144	333
134	43.83	15.46	418	146	339
136	44.26	15.68	424	148	344
138	44.72	15.90	430	150	351
140	45.19	16.14	437	152	357

Table 9 Continued: NMP-1 Beltline Region, Curve B, for 46 EFPY

Guage Fluid Temperature (°F)	K_{Ic} (ksi·√in)	K_{Im} (ksi·√in)	Guage Pressure (psig)	Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
142	45.68	16.38	443	154	364
144	46.18	16.64	450	156	370
146	46.71	16.90	457	158	378
148	47.27	17.18	465	160	385
150	47.84	17.46	473	162	393
152	48.44	17.76	481	164	401
154	49.06	18.07	489	166	409
156	49.71	18.40	498	168	418
158	50.38	18.73	507	170	427
160	51.08	19.08	517	172	437
162	51.81	19.45	526	174	447
164	52.57	19.83	537	176	457
166	53.36	20.22	547	178	468
168	54.18	20.64	559	180	479
170	55.04	21.06	570	182	490
172	55.93	21.51	582	184	502
174	56.86	21.97	595	186	515
176	57.83	22.46	608	188	528
178	58.83	22.96	621	190	542
180	59.88	23.48	636	192	556
182	60.96	24.03	650	194	570
184	62.10	24.59	666	196	586
186	63.28	25.18	682	198	602
188	64.50	25.80	698	200	618
190	65.78	26.43	715	202	636
192	67.11	27.10	733	204	654
194	68.50	27.79	752	206	672
196	69.94	28.51	772	208	692
198	71.44	29.26	792	210	712
200	73.00	30.04	813	212	733
202	74.62	30.85	835	214	755
204	76.31	31.70	858	216	778
206	78.07	32.58	882	218	802
208	79.90	33.49	907	220	827
210	81.81	34.45	932	222	852
212	83.79	35.44	959	224	879
214	85.86	36.47	987	226	907
216	88.00	37.55	1016	228	936
218	90.24	38.66	1046	230	967
220	92.57	39.83	1078	232	998
222	94.99	41.04	1111	234	1031
224	97.51	42.30	1145	236	1065
226	100.14	43.61	1180	238	1101
228	102.87	44.98	1217	240	1138
230	105.71	46.40	1256	242	1176
232	108.67	47.88	1296	244	1216
234	111.75	49.42	1338	246	1258
236	114.96	51.02	1381	248	1301
238	118.30	52.69	1426	250	1346
240	121.77	54.43	1473	252	1393
242	125.38	56.23	1522	254	1442
244	129.14	58.12	1573	256	1493
246	133.06	60.07	1626	258	1546
248	137.14	62.11	1681	260	1601
250	141.38	64.23	1739	262	1659
252	145.79	66.44	1798	264	1718
254	150.39	68.74	1860	266	1781
256	155.17	71.13	1925	268	1845
258	160.15	73.62	1993	270	1913

Table 10: NMP-1 Bottom Head Region, Curve B, for all EFPY

Plant =	NMP-1	
Component =	*Bottom Head*	*(penetrations portion)*
Bottom Head thickness, t =	8.75	inches
Bottom Head Radius, R =	106.719	inches
ART =	40.0	°F =====> All EFPY
K_{It} =	21.58	ksi·√in
Safety Factor =	2.0	
Stress Concetration Factor =	3.0	(bottom head penetrations)
M_m =	2.739	
Temperature Adjustment =	17.2	°F (instrument uncertainty)
Pressure Adjustment =	27.7	psig (hydrostatic pressure head for a full vessel at 70°F)
Pressure Adjustment =	52.2	psig (instrument uncertainty)
Heat Up and Cool Down Rate =	100	°F/Hr

Guage Fluid *Temperature* (°F)	K_K (ksi·√in)	K_{Im} (ksi·√in)	Guage Pressure (psig)	Temperature *for P-T Curve* (°F)	Adjusted Pressure for *P-T Curve* (psig)
48	57.53	17.97	0	60	0
48	57.53	17.97	359	60	279
50	58.52	18.47	369	62	289
52	59.56	18.99	379	64	299
54	60.63	19.53	390	66	310
56	61.75	20.09	401	68	321
58	62.92	20.67	412	70	333
60	64.13	21.27	425	72	345
62	65.39	21.91	437	74	357
64	66.71	22.56	450	76	370
66	68.08	23.25	464	78	384
68	69.50	23.96	478	80	398
70	70.98	24.70	493	82	413
72	72.52	25.47	508	84	428
74	74.13	26.27	524	86	444
76	75.80	27.11	541	88	461
78	77.54	27.98	558	90	478
80	79.34	28.88	576	92	496
82	81.23	29.82	595	94	515
84	83.19	30.80	615	96	535
86	85.23	31.82	635	98	555
88	87.35	32.88	656	100	576
90	89.56	33.99	678	102	598
92	91.86	35.14	701	104	621
94	94.25	36.34	725	106	645
96	96.75	37.58	750	108	670
98	99.34	38.88	776	110	696
100	102.04	40.23	803	112	723
102	104.85	41.63	831	114	751
104	107.77	43.09	860	116	780
106	110.82	44.62	890	118	810
108	113.98	46.20	922	120	842
110	117.28	47.85	955	122	875
112	120.71	49.56	989	124	909
114	124.28	51.35	1025	126	945
116	128.00	53.21	1062	128	982
118	131.87	55.14	1100	130	1021
120	135.90	57.16	1141	132	1061
122	140.09	59.25	1182	134	1103
124	144.45	61.43	1226	136	1146
126	148.99	63.70	1271	138	1191
128	153.72	66.07	1318	140	1239
130	158.63	68.53	1367	142	1288
132	163.75	71.08	1419	144	1339
134	169.08	73.75	1472	146	1392
136	174.63	76.52	1527	148	1447
138	180.40	79.41	1585	150	1505
140	186.40	82.41	1645	152	1565
142	192.66	85.54	1707	154	1627
144	199.16	88.79	1772	156	1692
146	205.94	92.18	1839	158	1760
148	212.99	95.70	1910	160	1830
150	220.32	99.37	1983	162	1903

Table 11: NMP-1 Upper Vessel Region, Curve B, for all EFPY

Plant =	NMP-1		
Component =	Upper Vessel		
ART =	40.0	°F =====>	All EFPY
Vessel Radius =	106.5	inches	
Nozzle corner thickness, t =	7.843	inches	
Nozzle K_{It} =	45.60	ksi√in	
Nozzle $K_{Ip\text{-}applied}$ =	86.72	ksi√in	
Crack Depth, a =	1.961	inches	
Safety Factor =	2.0		
Temperature Adjustment =	12.2	°F (instrument uncertainty)	
Pressure Adjustment =	27.7	psig (hydrostatic pressure head for a full vessel at 70°F)	
Pressure Adjustment =	52.2	psig (instrument uncertainty)	
Reference Pressure =	1,000	psig (pressure at which FEA stress coefficients are valid) [GREEN	
Unit Pressure =	1,875	psig (hydrostatic pressure)	
Flange RT_{NDT} =	40.0	°F =====>	All EFPY

