Enclosure 3 Contains Proprietary Information to be Withheld from Public Disclosure Pursuant to 10 CFR 2.390

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JUN 08 2018

TS 6.9.1.10

LR-N18-0057

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Hope Creek Generating Station
Renewed Facility Operating License No. NPF-57
NRC Docket No. 50-354

Subject: **PRESSURE AND TEMPERATURE LIMITS REPORT (PTLR) Revision 1**

PSEG Nuclear LLC (PSEG) is transmitting Revision 1 of the PTLR in accordance with Hope Creek Generating Station (HCGS) Technical Specification (TS) 6.9.1.10. Revision 1 of the PTLR was issued as a result of the increase in maximum licensed thermal power level approved by the NRC in Hope Creek Amendment No. 212 on April 24, 2018.

Enclosure 1 provides Revision 1 of the Hope Creek PTLR (Non-Proprietary). Enclosure 2 includes an affidavit from Electric Power Research Institute (EPRI) requesting withholding the proprietary information from public disclosure. Enclosure 3 provides Revision 1 of the Hope Creek PTLR (Proprietary) to be withheld from public disclosure under 10 CFR 2.390(a)(4).

Enclosure 3 contains proprietary information as defined by 10 CFR 2.390(a)(4). EPRI, as the owner of the proprietary information, has executed the Enclosure 2 affidavit identifying that the proprietary information has been handled and classified as proprietary, is customarily held in confidence, and has been withheld from public disclosure. EPRI requests that the proprietary information in Enclosure 3 be withheld from public disclosure, in accordance with the requirements of 10 CFR 2.390(a)(4).

No new regulatory commitments are established by this submittal. If you have any questions or require additional information, please do not hesitate to contact Mr. Brian Thomas at (856) 339-2022.

JUN 08 2018

Respectfully,

Jean Fleming
Director – Site Regulatory Compliance

Enclosures:

1. Hope Creek Pressure and Temperature Limits Report Revision 1 (Non-Proprietary)

2. EPRI Affidavit supporting the withholding of information in Enclosure 3 from public disclosure

3. Hope Creek Pressure and Temperature Limits Report Revision 1 (Proprietary)

cc: Administrator, Region I, NRC
NRC Project Manager, Hope Creek
NRC Senior Resident Inspector, Hope Creek
Mr. P. Mulligan, Chief, NJBNE
Mr. L. Marabella, Corporate Commitment Tracking Coordinator
Mr. T. MacEwen, Hope Creek Commitment Tracking Coordinator

Enclosure 1
LR-N18-0057

Hope Creek Pressure and Temperature Limits Report Revision 1

Non-Proprietary

This is the non-proprietary version of Enclosure 3 of this letter which has the proprietary information removed. Portions of the document that have been removed are indicated by white space inside open and closed brackets as shown here {{ }}.

PSEG Nuclear LLC

Hope Creek Generating Station

Pressure and Temperature Limits Report (PTLR) for 32, 44, and 56 Effective Full-Power Years (EFPY)

Revision 1-NP

Prepared by: Donnamarie Bush   Date: 9/7/17
Donnamarie Bush
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Reviewed by: [signature]   Date: 9/11/17
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[Manager, Engineering Programs]

Approved by: [signature]   Date: 9-11-17
Bill Kopchick
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1.0 Purpose

The purpose of the Hope Creek Generating Station (HCGS) Pressure and Temperature Limits Report (PTLR) is to present operating limits relating to:

1. Reactor Coolant System (RCS) Pressure versus Temperature limits during Heat-up, Cool-down and Hydrostatic/Class 1 Leak Testing;
2. RCS Heat-up and Cool-down rates;
3. RPV head flange boltup temperature limits.

This report has been prepared in accordance with the requirements of Licensing Topical Reports SIR-05-044, Revision 1-A, contained within BWROG-TP-11-022-A, Revision 1 [1].

2.0 Applicability

This report is applicable to the HCGS RPV for up to 32, 44, and 56 Effective Full-Power Years (EFPY).

The following HCGS Technical Specifications (TS) are affected by the information contained in this report:

TS 3.4.6	RCS Pressure/Temperature (P-T) Limits
TS 4.4.6	Surveillance Requirements

3.0 Methodology

The limits in this report were derived as follows:

1. The methodology used is in accordance with Reference [1], "Pressure – Temperature Limits Report Methodology for Boiling Water Reactors," August 2013, incorporating the NRC Safety Evaluation in Reference [2].

2. The neutron fluence is calculated in accordance with NRC Regulatory Guide 1.190 (RG 1.190) [3], using the RAMA computer code, as documented in Reference [4].

3. The adjusted reference temperature (ART) values for the limiting beltline materials are calculated in accordance with NRC Regulatory Guide 1.99, Revision 2 (RG 1.99) [5], as documented in Reference [6].

4. The pressure and temperature limits, which were calculated in accordance with Reference [1], are documented in Reference [7].

5. This revision of the pressure and temperature limits report is to incorporate the following changes:
    - Revision 0: Initial issue of PTLR.
    - Revision 1: Updated fluence for 1.6% power uprate conditions.

Changes to the curves, limits, or parameters within this PTLR, based upon new irradiation fluence data of the RPV, or other plant design assumptions in the Updated Final Safety Analysis Report (UFSAR), can be made pursuant to 10 CFR 50.59 [8], provided the above methodologies are utilized. The revised PTLR shall be submitted to the NRC upon issuance.

Changes to the curves, limits, or parameters within this PTLR, based upon new surveillance capsule data of the RPV or other plant design assumption modifications in the UFSAR, cannot be made without prior NRC approval. Such analysis and revisions shall be submitted to the NRC for review prior to incorporation into the PTLR.

4.0 Operating Limits

The pressure-temperature (P-T) curves included in this report represent steam dome pressure versus minimum vessel metal temperature and incorporate the appropriate non-beltline limits and irradiation embrittlement effects in the beltline region.

The operating limits for pressure and temperature are required for three categories of operation: (a) hydrostatic pressure tests and leak tests, referred to as Curve A; (b) core not critical operation, referred to as Curve B; and (c) core critical operation, referred to as Curve C.

Complete P-T curves were developed for 32, 44, and 56 EFPY for HCGS, as documented in Reference [7]. The HCGS P-T curves for 32 EFPY are provided in Figures 1 through 3, for 44 EFPY are in Figures 4 through 6, and for 56 EFPY are in Figures 7 through 9. A tabulation of the curves is included in Tables 1 through 3 for 32 EFPY, Tables 4 through 6 for 44 EFPY, and Tables 7 through 9 for 56 EFPY. The adjusted reference temperature (ART) tables for the HCGS vessel beltline materials are shown in Table 10 for 32 EFPY, Table 11 for 44 EFPY, and Table 12 for 56 EFPY [6].

The resulting P-T curves are based on the geometry, design and materials information for the HCGS vessel with the following conditions:

- Heat-up/Cool-down rate limit during Hydrostatic Class 1 Leak Testing (Figures 1, 4, and 7: Curve A): **≤ 25°F/hour**[1] [7].

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[1] Interpreted as the temperature change in any 1-hour period is less than or equal to 25°F.

- Normal Operating Heat-up/Cool-down rate limit (Figures 2, 5, and 8: Curve B – non-nuclear heating, and Figures 3, 6, and 9: Curve C – nuclear heating): ≤ **100˚F/hour**[2] [7].
- RPV bottom head coolant temperature to RPV coolant temperature ΔT limit during Recirculation Pump startup: **≤ 145°F** [1].
- Recirculation loop coolant temperature to RPV coolant temperature ΔT limit during Recirculation Pump startup: **≤ 50°F** [1].
- RPV flange and adjacent shell temperature limit **≥ 79˚F** [7].

To address the NRC condition regarding lowest service temperature in Reference [2, Section 4.0], the minimum temperature is set to 79°F, which is equal to $RT_{NDT,max}$ + 60°F. This value is consistent with the minimum temperature limits and minimum bolt-up temperature in the current docketed P-T curves [9] (approved for use by the NRC in Reference [10]) and bounds the minimum temperature in the first set of P-T limits approved for initial operation [11].

5.0 <u>Discussion</u>

The adjusted reference temperature (ART) of the limiting beltline material is used to adjust beltline P-T curves to account for irradiation effects. RG 1.99 [5] provides the methods for determining the ART. The RG 1.99 methods for determining the limiting material and adjusting the P-T curves using ART are discussed in this section.

The vessel beltline copper (Cu) and nickel (Ni) values were obtained from the evaluation of the HCGS vessel plate, weld, and forging materials [6]. This evaluation included the results of two surveillance capsules for the representative plate and weld materials. The Cu and Ni values were used with Table 1 of RG 1.99 to determine a chemistry factor (CF) per Paragraph 1.1 of RG 1.99 for welds. The Cu and Ni values were used with Table 2 of RG 1.99 to determine a CF per

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[2] Interpreted as the temperature change in any 1-hour period is less than or equal to 100°F.

Paragraph 1.1 of RG 1.99 for plates and forgings. However, for materials where surveillance data exists (i.e. HCGS plate heat no. 5K3238/1 and weld heat no. D53040), a fitted CF has been used in the calculation of ART for those heats, in accordance with Regulatory Position 2.1 in RG 1.99 [5]. Use of surveillance data from the BWRVIP ISP for HCGS was approved by the NRC in Reference [12].

The peak RPV ID fluence values of 8.86 x 10^{17} n/cm^2 at 32 EFPY, 1.27 x 10^{18} n/cm^2 at 44 EFPY, and 1.65 x 10^{18} n/cm^2 at 56 EFPY used in the P-T curve evaluation were obtained from Reference [6] (interpolated from the fluence values at 24.1 and 56 EFPY in Reference [4]). Fluence values in Reference [4] were calculated in accordance with RG 1.190 [3]. These fluence values apply to the limiting beltline lower intermediate shell plates (heat nos. 5K2963/1, 5K2530/1, and 5K3238/1). A plant-specific damage assessment, in terms of displacements per atom (dpa), was performed to determine through-wall fluence for HCGS in Reference [4], as permitted by RG 1.99 [5]. The resulting attenuation factor is 0.70 for a postulated 1/4T flaw. Consequently, the 1/4T fluence for 32, 44, and 56 EFPY for the limiting lower intermediate shell plates are 6.15 x 10^{17} n/cm^2, 8.83 x 10^{17} n/cm^2, and 1.15 x 10^{18} n/cm^2, respectively, for HCGS. The limiting value for ART is 90.5°F at 32 EFPY, 103.6°F at 44 EFPY, and 114.3°F at 56 EFPY [6].

The P-T limits are developed to bound all ferritic materials in the RPV, including the consideration of stress levels from structural discontinuities such as nozzles. HCGS has two sets of nozzles in the RPV beltline: the instrument (N16) and low pressure coolant injection (LPCI, N17) nozzles are located in the intermediate shell beltline plates [13]. The feedwater (FW) nozzle is considered in the evaluation of the non-beltline (upper vessel) region P-T limits.

The limiting LPCI (N17) nozzles have an RPV ID fluence of 1.71 x 10^{17} n/cm^2 at 56 EFPY, obtained from Reference [4] and calculated in accordance with RG 1.190 [3]. Similar to the RPV beltline plates and welds described above, through-wall fluence for the LPCI nozzles was attenuated using the dpa methodology in Reference [4]. The resulting attenuation factor is 0.82 for a postulated 1/4T flaw in the LPCI nozzle blend radius. Consequently, the 1/4T fluence for 56 EFPY for the limiting LPCI nozzle location is 1.40 x 10^{17} n/cm^2. The limiting value for ART is 8.8°F at 56 EFPY [6]. Comparing the limiting ART value of the LPCI nozzles with the initial RT_{NDT} for non-beltline nozzles, 40°F, the non-beltline nozzles are more limiting. This assumption is further supported when comparing nozzle transients, where the FW nozzle, outside the beltline, experiences more severe thermal transients. Therefore, the P-T curves developed for the FW nozzle bound the LPCI nozzles. Due to this bounding assumption, LPCI nozzle evaluations should use the upper vessel P-T curve limits.

The instrument (N16) nozzle material is ferritic and is welded to the RPV using a partial penetration weld. The effect of the penetration on the adjacent shell is considered in the development of bounding beltline P-T limits as described in Reference [7]. The N16 nozzles have a limiting RPV ID fluence of 1.90 x 10^{17} n/cm^2 at 32 EFPY, 2.63 x 10^{17} n/cm^2 at 44 EFPY, and 3.37 x 10^{17} n/cm^2 at 56 EFPY [6]. This fluence value applies to the adjacent intermediate shell plates in which the nozzles are located. Similar to the RPV beltline plates and welds described above, through-wall fluence for the N16 nozzles was attenuated using the dpa methodology in Reference [4]. The resulting attenuation factor is 0.84 for a postulated 1/4T flaw in the N16 nozzle corner. Consequently, the 1/4T fluence for 32, 44, and 56 EFPY for the limiting N16 nozzle location is 1.59 x 10^{17} n/cm^2, 2.22 x 10^{17} n/cm^2, and 2.84 x 10^{18} n/cm^2, respectively, for HCGS. The limiting value for ART of the N16 nozzles is 52.6°F at 32 EFPY, 60.3°F at 44 EFPY, and 67.0°F at 56 EFPY [6].

The P-T curves for the core not critical and core critical operating conditions at a given EFPY apply for both the 1/4T and 3/4T locations. When combining pressure and thermal stresses, it is usually necessary to evaluate stresses at the 1/4T location (inside surface flaw) and the 3/4T location (outside surface flaw). This is because the thermal gradient tensile stress of interest is in the inner wall during cool-down and is in the outer wall during heat-up. However, as a conservative simplification, the thermal gradient stresses at the 1/4T location are assumed to be tensile for both heat-up and cool-down. This results in the approach of applying the maximum tensile stresses at the 1/4T location. This approach is conservative because irradiation effects cause the allowable toughness at the 1/4T to be less than that at 3/4T for a given metal temperature. This approach causes no operational difficulties, since the BWR is at steam saturation conditions during normal operation, and for a given pressure, the coolant saturation temperature is well above the P-T curve limiting temperature. Consequently, the material toughness at a given pressure would exceed the allowable toughness.

For the core not critical curve (Curve B) and the core critical curve (Curve C), the P-T curves specify a coolant heat-up and cool-down temperature rate of **≤ 100°F/hour** for which the curves are applicable. However, the core not critical and the core critical curves were also developed to bound Service Level A/B RPV thermal transients. For the hydrostatic pressure and leak test curve (Curve A), a coolant heat-up and cool-down temperature rate of **≤ 25°F/hour** must be maintained. The P-T limits and corresponding limits of either Curve A or B may be applied, if necessary, while achieving or recovering from test conditions. So, although Curve A applies during pressure testing, the limits of Curve B may be conservatively used during pressure testing if the pressure test heat-up/cool-down rate limits cannot be maintained.

The initial RT_{NDT}, chemistry (weight-percent copper and nickel), and ART at the 1/4T location for all RPV beltline materials significantly affected by fluence (i.e., fluence > 10^{17} n/cm^2 for E > 1MeV) are shown in Tables 10, 11, and 12 for 32, 44, and 56 EFPY, respectively [6]. Use of initial RT_{NDT} values in the determination of P-T curves for HCGS was approved by the NRC in Reference [14].

Per Reference [6] and in accordance with Appendix A of Reference [1], the HCGS representative weld and plate surveillance materials data were reviewed from the Boiling Water Reactor Vessel and Internals Project (BWRVIP) Integrated Surveillance Program (ISP) [15, 16].

The representative heat of the plate material (5K3238/1) in the ISP is not the same as the target plate material (5K3025/1) for HCGS. However, the surveillance heat 5K3238/1 does exist in the HCGS vessel beltline, and there are two irradiated data sets for this plate. For plate heat 5K3238/1, since the scatter in the fitted results is less than 1-sigma (17°F) [16], the data is credible per Reference [5], and a reduced margin term (σ_Δ = 17°F/2 = 8.5°F) is used for the plate material when calculating the ART. The representative heat of the weld material (D53040) in the ISP is the same as the limiting weld material in the vessel beltline region of HCGS. Per Reference [16], scatter in the surveillance data exceeds the credibility criteria for weld heat D53040, however, the fitted CF bounds the RG 1.99 CF. Therefore, the higher surveillance-based CF is used in the ART calculation for weld heat no. D53040, with a full margin term (σ_Δ = 28°F). The RG 1.99 table CFs were used in the determination of the ART values for all HCGS beltline materials except for plate heat 5K3238/1 and weld heat D53040.

The only computer code used in the determination of the HCGS P-T curves was the ANSYS finite element computer program:

- ANSYS, Release 8.1 (Service Pack 1) [17] for:
  - FW nozzle (non-beltline) through-wall thermal stress distributions in Reference [18].
  - Instrument nozzle thermal and pressure stress distributions in Reference [19].
- ANSYS Mechanical APDL and PrepPost, Release 11.0 (Service Pack 1) [20] for the FW nozzle (non-beltline) pressure stress distribution in Reference [21].

ANSYS finite element analyses were used to develop the stress distributions through the FW and instrument nozzles, and these stress distributions were used in the determination of the stress intensity factors for these nozzles [18, 19, 21]. At the time that each of the analyses above was performed, the ANSYS program was controlled under the vendor's 10 CFR 50 Appendix B [22] Quality Assurance Program for nuclear quality-related work. Benchmarking consistent with NRC GL 83-11, Supplement 1 [23] was performed as a part of the computer program verification by comparing the solutions produced by the computer code to hand calculations for several problems.

The plant-specific HCGS FW nozzle analyses were performed to determine through-wall pressure stress distributions and thermal stress distributions due to bounding thermal transients. Detailed information regarding the analyses can be found in References [18] and [21]. The following summarizes the development of the thermal and pressure stress intensity factors for the FW nozzle:

- A two-dimensional axisymmetric finite element model of the FW nozzle was constructed for the determination of thermal stresses (Figure 10). Details of the model and material properties are provided in Reference [24]. Temperature-dependent material properties were based on the ASME Code, Section II, Part D, 2001 Edition through 2003 Addenda [25].
- Heat transfer coefficients were calculated in Reference [24] and are a function of FW temperature and flow rate. Potential leakage past the primary thermal sleeve is considered in the heat transfer calculations.
- With respect to operating conditions, the bounding thermal transients during normal and upset operating conditions were analyzed [18]. The thermal stress distribution, corresponding to the limiting time presented in Reference [18], along a linear path through the nozzle corner is used. The boundary integral equation/influence function (BIE/IF) methodology presented in Reference [1] was used to calculate the thermal stress intensity factor, K_{It}, by fitting a third order polynomial equation to the path stress distribution for the thermal load case.
- A three-dimensional finite element model of the FW nozzle was constructed (Figure 11) for the determination of pressure stresses. Details of the model and material properties are provided in Reference [26]. Material properties were based on the ASME Code, Section II, Part D, 2001 Edition through 2003 Addenda [25]. The properties were taken at a

temperature of 350°F, which is the approximate average service temperature of the FW nozzle at HCGS [21]. The use of temperature-independent material properties is consistent with design basis documents. Use of temperature-dependent material properties is expected to have minimal impact on the results of the analysis.

- With respect to pressure stress, a unit pressure of 1000 psig was applied to the internal surfaces of the 3-D model in Reference [21]. The pressure stress distribution was taken along a linear path through the nozzle corner. The BIE/IF methodology presented in Reference [1] was used to calculate the applied pressure stress intensity factor, K_{Ip}, by fitting a third order polynomial equation to the path stress distribution for the pressure load case. The resulting K_{Ip} may be linearly scaled to determine the K_{Ip} for various RPV internal pressures.

The plant-specific HCGS instrument nozzle analysis was performed to determine through-wall pressure stress distributions and thermal stress distributions due to bounding thermal transients. Detailed information regarding the analysis can be found in Reference [19]. The following summarizes the development of the thermal and pressure stress intensity factors for the instrument nozzle:

- A one-quarter symmetric, three-dimensional finite element model of the instrument nozzle was constructed and is shown in Figure 12. Temperature-dependent material properties, taken from the ASME Code, Section II, Part D, 2001 Edition with 2003 Addenda edition [25], were used in the evaluation and are described in Reference [27].
- With respect to operating conditions, the bounding thermal transient for the region corresponding to the instrument nozzles during normal and upset operating conditions was analyzed [19]. The thermal stress distribution, corresponding to the limiting time in Reference [19], along a linear path through the nozzle corner is used. The BIE/IF methodology presented in Reference [1] was used to calculate the thermal stress intensity

factor, K_{IT}, due to the thermal stresses by fitting a third order polynomial equation to the path stress distribution for the thermal load case.

- Boundary conditions and heat transfer coefficients used for the thermal analysis are described in Reference [19].

- With respect to pressure stress, a unit pressure of 1000 psig was applied to the internal surfaces of the finite element model (FEM) [19]. The pressure stress distribution was taken along the same path as the thermal stress distribution. The BIE/IF methodology presented in Reference [1] is used to calculate the pressure stress intensity factor, K_{IP}, by fitting a third order polynomial equation to the path stress distribution for the pressure load case. The resulting K_{IP} can be linearly scaled to determine the K_{IP} for various RPV internal pressures

6.0 References

1. BWROG-TP-11-022-A, Revision 1, Pressure Temperature Limits Report Methodology for Boiling Water Reactors, August 2013. (ADAMS Accession No. ML13277A557)
2. U.S. NRC Letter to BWROG dated May 16, 2013, "Final Safety Evaluation for Boiling Water Reactor Owners' Group Topical Report BWROG-TP-11-022, Revision 1, November 2011, 'Pressure-Temperature Limits Report Methodology for Boiling Water Reactors'" (TAC NO. ME7649, ADAMS Accession No. ML13277A557).
3. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.190, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence", March 2001.
4. TransWare Report No. PSE-FLU-005-R-001, Revision 0, "Hope Creek Nuclear Generating Station Unit 1 Reactor Pressure Vessel Fluence Evaluation at End of Cycle 19 with Projections to 56 EFPY," February 27, 2017, SI File No. 1700220.201.
5. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials", May 1988.
6. Structural Integrity Associates Calculation No. 1601009.301, Revision 1, "Hope Creek RPV Beltline ART Evaluation", March 27, 2017.
7. Structural Integrity Associates Calculation No. 1601009.303, Revision 1, "Hope Creek Updated P-T Curve Calculation for 32, 44, and 56 EFPY", March 27, 2017.
8. U.S. Code of Federal Regulations, Title 10, Part 50, Section 59, "Changes, tests and experiments," August 28, 2007.
9. Attachment 3 to PSEG Letter No. LR-N04-0136, dated March 31, 2004, SI Report No. SIR-00-136, Revision 1, "Revised Pressure-Temperature (P-T) Curves for Hope Creek," March 23, 2004. (ADAMS Accession No. ML040990522)

10. Hope Creek License Amendment No. 157, Change of Pressure-Temperature Limits and Extension of Validity to 32 Effective Full-Power Years, dated November 1, 2004. (TAC No. MC2534, ADAMS Accession No. ML042050079)

11. PSEG Design Information Transmittal No. H-TODI-2016-0066, dated November 14, 2016. SI File No. 1601009.201.

12. Hope Creek License Amendment No. 151, Revision to the Reactor Pressure Vessel Material Surveillance Program, dated July 23, 2004. (TAC No. MB7151, ADAMS Accession No. ML033230591)

13. PSEG Document No. VTD 431282, SI Calculation No. 0800118.317, Revision 0, "Validation of Beltline Materials," September 12, 2008.