Guage Fluid Temperature (°F)	K_{Ic} (ksi√in)	K_{Im} (ksi√in)	Guage Pressure (psig)	P-T Curve Temperature (°F)	P-T Curve 10CFR50 Adjustments (psig)
48	57.53	16.74	0	60	0
48	57.53	16.74	193	60	113
50	58.52	17.10	197	62	117
52	59.56	17.48	202	64	122
54	60.63	17.88	206	66	126
56	61.75	18.29	211	68	131
58	62.92	18.73	216	70	136
60	64.13	19.19	221	72	141
62	65.39	19.66	227	74	147
64	66.71	20.17	233	76	153
66	68.08	20.69	239	78	159
68	69.50	21.24	245	80	165
70	70.98	21.82	252	82	172
72	72.52	22.43	259	84	179
74	74.13	23.06	266	86	186
76	75.80	23.73	274	88	194
78	77.54	24.42	282	90	202
80	79.34	25.15	290	92	210
82	81.23	25.91	299	94	219
84	83.19	26.71	308	96	228
86	85.23	27.55	318	98	238
88	87.35	28.43	328	100	248
90	89.56	29.34	338	102	259
92	91.86	30.30	349	104	270
94	94.25	31.31	361	106	281
96	96.75	32.36	373	108	293
98	99.34	33.46	386	110	306
100	102.04	34.61	399	112	319
102	104.85	35.81	413	114	333
104	107.77	37.07	427	116	348
106	110.82	38.38	443	118	363
108	113.98	39.83	459	130	375
110	117.28	41.48	478	130	375
112	120.71	43.20	498	130	375
114	124.28	44.98	519	130	375
116	128.00	46.84	540	130	375
118	131.87	48.78	562	130	375
120	135.90	50.79	586	132	375
122	140.09	52.89	610	134	375
124	144.45	55.07	635	136	375
126	148.99	57.34	661	138	375
128	153.72	59.70	688	140	375
130	158.63	62.16	717	142	375

Table 11 Continued: NMP-1 Upper Vessel Region, Curve B, for all EFPY

Guage Fluid Temperature (°F)	K_{Ic} (ksi√in)	K_{Im} (ksi√in)	Guage Pressure (psig)	P-T Curve Temperature (°F)	P-T Curve 10CFR50 Adjustments (psig)
132	163.75	64.72	746	144	375
134	169.08	67.38	777	146	375
136	174.63	70.15	809	148	375
138	180.40	73.04	842	150	375
140	186.40	76.04	877	152	375
142	192.66	79.17	913	154	375
144	199.16	82.42	950	156	375
146	205.94	85.81	989	158	375
148	212.99	89.34	1030	160	375
148	212.99	84.61	976	160	896
150	220.32	88.02	1015	162	935
152	227.96	91.58	1056	164	976
154	235.91	95.29	1099	166	1019
156	244.18	99.17	1143	168	1064
158	252.79	103.21	1190	170	1110
160	261.75	107.42	1239	172	1159
162	271.08	111.81	1289	174	1209
164	280.79	116.40	1342	176	1262
166	290.89	121.17	1397	178	1317
168	301.41	126.16	1455	180	1375
170	312.36	131.35	1515	182	1435
172	323.75	136.77	1577	184	1497
174	335.61	142.41	1642	186	1562
176	347.95	148.30	1710	188	1630
178	360.79	154.43	1781	190	1701
180	374.16	160.82	1854	192	1775
182	388.08	167.49	1931	194	1851
184	402.56	174.43	2011	196	1932

Table 12: NMP-1 Curve C Values for 28 EFPY

Plant =	NMP-1	
Curve A Leak Test Temperature =	169.2	°F
Curve A Leak Test Pressure =	1,055	psig
Unit Pressure =	1,875	psig (hydrostatic pressure)
Flange RT_{NDT} =	40.0	°F

Adjusted P-T Curve Temperature (°F)	Adjusted P-T Curve Pressure (psig)
100	0
100	113
102	119
104	122
106	126
108	131
110	136
112	141
114	147
116	153
118	159
120	165
122	172
124	179
126	186
128	194
130	202
132	210
134	219
136	228
138	238
140	248
142	259
144	270
146	281
148	287
150	291
152	295
154	299
156	303
158	308
160	312
162	317
164	322
166	327
168	333
170	339
172	344
174	351
176	357
178	364
180	370
182	375
184	375
186	375
188	375
190	375

Table 12 Continued: NMP-1 Curve C Values for 28 EFPY

Adjusted P-T Curve Temperature (°F)	Adjusted P-T Curve Pressure (psig)
192	375
194	375
196	375
198	375
200	375
200	457
202	468
204	479
206	490
208	502
210	515
212	528
214	542
216	556
218	570
220	586
222	602
224	618
226	636
228	654
230	672
232	692
234	712
236	733
238	755
240	778
242	802
244	827
246	852
248	879
250	907
252	936
254	967
256	998
258	1031
260	1065
262	1101
264	1138
266	1176
268	1216
270	1258
272	1301
274	1346
276	1393
278	1442
280	1493
282	1546
284	1601
286	1659
288	1718
290	1781
292	1845
294	1913

Table 13: NMP-1 Curve C Values for 36 EFPY

Plant =	NMP-1	
Curve A Leak Test Temperature =	176.8	°F
Curve A Leak Test Pressure =	1,055	psig
Unit Pressure =	1,875	psig (hydrostatic pressure)
Flange RT_{NDT} =	40.0	°F

Adjusted P-T Curve Temperature (°F)	Adjusted P-T Curve Pressure (psig)
100	0
100	113
102	119
104	122
106	126
108	131
110	136
112	141
114	147
116	153
118	159
120	165
122	172
124	179
126	186
128	194
130	202
132	210
134	219
136	228
138	238
140	248
142	259
144	268
146	271
148	274
150	278
152	281
154	284
156	288
158	292
160	296
162	300
164	304
166	309
168	313
170	318
172	323
174	329
176	334
178	340
180	346
182	352
184	358
186	365
188	372
190	375

Table 13 Continued: NMP-1 Curve C Values for 36 EFPY

Adjusted P-T Curve Temperature (°F)	Adjusted P-T Curve Pressure (psig)
192	375
194	375
196	375
198	375
200	375
200	420
202	429
204	439
206	449
208	459
210	470
212	481
214	493
216	505
218	517
220	531
222	544
224	559
226	573
228	589
230	605
232	622
234	639
236	657
238	676
240	696
242	716
244	738
246	760
248	783
250	807
252	832
254	858
256	885
258	913
260	942
262	973
264	1005
266	1038
268	1072
270	1108
272	1145
274	1184
276	1224
278	1266
280	1310
282	1356
284	1403
286	1452
288	1504
290	1557
292	1613
294	1670
296	1731
298	1793
300	1859
302	1926

Table 14: NMP-1 Curve C Values for 46 EFPY

Plant =	NMP-1	
Curve A Leak Test Temperature =	185.2	°F
Curve A Leak Test Pressure =	1,055	psig
Unit Pressure =	1,875	psig (hydrostatic pressure)
Flange RT_{NDT} =	40.0	°F

Adjusted P-T Curve Temperature (°F)	Adjusted P-T Curve Pressure (psig)
100	0
100	113
102	119
104	122
106	126
108	131
110	136
112	141
114	147
116	153
118	159
120	165
122	172
124	179
126	186
128	194
130	202
132	210
134	219
136	228
138	238
140	248
142	254
144	257
146	259
148	262
150	265
152	268
154	271
156	274
158	277
160	280
162	284
164	287
166	291
168	295
170	299
172	303
174	308
176	312
178	317
180	322
182	327
184	333
186	339
188	344
190	351
192	357
194	364
196	370
198	375
200	375

Table 14 Continued: NMP-1 Curve C Values for 46 EFPY

Adjusted P-T Curve Temperature (°F)	Adjusted P-T Curve Pressure (psig)
200	385
202	393
204	401
206	409
208	418
210	427
212	437
214	447
216	457
218	468
220	479
222	490
224	502
226	515
228	528
230	542
232	556
234	570
236	586
238	602
240	618
242	636
244	654
246	672
248	692
250	712
252	733
254	755
256	778
258	802
260	827
262	852
264	879
266	907
268	936
270	967
272	998
274	1031
276	1065
278	1101
280	1138
282	1176
284	1216
286	1258
288	1301
290	1346
292	1393
294	1442
296	1493
298	1546
300	1601
302	1659
304	1718
306	1781
308	1845
310	1913