14. Hope Creek Generating Station, Issuance of Amendment 88 (TAC No. M93054, ADAMS Accession No. ML011760521), November 28, 1995.

15. *BWRVIP-135, Revision 3: BWR Vessel and Internals Project, Integrated Surveillance Program (ISP) Data Source Book and Plant Evaluations*. EPRI, Palo Alto, CA: 2014. 3002003144. **EPRI PROPRIETARY INFORMATION**.

16. EPRI Letter 2017-017, Final BWRVIP Integrated Surveillance Program (ISP) Data Applicable to Hope Creek Generating Station, January 19, 2017. **EPRI PROPRIETARY INFORMATION.**

17. ANSYS, Release 8.1 (w/ Service Pack 1), ANSYS Inc., June 2004.

18. PSEG Document No. VTD 327370, Structural Integrity Associates Calculation No. HC-05Q-304, Revision 2, "Feedwater Nozzle (N4A through N4F) Thermal and Stress Analysis," October 22, 2009.

19. PSEG Document No. VTD 431277, Structural Integrity Associates Calculation No. 0800118.311, Revision 1, "Stress Analysis of Reactor Pressure Vessel 2" Instrument Nozzles N16A through N16D," October 29, 2009.

20. ANSYS Mechanical and PrepPost, Release 11.0 (w/ Service Pack 1), ANSYS, Inc., August 2007.

21. PSEG Document No. VTD 432637, Structural Integrity Associates Calculation No. 1200619.305, Revision 0, "Greens Function Analysis of Feedwater Nozzle," March 19, 2015.

22. U.S. Code of Federal Regulations, Title 10, Energy, Part 50, Appendix B, "Quality Assurance for Nuclear Power Plants and Fuel Reprocessing Plants".

23. U.S. Nuclear Regulatory Commission, Generic Letter 83-11, Supplement 1, "License Qualification for Performing Safety Analyses", June 24, 1999.

24. PSEG Document No. VTD 327367, Structural Integrity Associates Calculation No. HC-05Q-301, Revision 3, "Feedwater Nozzle (N4A through N4F) Finite Element Model and Heat Transfer Coefficients," June 4, 2010.

25. ASME Boiler and Pressure Vessel Code, Section II, Part D, Material Properties, 2001 Edition with Addenda through 2003.

26. PSEG Document No. VTD 431269, Structural Integrity Associates Calculation No. 0800118.303, Revision 1, "Feedwater Nozzle (N4A through N4F) Finite Element Model," October 19, 2009.

27. PSEG Document No. VTD 431267, Structural Integrity Associates Calculation No. 0800118.301, Revision 0, "Material Properties and Methodology of Heat Transfer Coefficient Calculation for Hope Creek Environmental Fatigue Evaluation," May 30, 2008.

28. U.S. Code of Federal Regulations, Title 10, Part 50, Appendix H, "Reactor Vessel Material Surveillance Program Requirements," January 31, 2008.

29. GE Nuclear Energy Report No. GE-NE-523-A164-1294R1, "Hope Creek Generating Station RPV Surveillance Materials Testing and Fracture Toughness Analysis," December 1997. SI File No. PSEG-10Q-201P. **GE PROPRIETARY INFORMATION**.

30. *BWRVIP- 298NP: BWR Vessel and Internals Project: Testing and Evaluation of the Hope Creek 120° Capsule,* EPRI, Palo Alto, CA: 2014. 3002007844. SI File No. 1601009.201.

31. *BWRVIP-86, Revision 1-A: BWR Vessel and Internals Project, Updated BWR Integrated Surveillance Program (ISP) Implementation Plan*. EPRI, Palo Alto, CA: 2012. 1025144. **EPRI PROPRIETARY INFORMATION.**

Figure 1: HCGS P-T Curve A (Hydrostatic Pressure and Leak Tests) for 32 EFPY

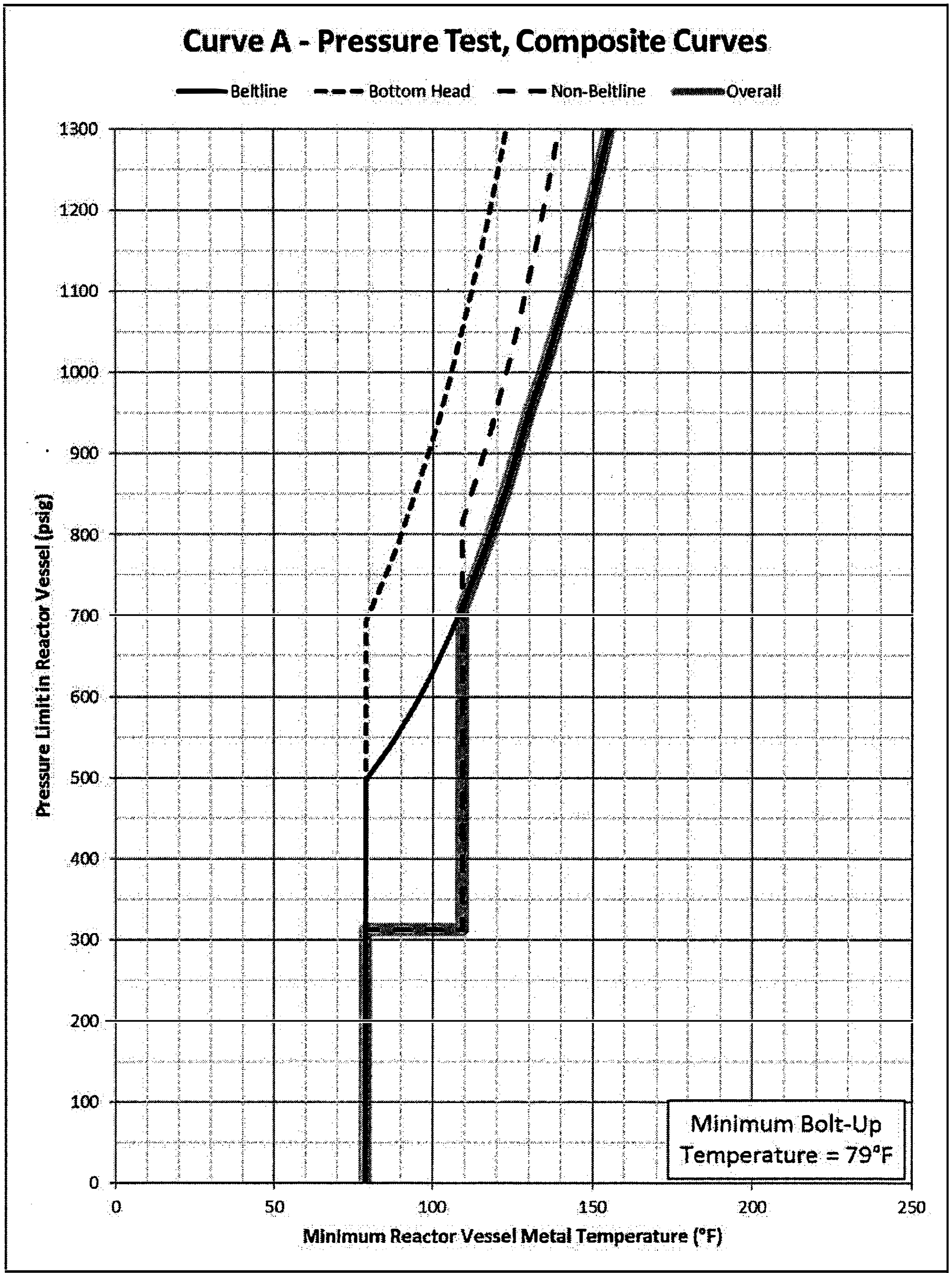


Figure 2: HCGS P-T Curve B (Normal Operation – Core Not Critical) for 32 EFPY

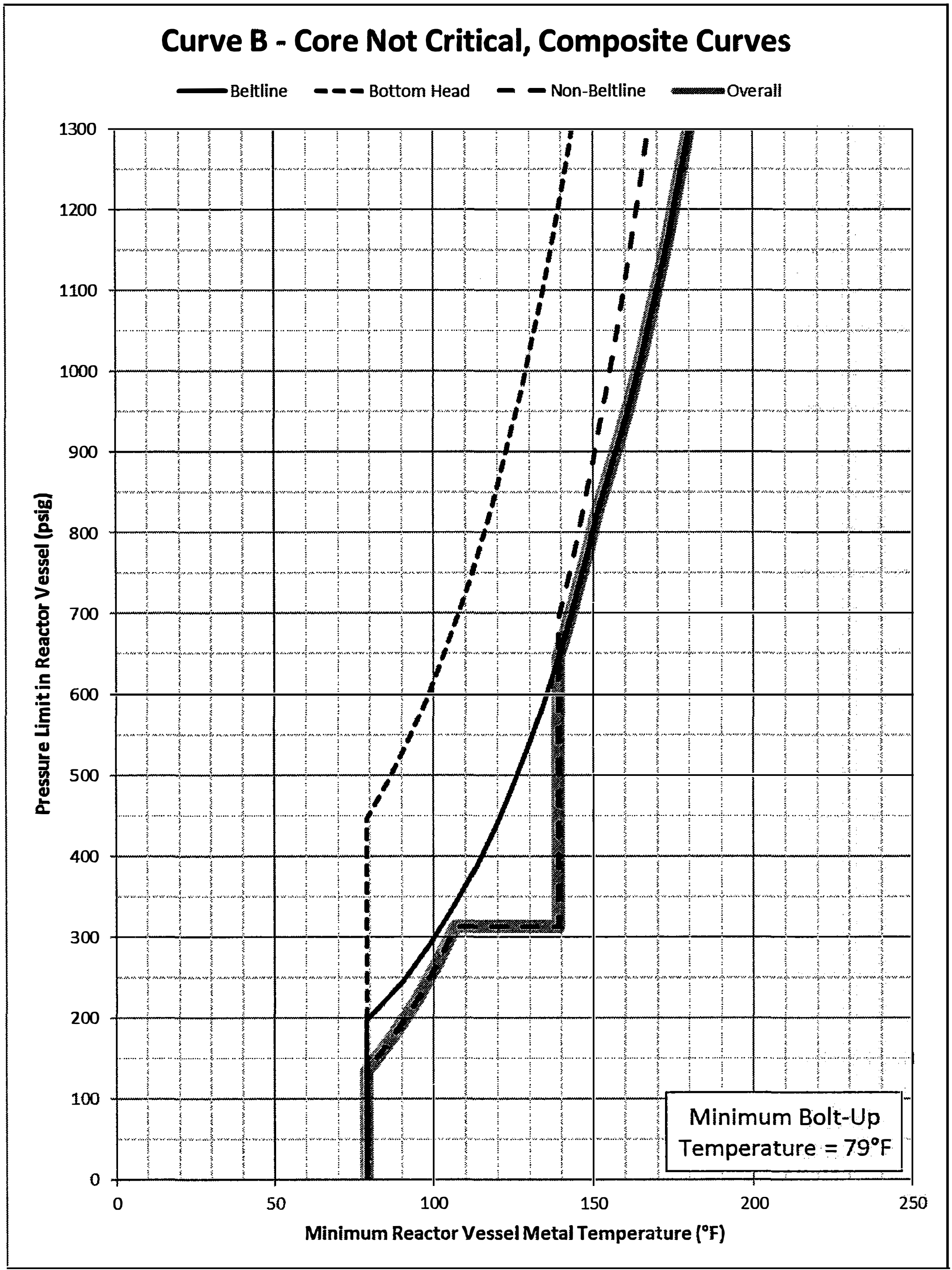


Figure 3: HCGS P-T Curve C (Normal Operation – Core Critical) for 32 EFPY

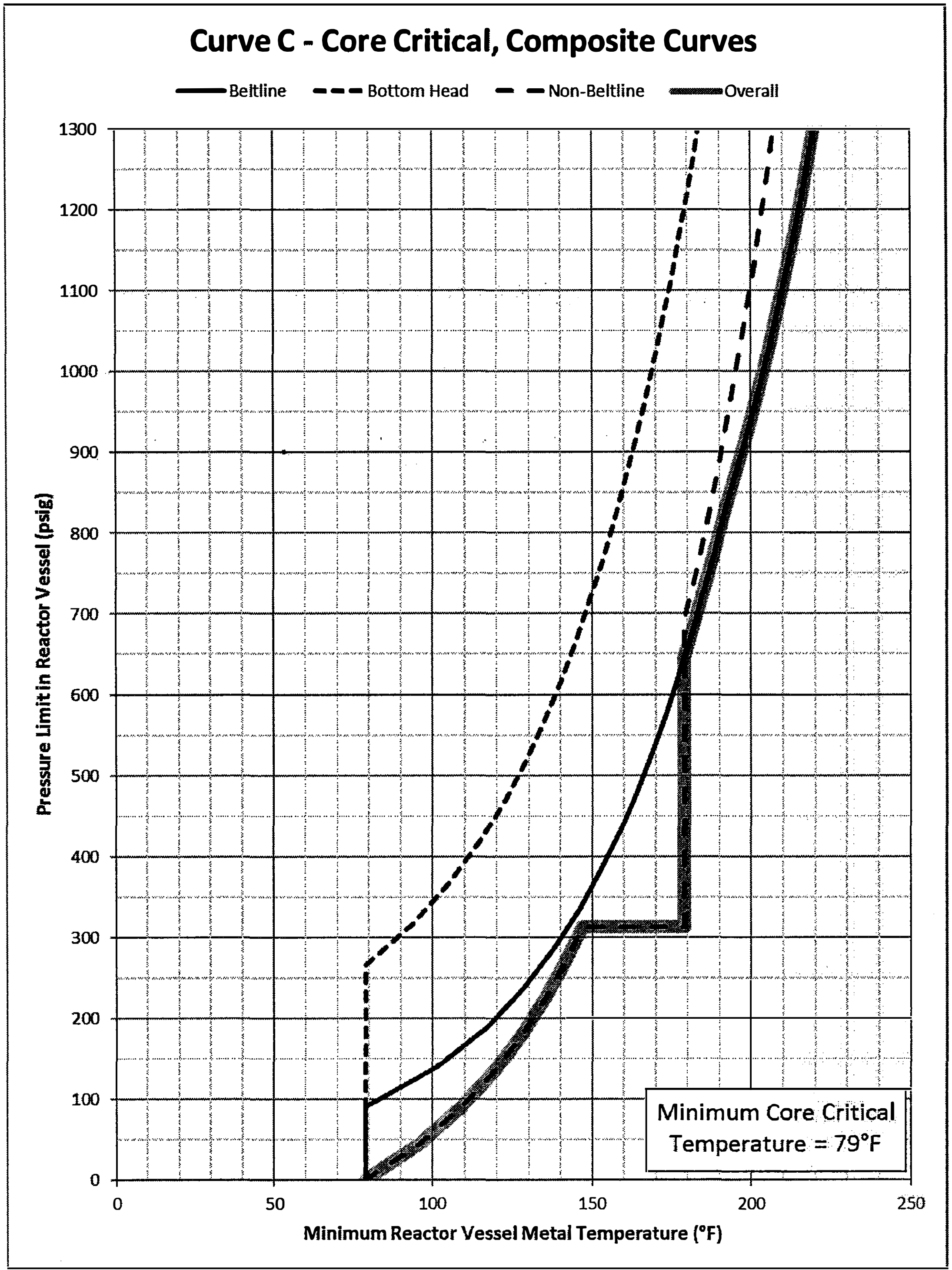


Figure 4: HCGS P-T Curve A (Hydrostatic Pressure and Leak Tests) for 44 EFPY