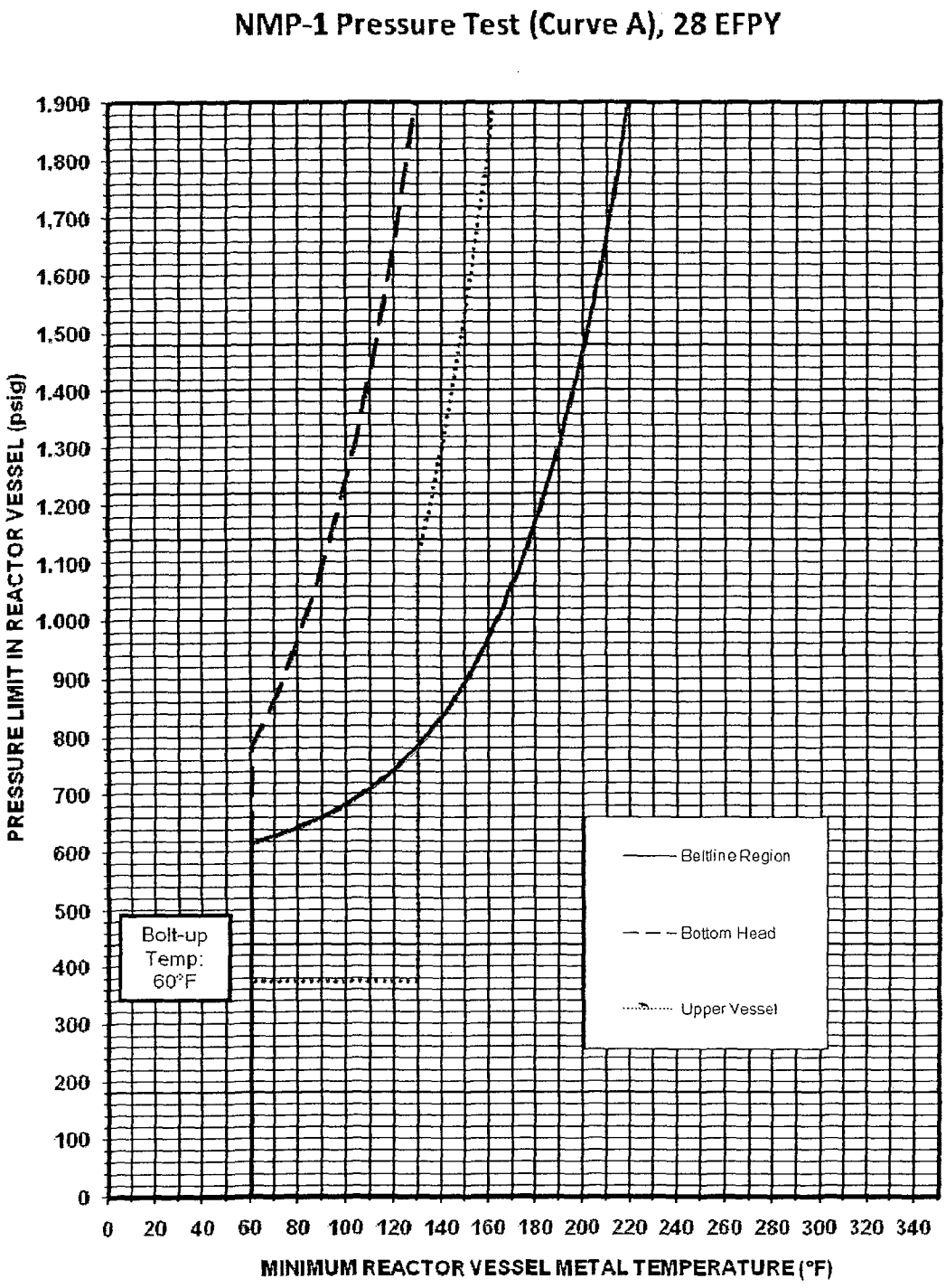

Figure 1: NMP-1 P-T Curve A (Hydrostatic Pressure and Leak Tests) for 28 EFPY

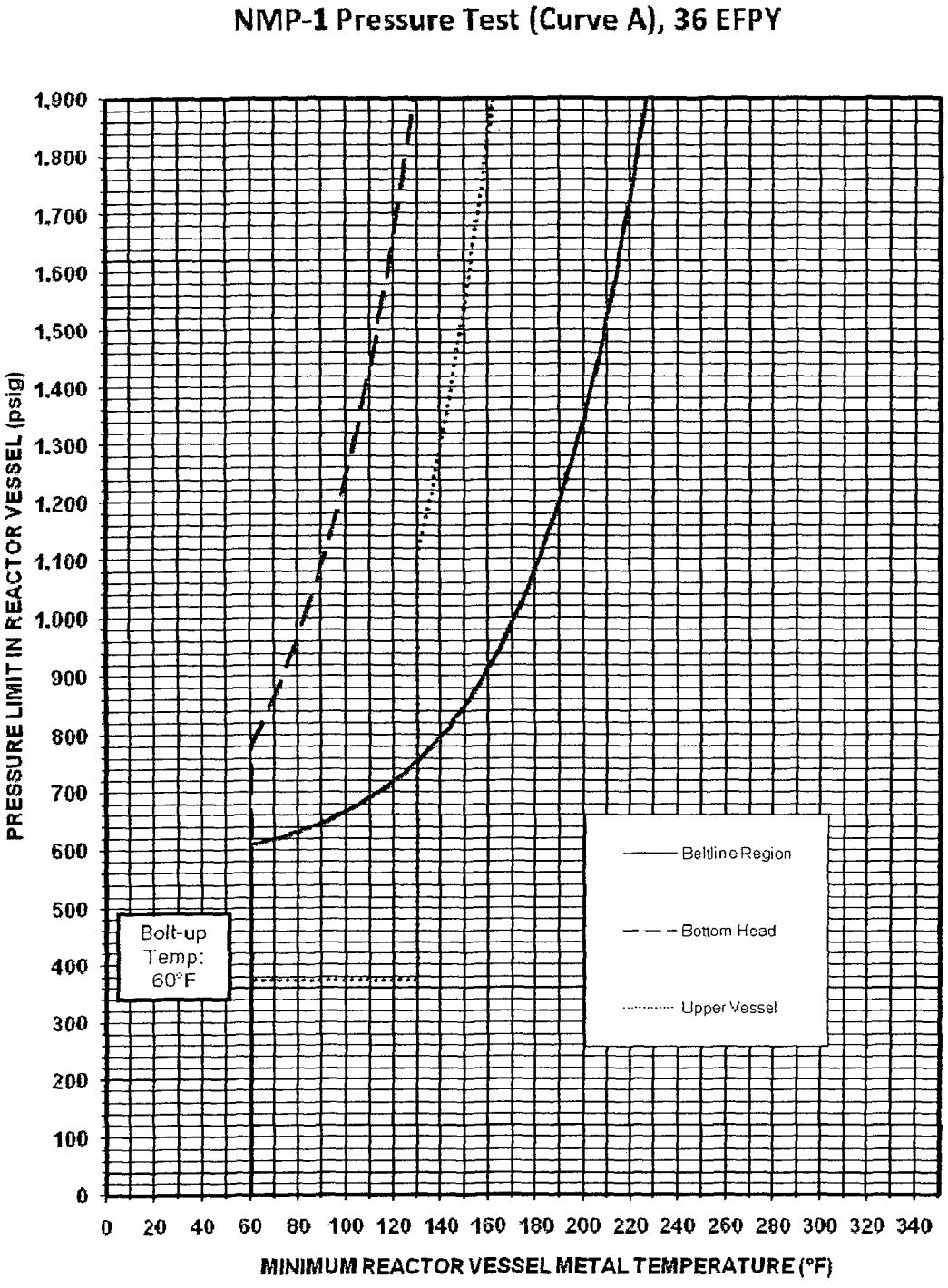

Figure 2: NMP-1 P-T Curve A (Hydrostatic Pressure and Leak Tests) for 36 EFPY

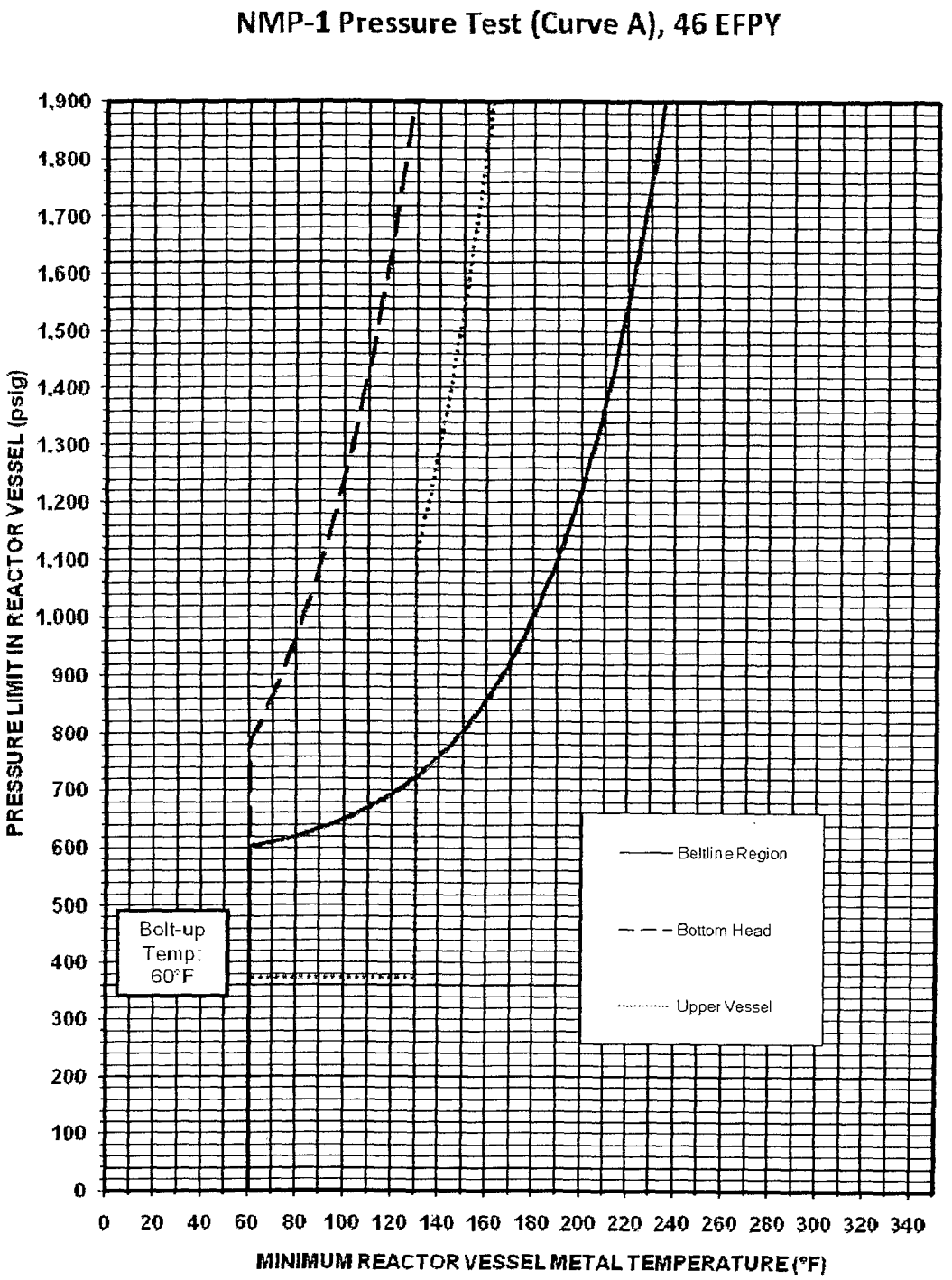

Figure 3: NMP-1 P-T Curve A (Hydrostatic Pressure and Leak Tests) for 46 EFPY

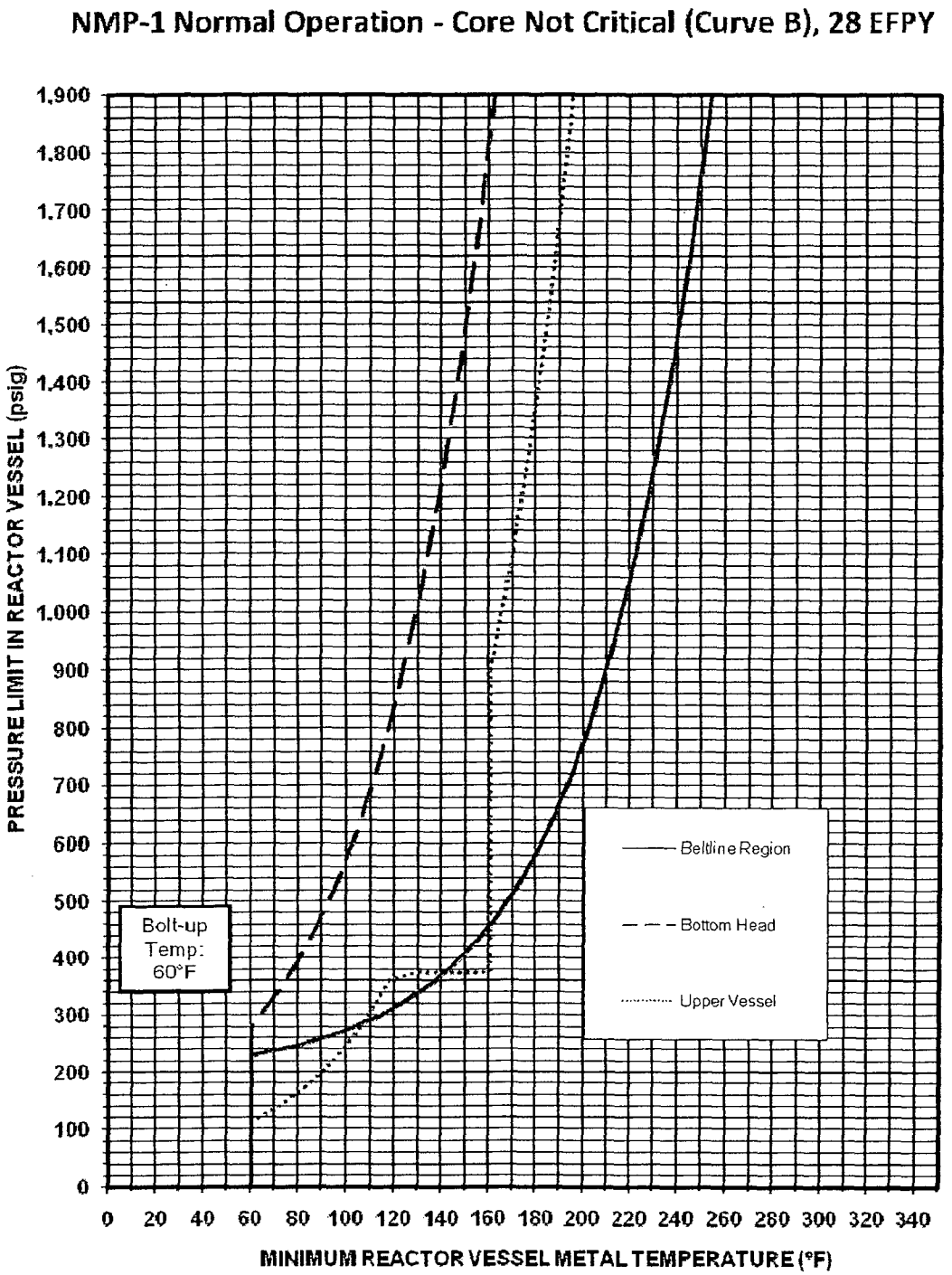

Figure 4: NMP-1 P-T Curve B (Normal Operation – Core Not Critical) for 28 EFPY

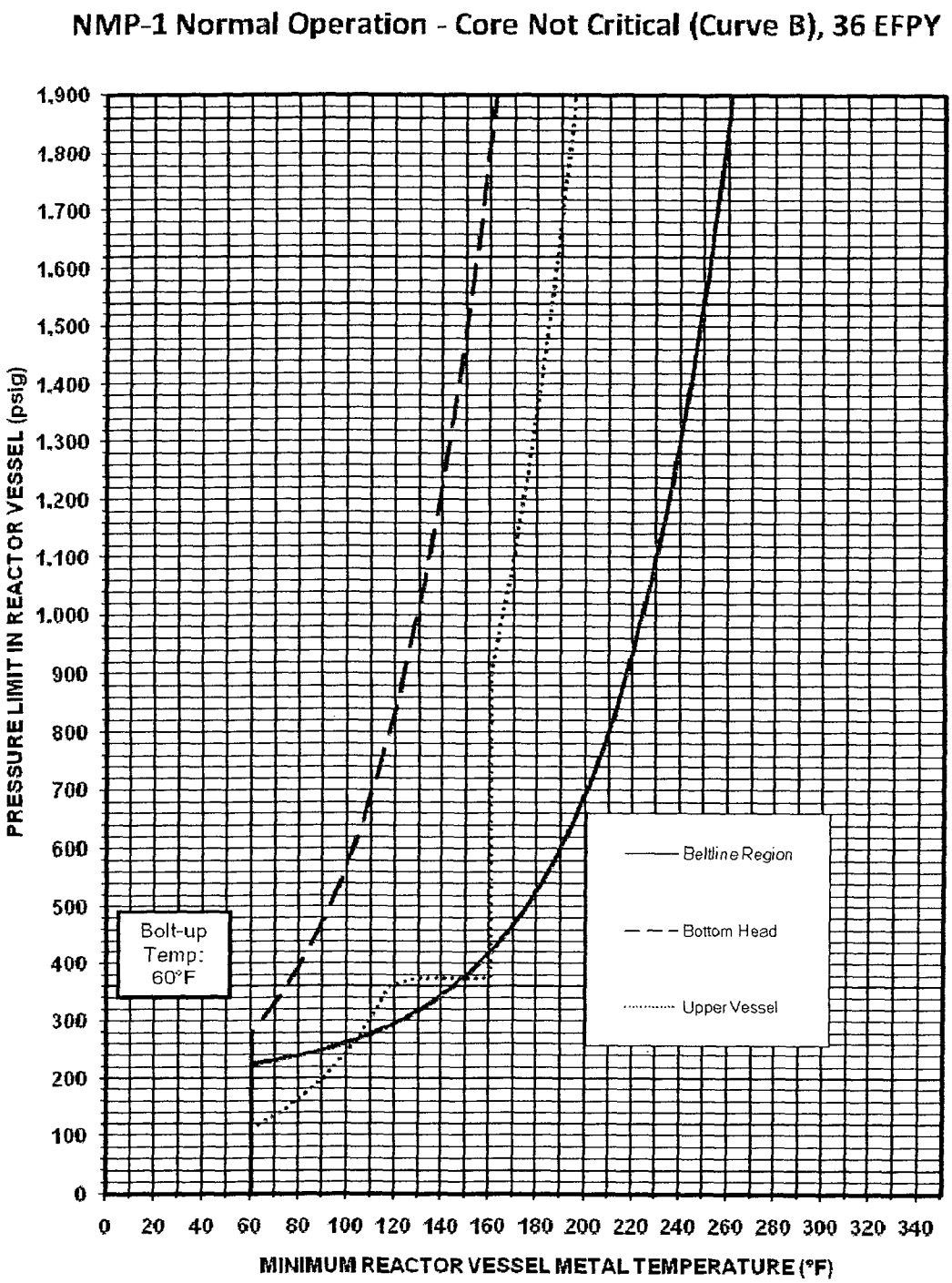

Figure 5: NMP-1 P-T Curve B (Normal Operation – Core Not Critical) for 36 EFPY

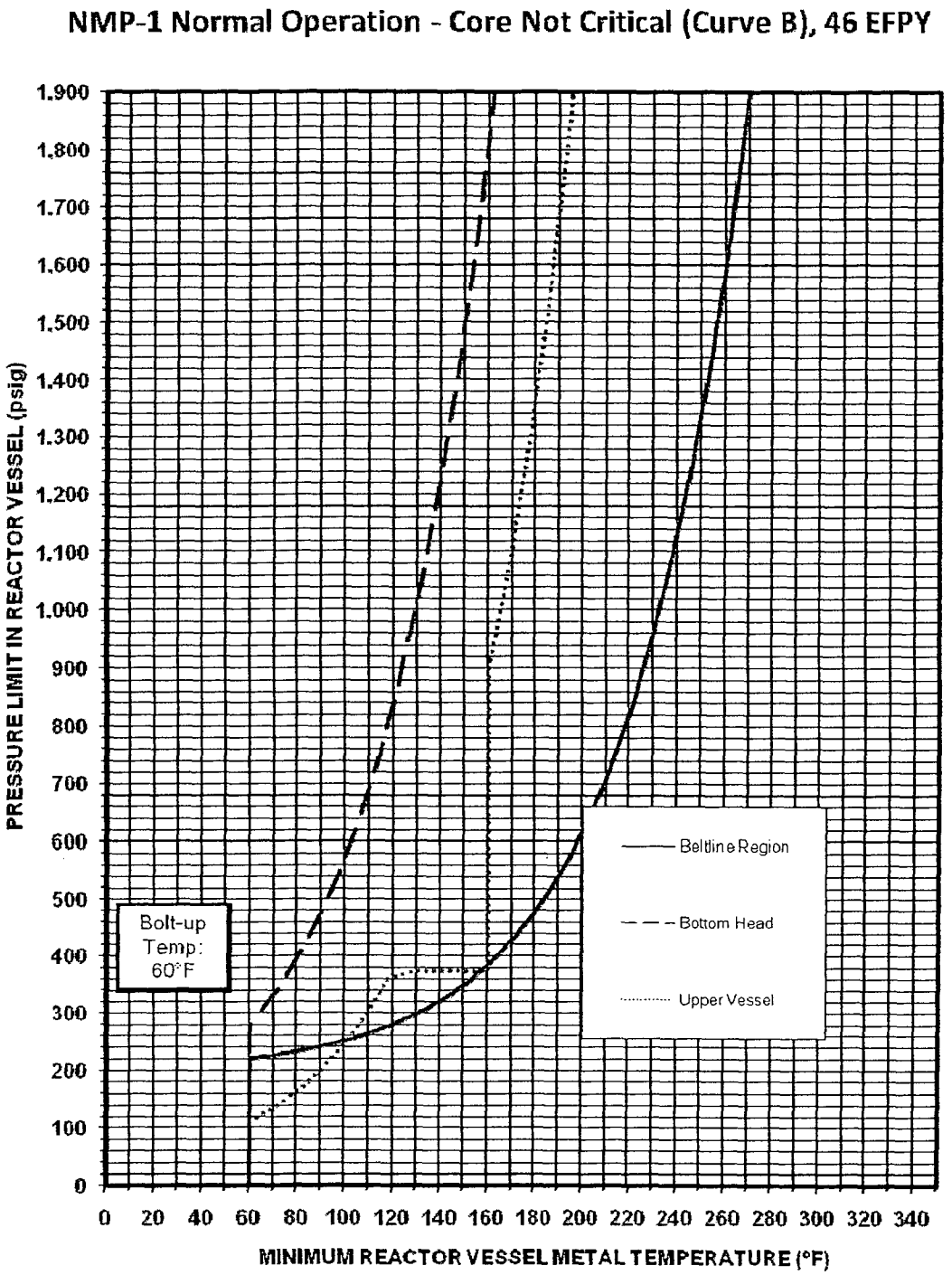

Figure 6: NMP-1 P-T Curve B (Normal Operation – Core Not Critical) for 46 EFPY

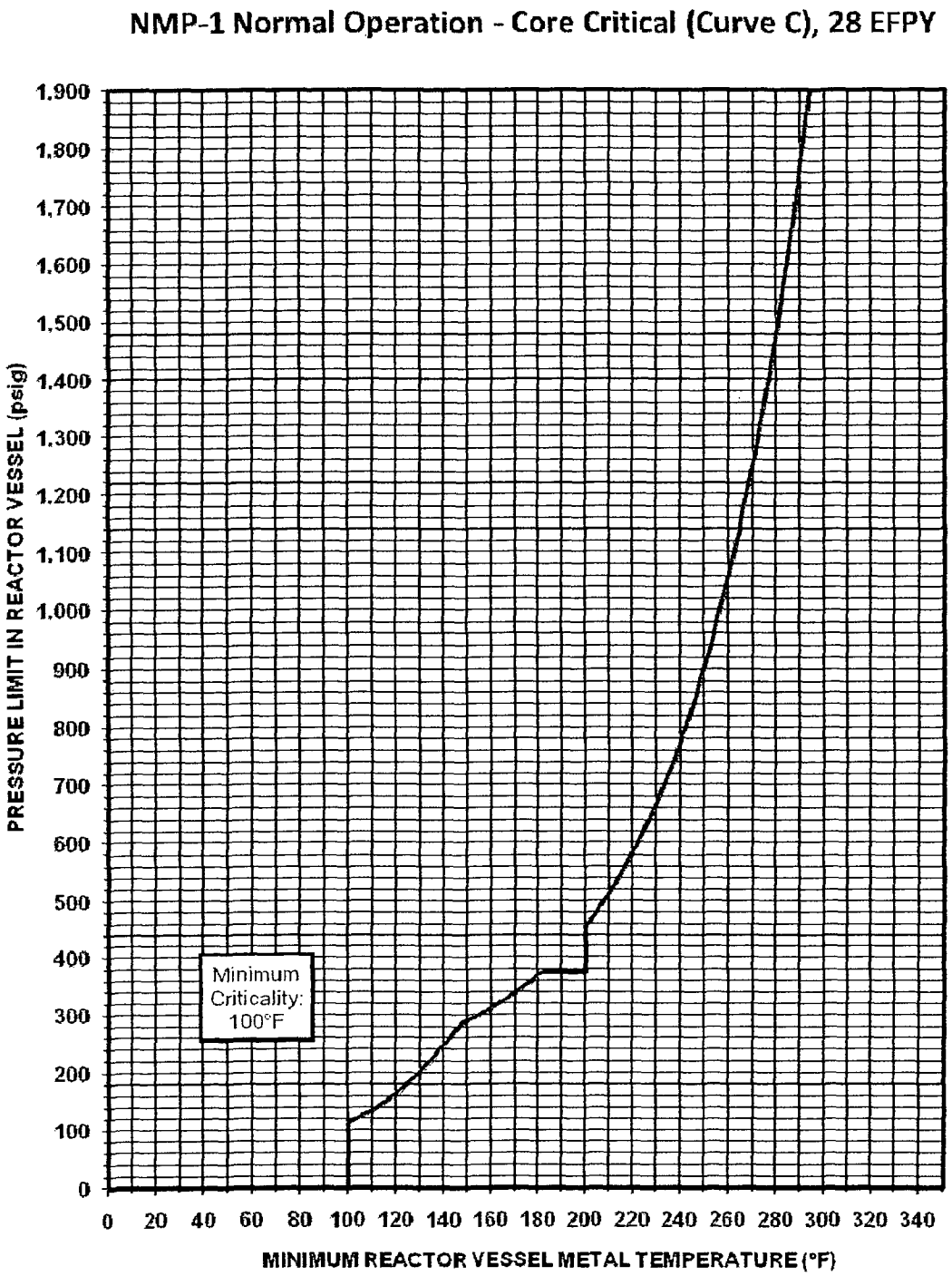

Figure 7: NMP-1 P-T Curve C (Normal Operation – Core Critical) for 28 EFPY

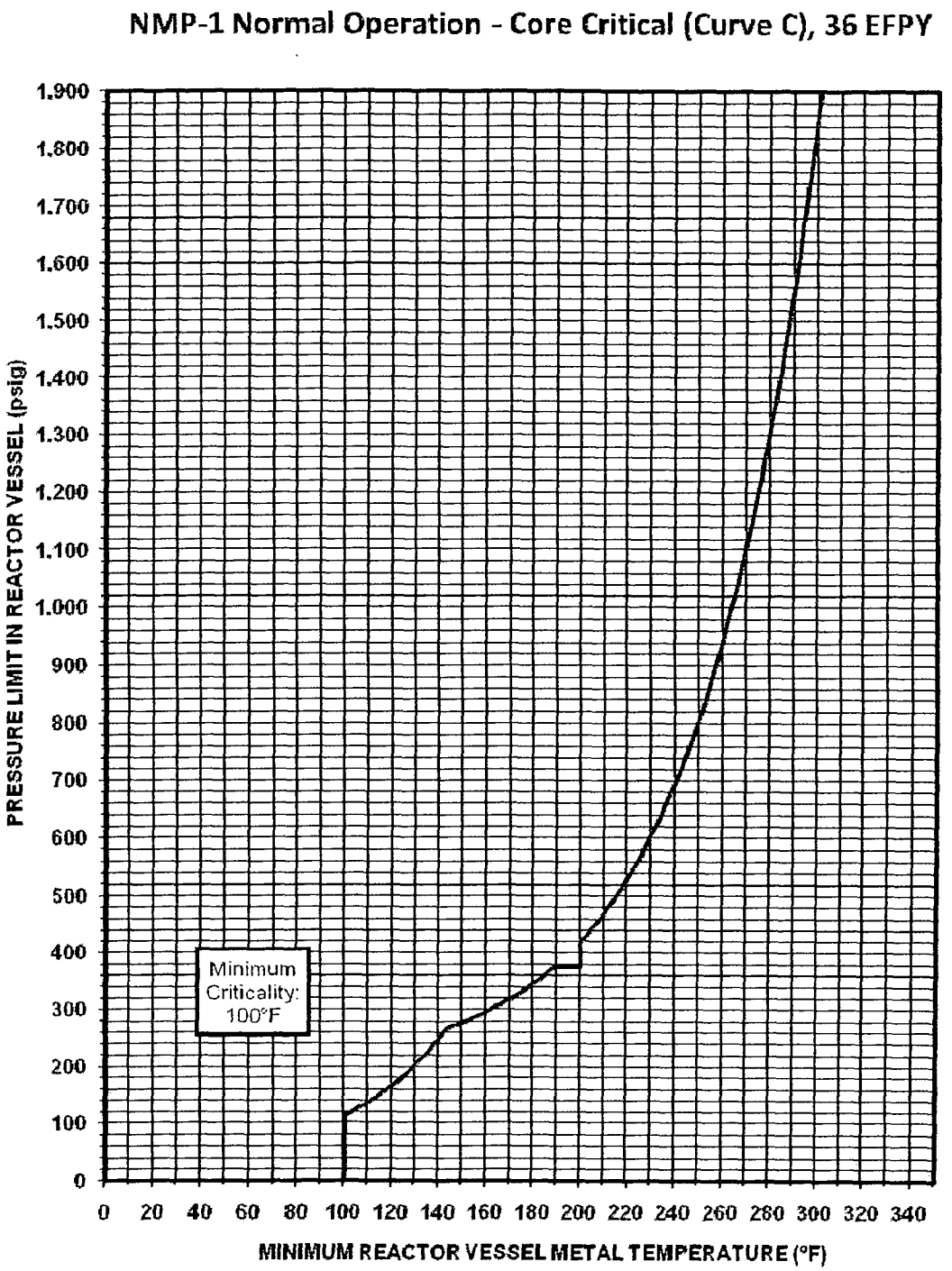