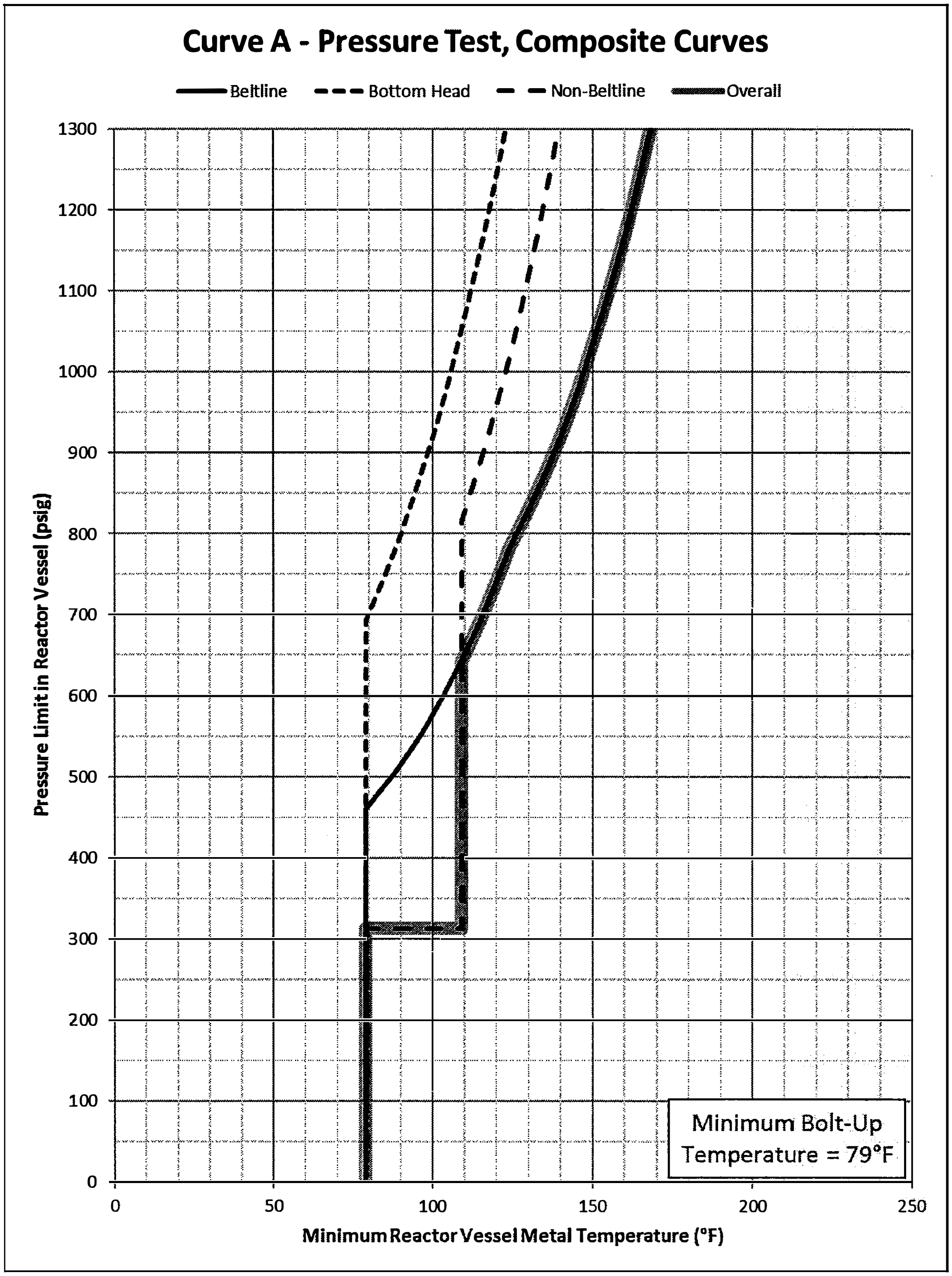


Figure 5: HCGS P-T Curve B (Normal Operation – Core Not Critical) for 44 EFPY

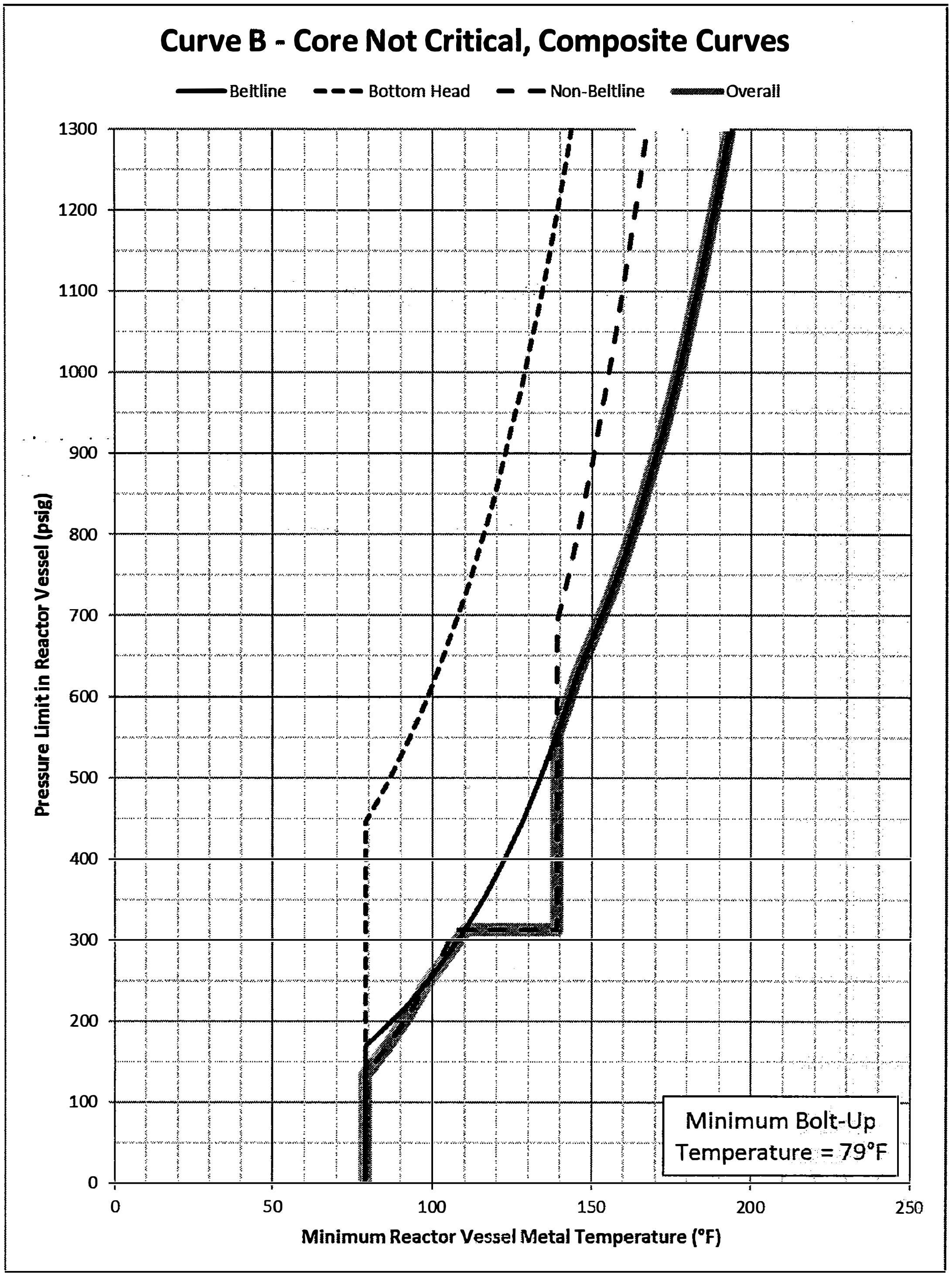


Figure 6: HCGS P-T Curve C (Normal Operation – Core Critical) for 44 EFPY

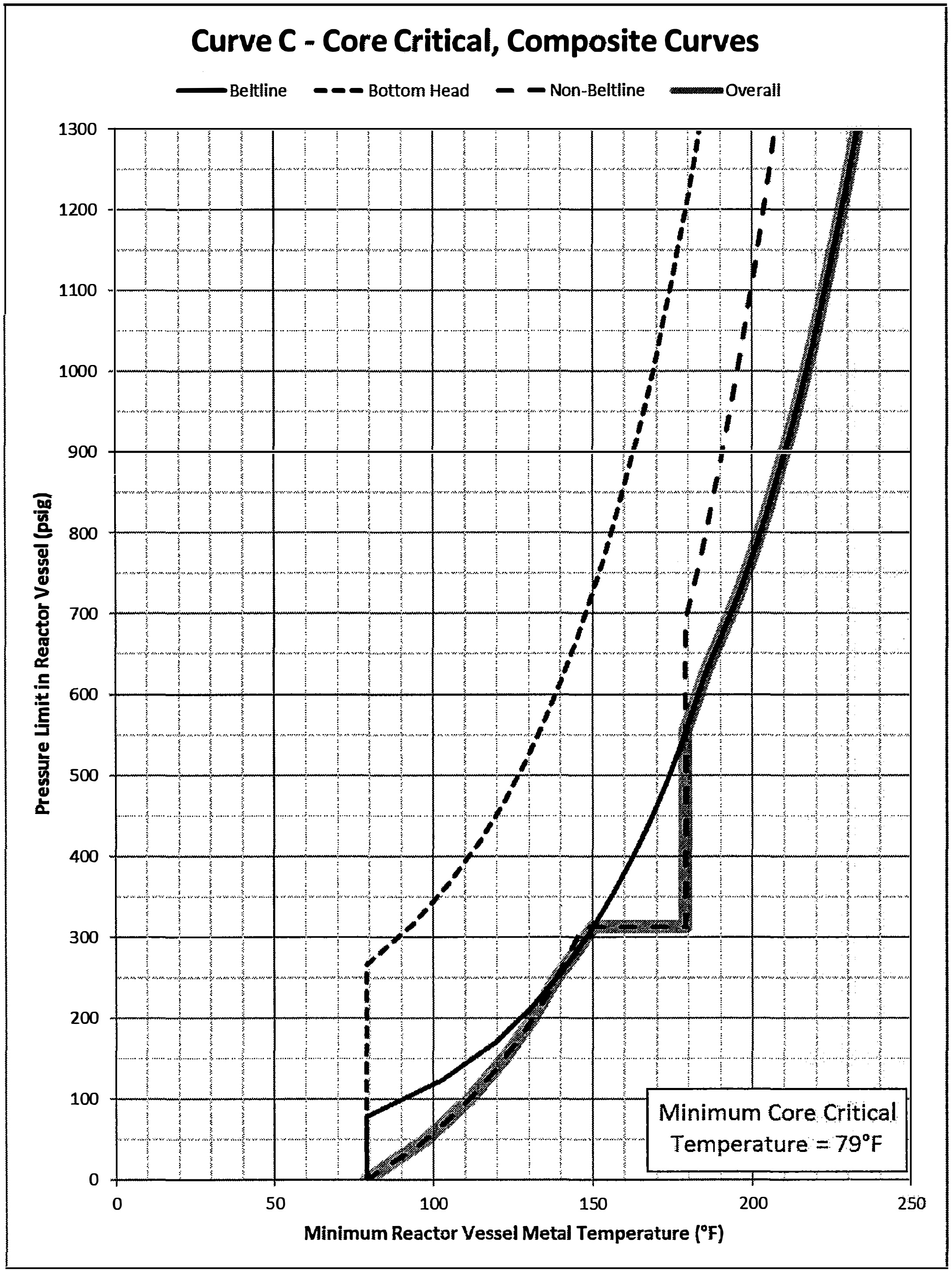


Figure 7: HCGS P-T Curve A (Hydrostatic Pressure and Leak Tests) for 56 EFPY

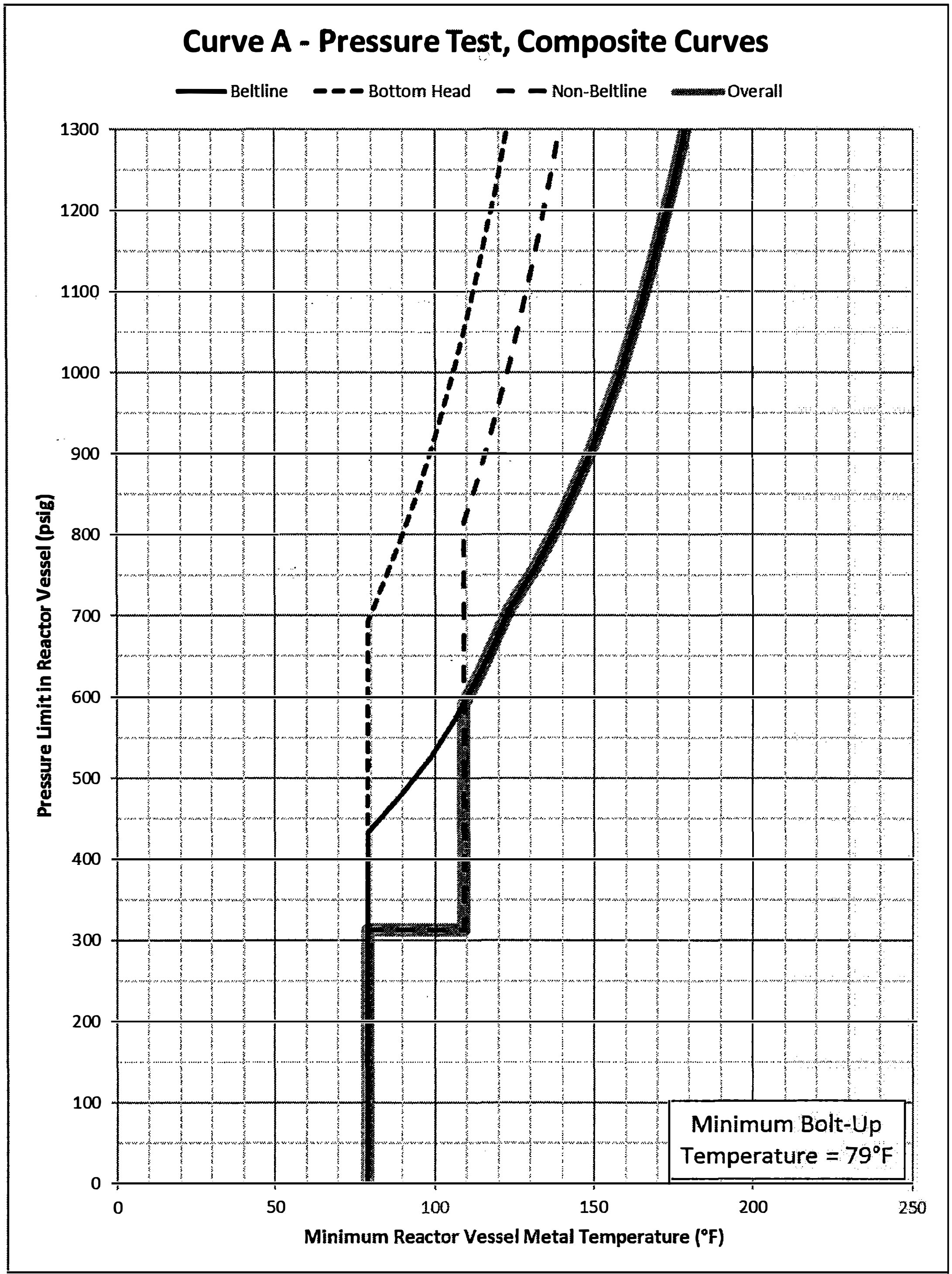


Figure 8: HCGS P-T Curve B (Normal Operation – Core Not Critical) for 56 EFPY

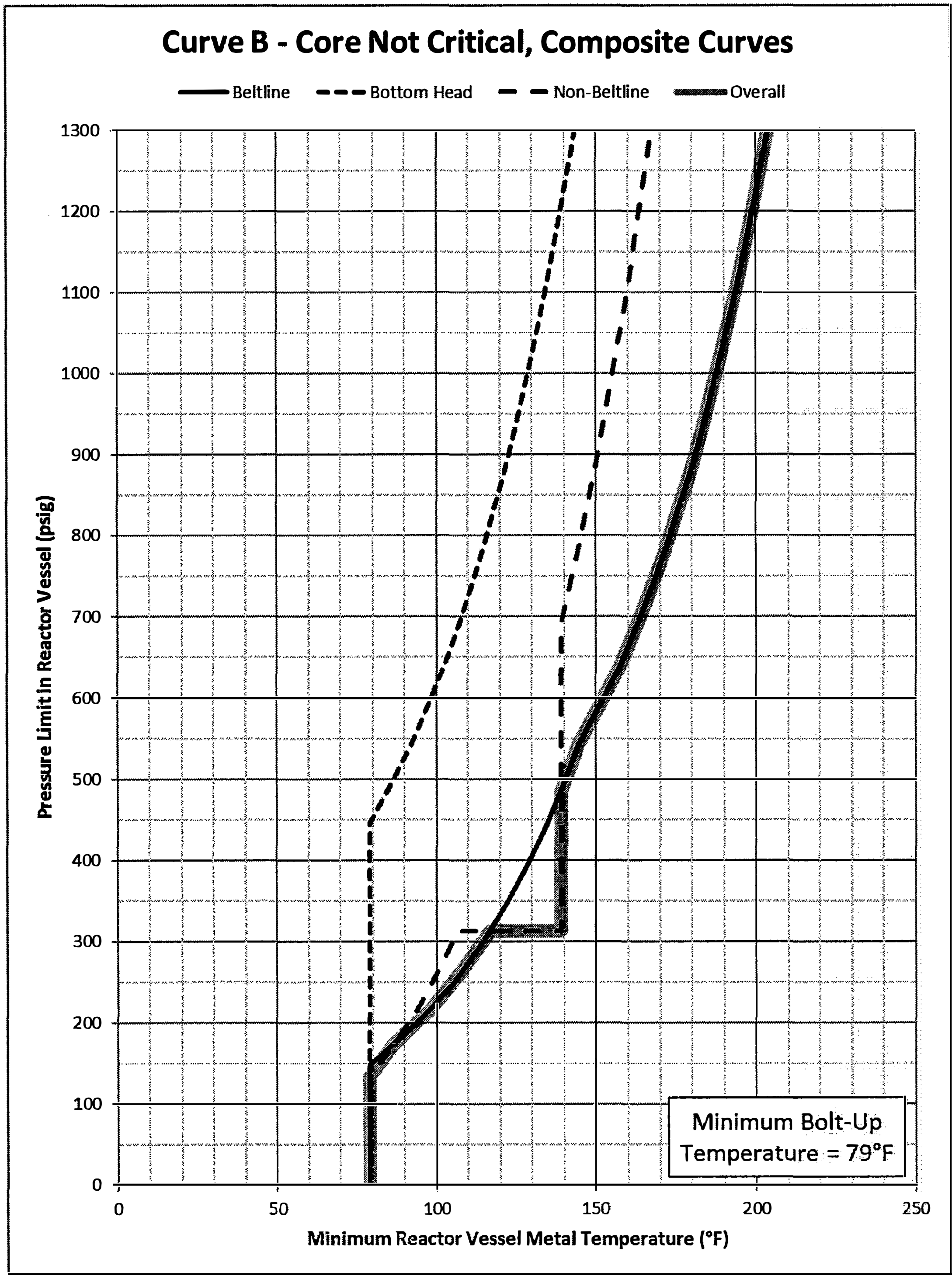


Figure 9: HCGS P-T Curve C (Normal Operation – Core Critical) for 56 EFPY

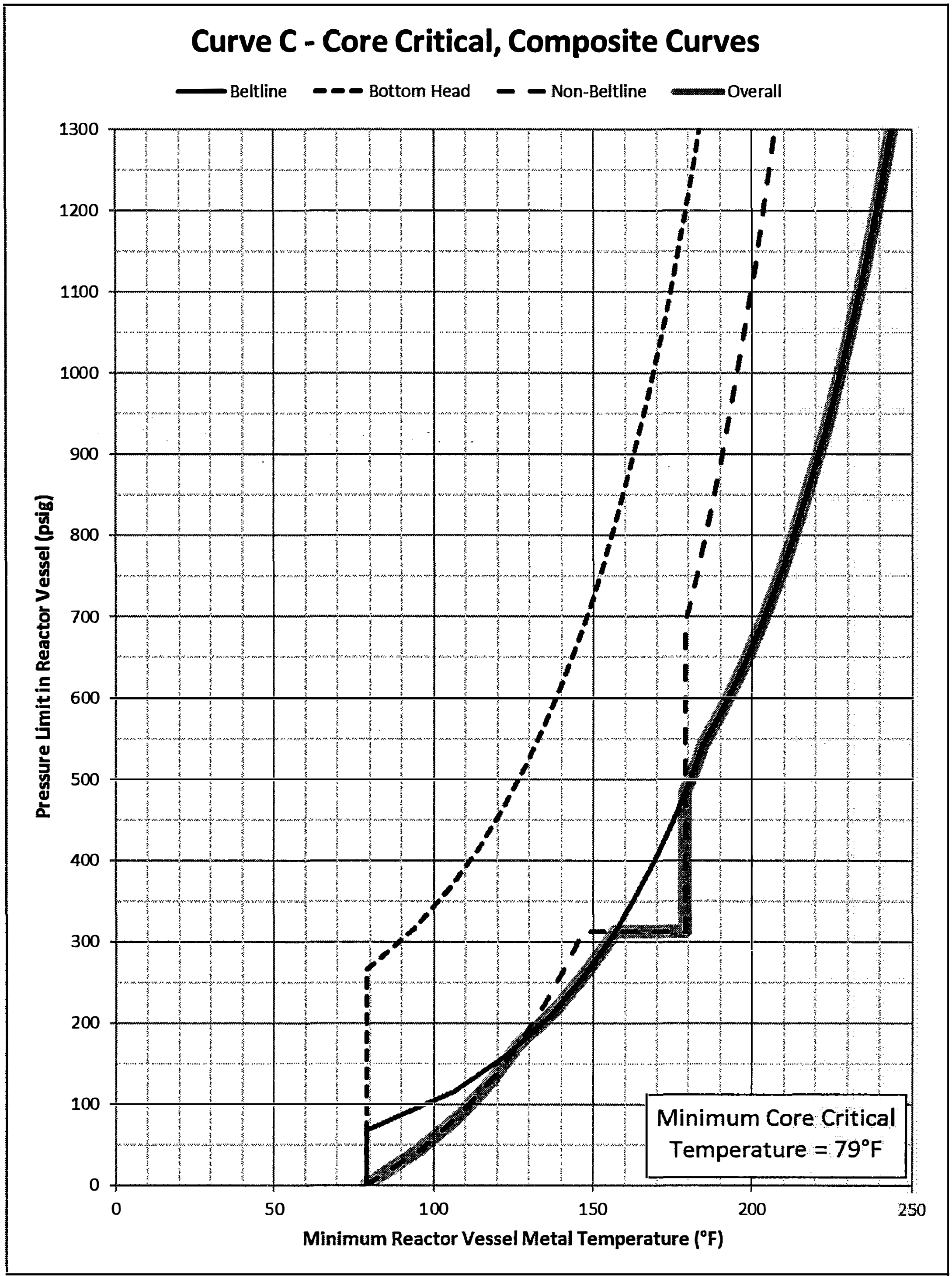


Figure 10: HCGS Feedwater Nozzle 2-D Finite Element Model for Thermal Stress [24]

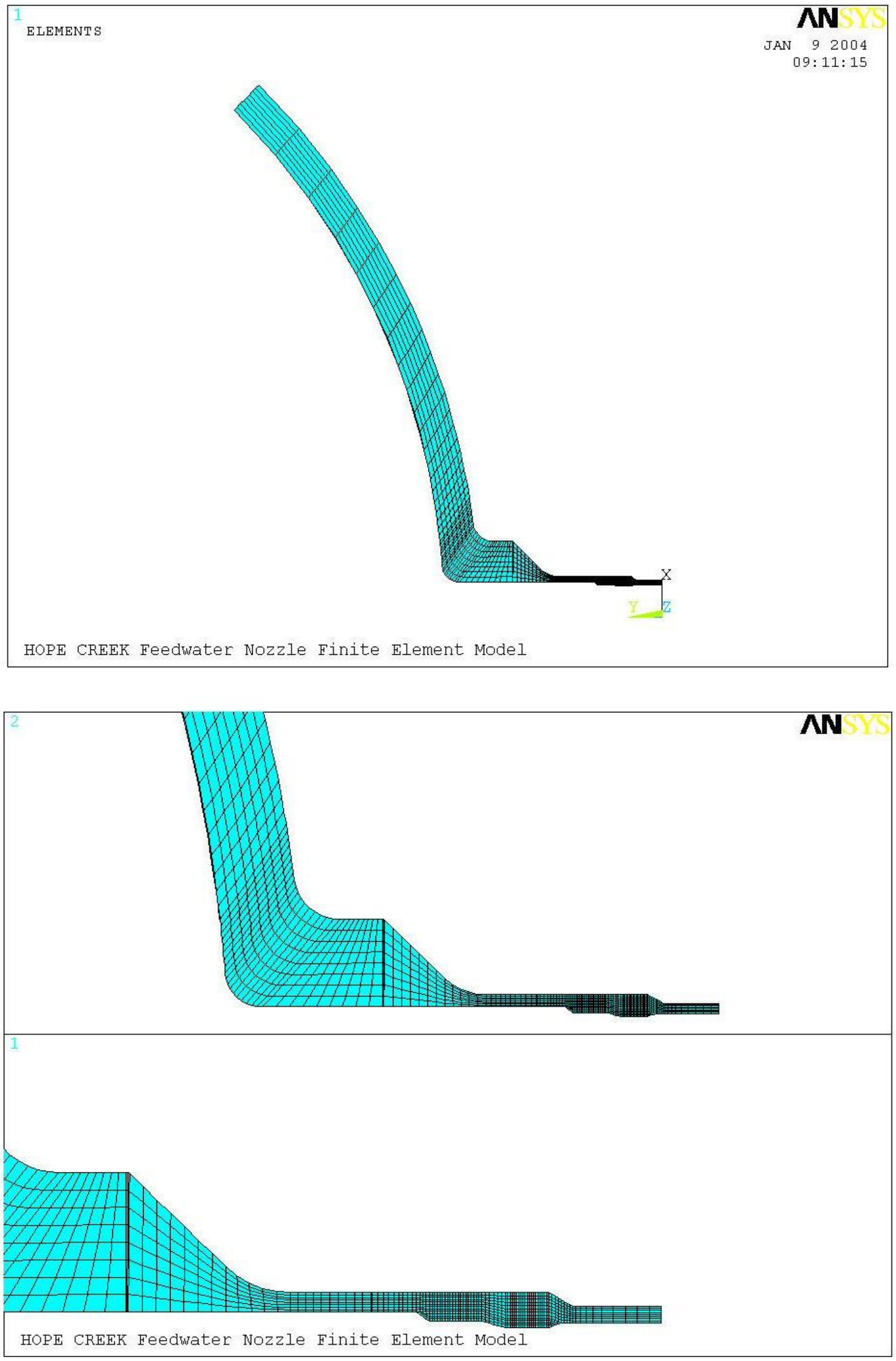


Figure 11: HCGS Feedwater Nozzle 3-D Finite Element Model for Pressure Stress [26]

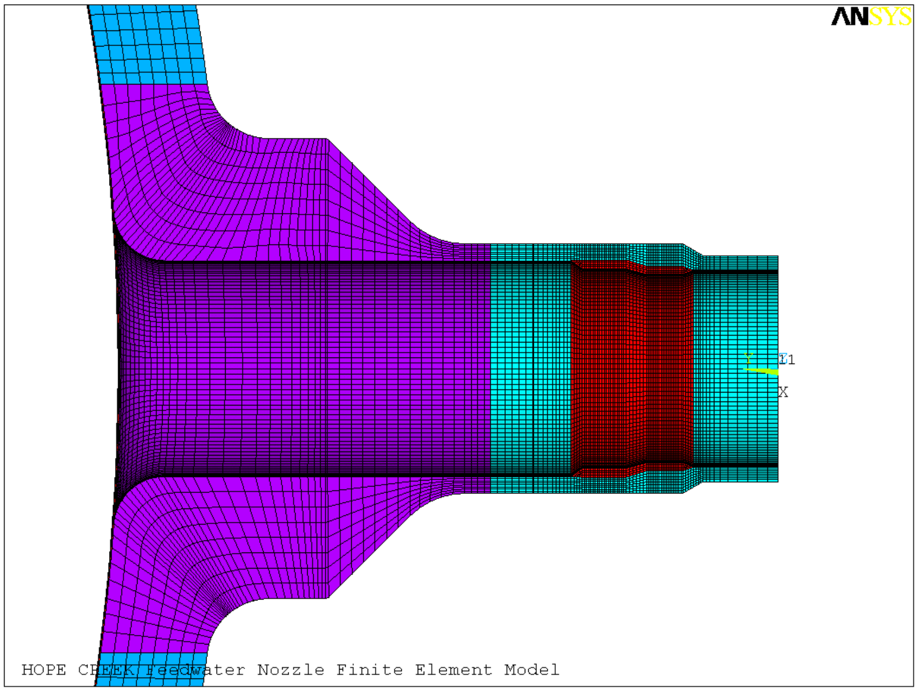
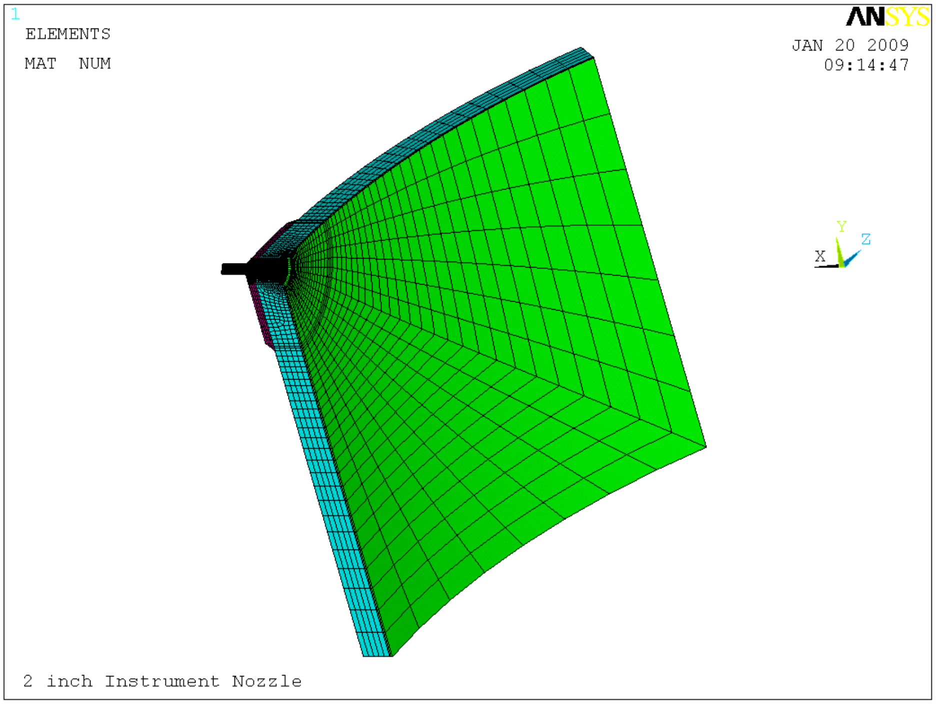