Figure 8: NMP-1 P-T Curve C (Normal Operation – Core Critical) for 36 EFPY

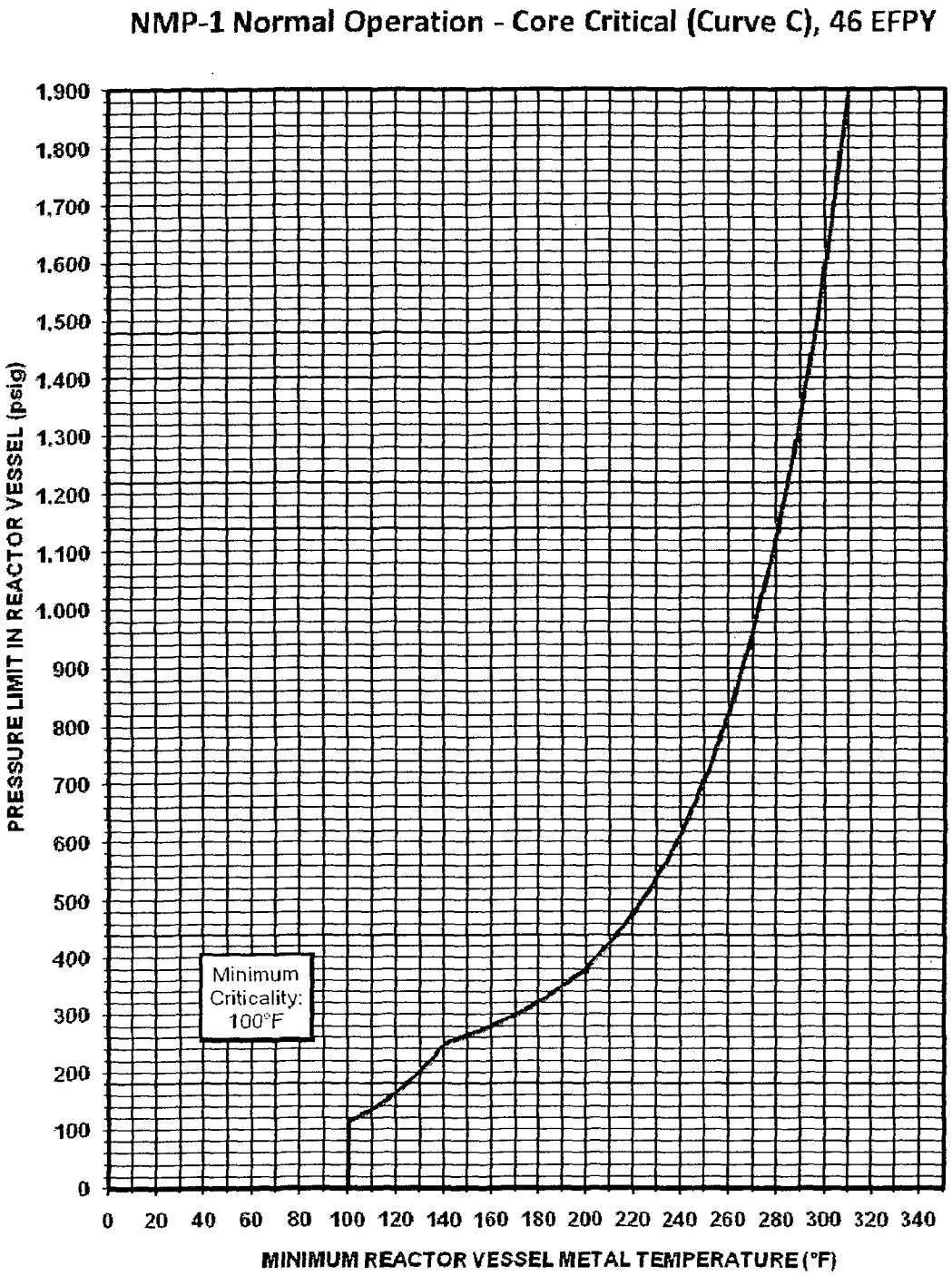

Figure 9: NMP-1 P-T Curve C (Normal Operation – Core Critical) for 46 EFPY.

APPENDIX A:

P-T CURVE INPUT LISTING

List of Design Inputs and Source References for NMP-1 P-T Curves at 28, 36, and 46 EFPY

		Reference
Instrument Uncertainty		
Reactor Vessel Metal Temperature (Hydrotest)	4 °F	[17]
Reactor Vessel Pressure (Hydrotest)	10 psig	[17]
Reactor Vessel Metal Temperature	12.2 °F	[17]
Reactor Vessel Pressure	52.2 psig	[17]
Geometry		
Vessel Radius	106.5 in	[6, Table 4-5]
Vessel Shell Thickness	7.125 in	[6, Table 4-5]
Bottom Head Thickness	8.75 in	[10, p. A-3]
Bottom Head Radius	106.719 in	[10, p. A-6]
Feedwater Nozzle Blend Radius Thickness	7.8427 in	[9, Supporting Files]
Water Elevation - Full Height (pressure head)	766 in	[12b]
ART/RT_{NDT}		
Limiting Bottom Head RT_{NDT} *	40 °F	[13]
Limiting Upper Vessel (Feedwater) RT_{NDT}	40 °F	[12c, p. V-12]