Figure 12: HCGS Instrument Nozzle Finite Element Model [19]



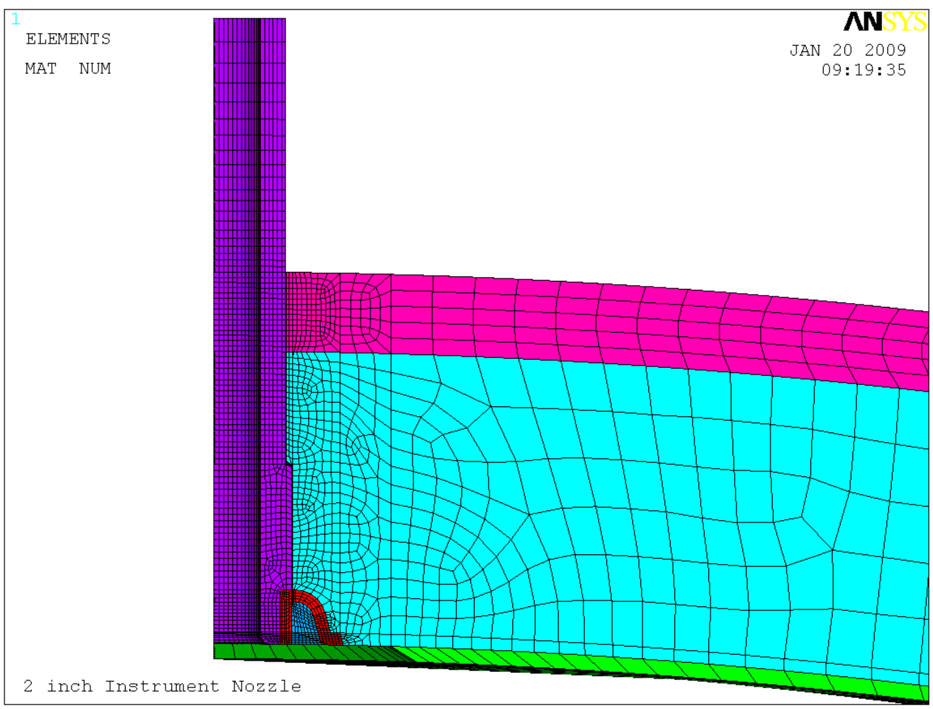


Table 1: HCGS Pressure Test (Curve A) P-T Curves for 32 EFPY

Beltline Region

Curve A - Pressure Test	
P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	497.3
87.1	542.8
94.1	588.4
100.3	633.9
105.7	679.5
110.7	725.0
115.1	770.5
119.2	816.1
123.0	861.6
126.6	907.2
129.9	952.7
134.1	999.6
137.9	1046.6
141.5	1093.5
144.9	1140.5
148.0	1187.4
151.0	1234.4
153.8	1281.3
156.4	1328.3

Table 1: HCGS Pressure Test (Curve A) P-T Curves for 32 EFPY (continued)

<u>Non-Beltline Region</u>

Curve A - Pressure Test

P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	312.6
109.0	312.6
109.0	815.1
113.1	864.9
116.9	914.8
120.4	964.7
123.7	1014.5
126.8	1064.4
129.7	1114.2
132.4	1164.1
135.0	1214.0
137.5	1263.8
139.8	1313.7

Table 1: HCGS Pressure Test (Curve A) P-T Curves for 32 EFPY (continued)

<u>Bottom Head Region</u>

Curve A - Pressure Test

P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	693.7
84.3	742.0
89.1	790.3
93.4	838.6
97.4	886.9
101.1	935.2
104.6	983.5
107.8	1031.8
110.9	1080.1
113.7	1128.4
116.4	1176.6
119.0	1224.9
121.4	1273.2
123.8	1321.5

Table 2: HCGS Core Not Critical (Curve B) P-T Curves for 32 EFPY

Beltline Region

Curve B - Core Not Critical

P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	197.0
90.1	245.1
99.2	293.3
106.9	341.4
113.5	389.5
119.4	437.6
124.7	485.7
129.4	533.8
133.8	581.9
137.8	630.1
141.5	678.2
144.9	726.3
148.1	774.4
151.2	822.5
155.0	871.9
158.6	921.2
161.9	970.6
165.1	1020.0
168.0	1069.3
170.8	1118.7
173.4	1168.1
175.9	1217.4
178.3	1266.8
180.6	1316.2

Table 2: HCGS Core Not Critical (Curve B) P-T Curves for 32 EFPY (continued)

Non-Beltline Region

Curve B - Core Not Critical

P-T Curve Temperature *°F*	P-T Curve Pressure *psi*
79.0	0.0
79.0	133.7
87.5	178.4
94.8	223.2
101.1	267.9
106.8	312.6
139.0	312.6
139.0	692.3
141.9	740.7
144.7	789.0
147.3	837.4
149.8	885.8
152.2	934.2
154.5	982.5
156.7	1030.9
158.7	1079.3
160.7	1127.6
162.7	1176.0
164.5	1224.4
166.3	1272.8
168.0	1321.1

Table 2: HCGS Core Not Critical (Curve B) P-T Curves for 32 EFPY (continued)

Bottom Head Region

Curve B - Core Not Critical

P-T Curve Temperature °F	P-T Curve Pressure psi
79.0	0.0
79.0	445.5
86.0	494.1
92.1	542.7
97.5	591.3
102.4	639.9
106.9	688.4
111.0	737.0
114.8	785.6
118.3	834.2
121.6	882.8
124.7	931.4
127.6	980.0
130.3	1028.6
133.0	1077.1
135.4	1125.7
137.8	1174.3
140.0	1222.9
142.2	1271.5
144.3	1320.1

Table 3: HCGS Core Critical (Curve C) P-T Curves for 32 EFPY

<u>Beltline Region</u>

Curve C - Core Critical

P-T Curve Temperature *°F*	P-T Curve Pressure *psi*
79.0	0.0
79.0	90.6
101.3	139.4
116.7	188.2
128.4	237.0
137.9	285.7
145.9	334.5
152.7	383.3
158.8	432.1
164.2	480.9
169.0	529.7
173.5	578.5
177.6	627.3
181.3	676.1
184.8	724.9
188.1	773.7
191.2	822.5
195.0	871.9
198.6	921.2
201.9	970.6
205.1	1020.0
208.0	1069.3
210.8	1118.7
213.4	1168.1
215.9	1217.4
218.3	1266.8
220.6	1316.2

Table 3: HCGS Core Critical (Curve C) P-T Curves for 32 EFPY (continued)

Non-Beltline Region

Curve C - Core Critical

P-T Curve Temperature *°F*	P-T Curve Pressure *psi*
79.0	0.0
79.0	1.1
96.2	45.6
109.0	90.1
119.2	134.6
127.6	179.1
134.9	223.6
141.2	268.1
146.8	312.6
179.0	312.6
179.0	692.3
181.9	740.7
184.7	789.0
187.3	837.4
189.8	885.8
192.2	934.2
194.5	982.5
196.7	1030.9
198.7	1079.3
200.7	1127.6
202.7	1176.0
204.5	1224.4
206.3	1272.8
208.0	1321.1

Table 3: HCGS Core Critical (Curve C) P-T Curves for 32 EFPY (continued)

Bottom Head Region

Curve C - Core Critical	
P-T Curve Temperature	**P-T Curve Pressure**
°F	*psi*
79.0	0.0
79.0	266.4
93.7	316.3
105.0	366.2
114.2	416.0
122.0	465.9
128.8	515.8
134.7	565.6
140.0	615.5
144.8	665.4
149.2	715.2
153.2	765.1
156.9	815.0
160.4	864.8
163.7	914.7
166.7	964.6
169.6	1014.4
172.3	1064.3
174.9	1114.2
177.3	1164.1
179.6	1213.9
181.9	1263.8
184.0	1313.7

Table 4: HCGS Pressure Test (Curve A) P-T Curves for 44 EFPY

Beltline Region

Curve A - Pressure Test	
P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	460.5
88.5	506.6
96.4	552.8
103.3	598.9
109.4	645.0
114.7	691.2
119.6	737.3
124.0	783.4
130.3	832.2
135.8	880.9
140.8	929.6
145.3	978.3
149.5	1027.1
153.3	1075.8
156.9	1124.5
160.2	1173.2
163.3	1221.9
166.2	1270.7
169.0	1319.4

Table 4: HCGS Pressure Test (Curve A) P-T Curves for 44 EFPY (continued)

Non-Beltline Region

Curve A - Pressure Test

P-T Curve Temperature *°F*	P-T Curve Pressure *psi*
79.0	0.0
79.0	312.6
109.0	312.6
109.0	815.1
113.1	864.9
116.9	914.8
120.4	964.7
123.7	1014.5
126.8	1064.4
129.7	1114.2
132.4	1164.1
135.0	1214.0
137.5	1263.8
139.8	1313.7

Table 4: HCGS Pressure Test (Curve A) P-T Curves for 44 EFPY (continued)

Bottom Head Region

Curve A - Pressure Test	
P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	693.7
84.3	742.0
89.1	790.3
93.4	838.6
97.4	886.9
101.1	935.2
104.6	983.5
107.8	1031.8
110.9	1080.1
113.7	1128.4
116.4	1176.6
119.0	1224.9
121.4	1273.2
123.8	1321.5

Table 5: HCGS Core Not Critical (Curve B) P-T Curves for 44 EFPY

Beltline Region

Curve B - Core Not Critical

P-T Curve Temperature *°F*	P-T Curve Pressure *psi*
79.0	0.0
79.0	169.4
91.2	215.3
101.0	261.2
109.2	307.1
116.3	352.9
122.4	398.8
127.9	444.7
132.9	490.6
137.4	536.4
141.5	582.3
145.3	628.2
150.8	677.4
155.8	726.6
160.3	775.8
164.5	825.0
168.3	874.2
171.9	923.4
175.2	972.6
178.3	1021.8
181.2	1071.0
184.0	1120.2
186.6	1169.4
189.1	1218.6
191.5	1267.8
193.7	1317.0

Table 5: HCGS Core Not Critical (Curve B) P-T Curves for 44 EFPY (continued)

Non-Beltline Region

Curve B - Core Not Critical

P-T Curve Temperature *°F*	P-T Curve Pressure *psi*
79.0	0.0
79.0	133.7
87.5	178.4
94.8	223.2
101.1	267.9
106.8	312.6
139.0	312.6
139.0	692.3
141.9	740.7
144.7	789.0
147.3	837.4
149.8	885.8
152.2	934.2
154.5	982.5
156.7	1030.9
158.7	1079.3
160.7	1127.6
162.7	1176.0
164.5	1224.4
166.3	1272.8
168.0	1321.1

Table 5: HCGS Core Not Critical (Curve B) P-T Curves for 44 EFPY (continued)

<u>Bottom Head Region</u>

Curve B - Core Not Critical

P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	445.5
86.0	494.1
92.1	542.7
97.5	591.3
102.4	639.9
106.9	688.4
111.0	737.0
114.8	785.6
118.3	834.2
121.6	882.8
124.7	931.4
127.6	980.0
130.3	1028.6
133.0	1077.1
135.4	1125.7
137.8	1174.3
140.0	1222.9
142.2	1271.5
144.3	1320.1

Table 6: HCGS Core Critical (Curve C) P-T Curves for 44 EFPY

Beltline Region

Curve C - Core Critical

P-T Curve Temperature *°F*	P-T Curve Pressure *psi*
79.0	0.0
79.0	78.2
103.0	124.0
119.1	169.8
131.3	215.7
141.1	261.5
149.3	307.3
156.3	353.2
162.5	399.0
167.9	444.8
172.9	490.7
177.4	536.5
181.5	582.3
185.3	628.2
190.8	677.4
195.8	726.6
200.3	775.8
204.5	825.0
208.3	874.2
211.9	923.4
215.2	972.6
218.3	1021.8
221.2	1071.0
224.0	1120.2
226.6	1169.4
229.1	1218.6
231.5	1267.8
233.7	1317.0