Flange Region (Boltup) RT_{NDT}	40 °F	[12c, p. V-12]
Limiting Beltline ART (28 EFPY)	151.4 °F	[4, Table 4]
Limiting Beltline ART (36 EFPY)	159.0 °F	[4, Table 5]
Limiting Beltline ART (46 EFPY)	167.4 °F	[4, Table 6]
Safety Factors/Stress Concentration Factor		
Core Not Critical (Curve B) Core Critical (Curve C)	2	PTLR [3]
Pressure (Curve A)	1.5	PTLR [3]
Lower Penetrations (SCF)	3	PTLR [3]
Water		
Density	62.4 lb/ft3	Assumed
Operating Pressure	1055 psig	[16]
Pre-Service Hydrostatic Test Pressure	1875 psig	[12a]
Static Pressure Head Adjustment	27.66 psig	Calculated
Temperatures		
Heat Up and Cool Down Rate	100 °F/hr	[11]
Bolt Up Temperature	60 °F	PTLR [3]

* Bottom head RT_{NDT} value bounded by that of the upper vessel/flange

APPENDIX B:

INCREASED COOL-DOWN RATE P-T CURVE

B1.0 INTRODUCTION

This appendix modifies the Nine Mile Point, Unit 1 P-T curves for a heat-up/cool-down rate of up to 200°F/Hr. A single curve is presented that bounds the beltline, bottom head, and non-beltline (feedwater nozzle / upper vessel) regions and is valid for up to 46 EFPY. The curve bounds the following plant conditions: Operating Pressure (Leak) Test (Curve A), Normal Operation – Core Not Critical (Curve B), and Normal Operation – Core Critical (Curve C). The curve is developed using the methodology of the 2001 Edition, 2003 Addenda of the ASME Code, Section XI, Appendix G [1], and 10CFR50 Appendix G [2]. This appendix has been developed in accordance with the methodology of the BWROG Licensing Topical Report, "Pressure-Temperature Limits Report Methodology for Boiling Water Reactors" [3]. This appendix is provided for engineering purposes only and is not intended to be included in the PTLR.

B2.0 METHODOLOGY

The methodology for calculating the P-T curve described in Section 2.0 remains unchanged. Only the calculation of the thermal stress intensity factor, K_{It}, is affected by the increased heat-up / cool-down rate. K_{It} is computed in different ways based on the evaluation region. As described in Section 2.0, the feedwater nozzle / upper vessel region K_{It} is obtained from the stress distribution output of a finite element model. The transient "Turbine Roll and Increase to Rated Power" consists of a 450°F step change [14], which bounds the increased heat-up / cool-down rate. Thus, the K_{It} calculation for the feedwater nozzle / upper vessel region is unaffected. For the beltline and bottom head regions, K_{It} is determined based on the ASME Section XI, Nonmandatory Appendix G method, using the following equation from Section 2.0:

$$K_{It} = 0.953 \times 10^{-3} \cdot CR \cdot t^{2.5} \tag{3}$$

Where: CR = the cooldown rate of the vessel (°F/hr).
t = the RPV wall thickness, unique for each region (in).

B3.0 CALCULATIONS

The P-T curve is developed using an Excel spreadsheet, which is independently verified for use on a project-specific basis in accordance with SI's QA Program.

Figure B1 presets the bounding curve for a 200°F/Hr heat-up / cool-down rate. This information is also presented in tabular form in Table B1. The P-T curve bounds the beltline, bottom head, and non-beltline (feedwater nozzle / upper vessel) regions and is valid for up to 46 EFPY. The curve bounds the following plant conditions: Operating Pressure (Leak) Test (Curve A), Normal Operation – Core Not Critical (Curve B), and Normal Operation – Core Critical (Curve C).

Table B1: NMP-1 Bounding P-T Curve for 200°F/Hr Heat-up / Cool-Down

Plant =	NMP-1	
Curve A Leak Test Temperature =	185.2	°F
Curve A Leak Test Pressure =	1,055	psig
Unit Pressure =	1,875	psig (hydrostatic pressure)
Flange RT_{NDT} =	40.0	°F

Adjusted P-T Curve Temperature (°F)	Adjusted P-T Curve Pressure (psig)
100	0
100	46
102	47
104	48
106	49
108	50
110	51
112	53
114	54
116	55
118	57
120	58
122	60
124	62
126	63
128	65
130	67
132	69
134	71
136	73
138	75
140	77
142	80
144	82
146	85
148	87
150	90
152	93
154	96
156	99
158	102
160	105
162	109
164	113
166	116
168	120
170	124
172	129
174	133
176	138
178	143
180	148
182	153
184	158
186	164
188	170
190	176
192	182
194	189
196	196
198	203
200	210
200	210
202	218
204	226
206	235
208	243
210	252
212	262
214	272
216	282
218	293
220	304

Table B1 Cont.: NMP-1 Bounding P-T Curve for 200°F/Hr Heat-up / Cool-Down

Adjusted P-T Curve Temperature (°F)	Adjusted P-T Curve Pressure (psig)
222	315
224	328
226	340
228	353
230	367
232	381
234	396
236	411
238	427
240	444
242	461
244	479
246	498
248	517
250	537
252	558
254	580
256	603
258	627
260	652
262	678
264	705
266	733
268	762
270	792
272	823
274	856
276	890
278	926
280	963
282	1001
284	1041
286	1083
288	1126
290	1172
292	1219
294	1267
296	1318
298	1371
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304	1544
306	1606
308	1671
310	1738
312	1808
314	1881
316	1957

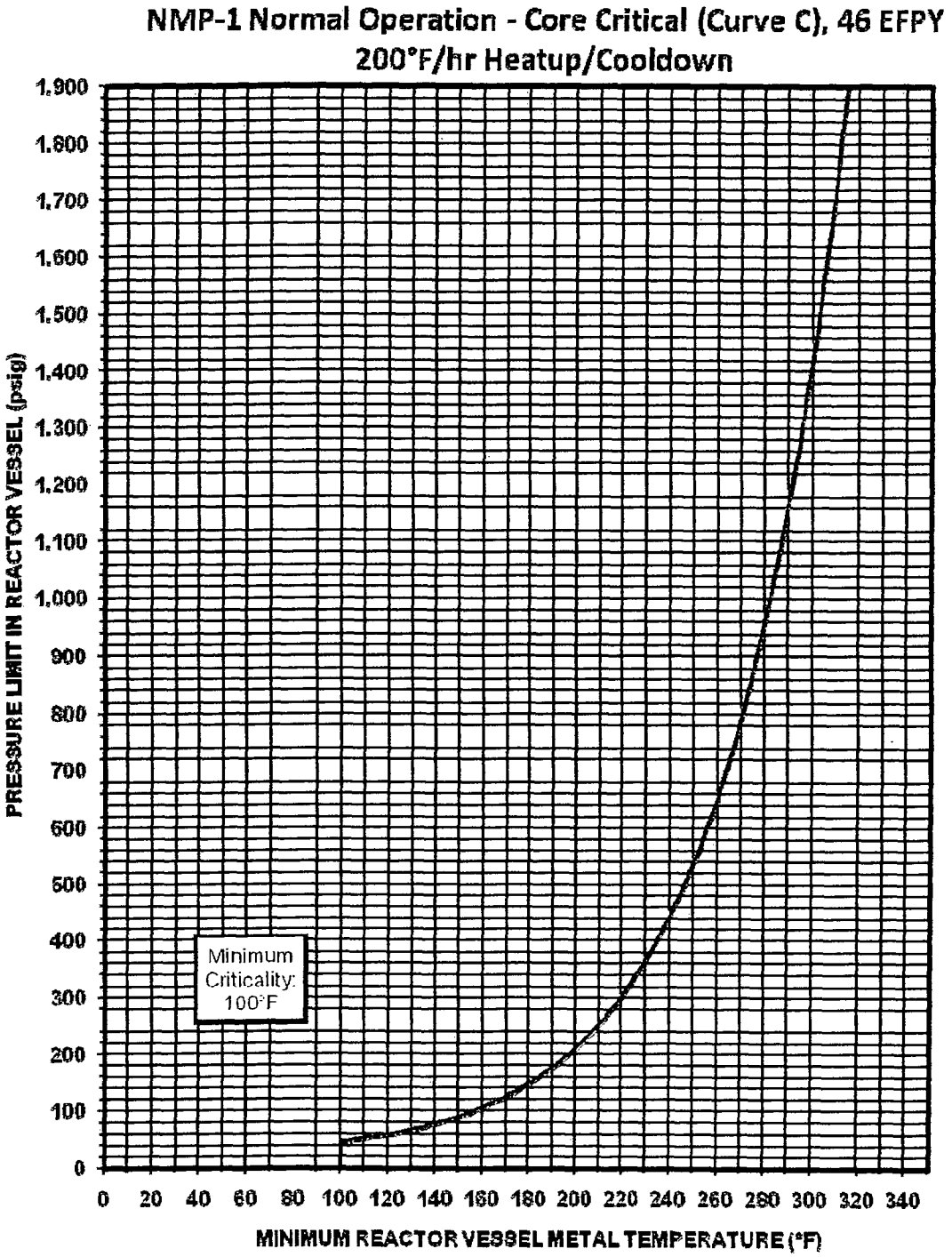

Figure B1: NMP-1 Bounding P-T Curve for 200°F/Hr Heat-up / Cool-Down

APPENDIX C:

ANSYS SUPPORTING FILES

The following list of electronic files is included in the project files:

FILE NAME	DESCRIPTION
NMP_FWN_GEOM.inp	ANSYS input file for creation of nozzle geometry
NMP_FWN_PRES.inp	ANSYS input file for application of pressure loads
NMP_FWN_THSTR.inp	ANSYS input file for application of thermal shock
BR_FLW.OUT	Blend Radius Stress Intensity output file from extraction of Thermal Load Application (Used only to determine nozzle corner thickness)
BR_PRES_FLW.OUT	Blend Radius Stress Intensity output file from extraction of Pressure Load Application (Used only to determine nozzle corner thickness)
map_stress_press.POS	Hoop stress extraction file for Blend Radius location from Pressure Load application
map_stress_therm.POS	Hoop stress extraction file for Blend Radius location from Thermal Shock application
MAP_PRESS_HOOP_1.TXT	Output file containing hoop stresses for Blend Radius location from Pressure Load
MAP_TH_HOOP_1.TXT	Output file containing hoop stresses for Blend Radius location from Thermal Shock
MAP_PRESS_HOOP_1(Scaled).TXT	Output file containing scaled hoop stresses for Blend Radius location from Pressure Load
MAP_PRESS_HOOP_1(Scaled).xls	Excel file containing Blend Radius polynomial coefficients and KIt (scaled hoop stresses) from Pressure Load
MAP_TH_HOOP_1.xls	Excel file containing Blend Radius polynomial coefficients and KIt from Thermal Shock