Table 6: HCGS Core Critical (Curve C) P-T Curves for 44 EFPY (continued)

<u>Non-Beltline Region</u>

Curve C - Core Critical

P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	1.1
96.2	45.6
109.0	90.1
119.2	134.6
127.6	179.1
134.9	223.6
141.2	268.1
146.8	312.6
179.0	312.6
179.0	692.3
181.9	740.7
184.7	789.0
187.3	837.4
189.8	885.8
192.2	934.2
194.5	982.5
196.7	1030.9
198.7	1079.3
200.7	1127.6
202.7	1176.0
204.5	1224.4
206.3	1272.8
208.0	1321.1

Table 6: HCGS Core Critical (Curve C) P-T Curves for 44 EFPY (continued)

Bottom Head Region

Curve C - Core Critical

P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	266.4
93.7	316.3
105.0	366.2
114.2	416.0
122.0	465.9
128.8	515.8
134.7	565.6
140.0	615.5
144.8	665.4
149.2	715.2
153.2	765.1
156.9	815.0
160.4	864.8
163.7	914.7
166.7	964.6
169.6	1014.4
172.3	1064.3
174.9	1114.2
177.3	1164.1
179.6	1213.9
181.9	1263.8
184.0	1313.7

Table 7: HCGS Pressure Test (Curve A) P-T Curves for 56 EFPY

Beltline Region

Curve A - Pressure Test

P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	432.8
89.7	478.7
98.4	524.7
105.9	570.6
112.4	616.5
118.2	662.5
123.3	708.4
130.8	755.9
137.4	803.4
143.2	850.8
148.3	898.3
153.0	945.8
157.3	993.3
161.3	1040.8
164.9	1088.2
168.4	1135.7
171.5	1183.2
174.5	1230.7
177.4	1278.1
180.1	1325.6

Table 7: HCGS Pressure Test (Curve A) P-T Curves for 56 EFPY (continued)

Non-Beltline Region

Curve A - Pressure Test

P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	312.6
109.0	312.6
109.0	815.1
113.1	864.9
116.9	914.8
120.4	964.7
123.7	1014.5
126.8	1064.4
129.7	1114.2
132.4	1164.1
135.0	1214.0
137.5	1263.8
139.8	1313.7

Table 7: HCGS Pressure Test (Curve A) P-T Curves for 56 EFPY (continued)

<u>Bottom Head Region</u>

Curve A - Pressure Test

P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	693.7
84.3	742.0
89.1	790.3
93.4	838.6
97.4	886.9
101.1	935.2
104.6	983.5
107.8	1031.8
110.9	1080.1
113.7	1128.4
116.4	1176.6
119.0	1224.9
121.4	1273.2
123.8	1321.5

Table 8: HCGS Core Not Critical (Curve B) P-T Curves for 56 EFPY

Beltline Region

Curve B - Core Not Critical

P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	148.6
93.6	197.8
104.9	247.0
114.1	296.2
121.9	345.3
128.6	394.5
134.5	443.7
139.8	492.9
144.6	542.0
151.4	590.7
157.3	639.3
162.6	687.9
167.5	736.5
171.8	785.1
175.9	833.7
179.6	882.4
183.1	931.0
186.3	979.6
189.4	1028.2
192.2	1076.8
195.0	1125.4
197.5	1174.1
200.0	1222.7
202.3	1271.3
204.6	1319.9

Table 8: HCGS Core Not Critical (Curve B) P-T Curves for 56 EFPY (continued)

Non-Beltline Region

Curve B - Core Not Critical	
P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	133.7
87.5	178.4
94.8	223.2
101.1	267.9
106.8	312.6
139.0	312.6
139.0	692.3
141.9	740.7
144.7	789.0
147.3	837.4
149.8	885.8
152.2	934.2
154.5	982.5
156.7	1030.9
158.7	1079.3
160.7	1127.6
162.7	1176.0
164.5	1224.4
166.3	1272.8
168.0	1321.1

Table 8: HCGS Core Not Critical (Curve B) P-T Curves for 56 EFPY (continued)

Bottom Head Region

Curve B - Core Not Critical

P-T Curve Temperature *°F*	P-T Curve Pressure *psi*
79.0	0.0
79.0	445.5
86.0	494.1
92.1	542.7
97.5	591.3
102.4	639.9
106.9	688.4
111.0	737.0
114.8	785.6
118.3	834.2
121.6	882.8
124.7	931.4
127.6	980.0
130.3	1028.6
133.0	1077.1
135.4	1125.7
137.8	1174.3
140.0	1222.9
142.2	1271.5
144.3	1320.1

Table 9: HCGS Core Critical (Curve C) P-T Curves for 56 EFPY

Beltline Region

Curve C - Core Critical

P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	68.8
106.3	116.1
123.9	163.5
136.8	210.8
147.1	258.1
155.7	305.4
162.9	352.8
169.3	400.1
174.9	447.4
180.0	494.7
184.6	542.0
191.4	590.7
197.3	639.3
202.6	687.9
207.5	736.5
211.8	785.1
215.9	833.7
219.6	882.4
223.1	931.0
226.3	979.6
229.4	1028.2
232.2	1076.8
235.0	1125.4
237.5	1174.1
240.0	1222.7
242.3	1271.3
244.6	1319.9

Table 9: HCGS Core Critical (Curve C) P-T Curves for 56 EFPY (continued)

Non-Beltline Region

Curve C - Core Critical

P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	1.1
96.2	45.6
109.0	90.1
119.2	134.6
127.6	179.1
134.9	223.6
141.2	268.1
146.8	312.6
179.0	312.6
179.0	692.3
181.9	740.7
184.7	789.0
187.3	837.4
189.8	885.8
192.2	934.2
194.5	982.5
196.7	1030.9
198.7	1079.3
200.7	1127.6
202.7	1176.0
204.5	1224.4
206.3	1272.8
208.0	1321.1

Table 9: HCGS Core Critical (Curve C) P-T Curves for 56 EFPY (continued)

Bottom Head Region

Curve C - Core Critical

P-T Curve Temperature *°F*	**P-T Curve Pressure** *psi*
79.0	0.0
79.0	266.4
93.7	316.3
105.0	366.2
114.2	416.0
122.0	465.9
128.8	515.8
134.7	565.6
140.0	615.5
144.8	665.4
149.2	715.2
153.2	765.1
156.9	815.0
160.4	864.8
163.7	914.7
166.7	964.6
169.6	1014.4
172.3	1064.3
174.9	1114.2
177.3	1164.1
179.6	1213.9
181.9	1263.8
184.0	1313.7

Table 10: HCGS ART Calculations for 32 EFPY

	Description	Heat/Lot No.	Flux Type	Initial RT_{NDT} (°F)	Chemistry (wt%)		Chemistry Factor, CF (°F)	Fluence at ID (n/cm^2)	Fluence at 1/4T (n/cm^2)	Fluence Factor, FF	Adjustments For 1/4T			
											ΔRT_{NDT} (°F)	Margin Terms		ART (°F)
					Cu	Ni						σ_Δ (°F)	σ_i (°F)	
Plates	Intermediate Shell (3)	5K3025/1	-	19	0.15	0.71	112.8	3.15E+17	2.23E+17	0.184	20.8	10.4	0.0	60.5
	Intermediate Shell (3)	5K2608/1	-	19	0.09	0.58	58.0	3.15E+17	2.23E+17	0.184	10.7	5.3	0.0	40.4
	Intermediate Shell (3)	5K2698/1	-	19	0.10	0.58	65.0	3.15E+17	2.23E+17	0.184	12.0	6.0	0.0	42.9
	Lower Intermediate Shell (4)	5K2963/1	-	-10	0.07	0.58	44.0	8.86E+17	6.15E+17	0.327	14.4	7.2	0.0	18.8
	Lower Intermediate Shell (4)	5K2530/1	-	19	0.08	0.56	51.0	8.86E+17	6.15E+17	0.327	16.7	8.3	0.0	52.3
	Lower Intermediate Shell (4)	5K3238/1	-	7	0.09	0.64	58.0	8.86E+17	6.15E+17	0.327	19.0	9.5	0.0	44.9
	Lower Shell (5)	5K3230/1	-	-10	0.07	0.56	44.0	6.08E+17	4.24E+17	0.267	11.8	5.9	0.0	13.5
	Lower Shell (5)	6C35/1	-	-11	0.09	0.54	58.0	6.08E+17	4.24E+17	0.267	15.5	7.8	0.0	20.0
	Lower Shell (5)	6C45/1	-	1	0.08	0.57	51.0	6.08E+17	4.24E+17	0.267	13.6	6.8	0.0	28.3
Welds	Vertical W13	510-01205	SMAW	-40	0.09	0.54	108.7	3.11E+17	2.20E+17	0.182	19.8	9.9	0.0	-0.4
	Vertical W13	D53040/1125-02205	SAW	-30	0.08	0.63	110.1	3.11E+17	2.20E+17	0.182	20.1	10.0	0.0	10.1
	Vertical W14	510-01205	SMAW	-40	0.09	0.54	108.7	7.75E+17	5.43E+17	0.306	33.3	16.6	0.0	26.5
	Vertical W14	D53040/1125-02205	SAW	-30	0.08	0.63	110.1	7.75E+17	5.43E+17	0.306	33.7	16.8	0.0	37.4
	Vertical W15	510-01205	SMAW	-40	0.09	0.54	108.7	5.29E+17	3.69E+17	0.247	26.9	13.5	0.0	13.8
	Vertical W15	D53040/1125-02205	SAW	-30	0.08	0.63	110.1	5.29E+17	3.69E+17	0.247	27.3	13.6	0.0	24.5
	Girth W6 (Shell 3-4)	519-01205	SMAW	-49	0.01	0.53	20.0	3.15E+17	2.23E+17	0.184	3.7	1.8	0.0	-41.6
	Girth W6 (Shell 3-4)	504-01205	SMAW	-31	0.01	0.51	20.0	3.15E+17	2.23E+17	0.184	3.7	1.8	0.0	-23.6
	Girth W6 (Shell 3-4)	510-01205	SMAW	-40	0.09	0.54	108.7	3.15E+17	2.23E+17	0.184	20.0	10.0	0.0	0.0
	Girth W6 (Shell 3-4)	D53040/1810-02205	SAW	-49	0.08	0.63	110.1	3.15E+17	2.23E+17	0.184	20.3	10.1	0.0	-8.5
	Girth W6 (Shell 3-4)	D55733/1810-02205	SAW	-40	0.10	0.68	126.4	3.15E+17	2.23E+17	0.184	23.3	11.6	0.0	6.5
	Girth W7 (Shell 4-5)	510-01205	SMAW	-40	0.09	0.54	108.7	6.08E+17	4.24E+17	0.267	29.1	14.5	0.0	18.1
	Girth W7 (Shell 4-5)	D53040/1125-02205	SAW	-30	0.08	0.63	110.1	6.08E+17	4.24E+17	0.267	29.5	14.7	0.0	28.9
Nozzles	LPCI (N17; A-D)	19468/1	-	-20	0.12	0.80	86.0	9.80E+16	8.04E+16	0.094	8.1	4.1	0.0	-3.8
	LPCI (N17; A-D)	10024/1	-	-20	0.14	0.82	105.1	9.80E+16	8.04E+16	0.094	9.9	5.0	0.0	-0.2
	Instrument (N16; A, D)	5K3025/1 (adj. plate)	-	19	0.15	0.71	112.8	1.90E+17	1.59E+17	0.149	16.8	8.4	0.0	52.6
	Instrument (N16; B, C)	5K2698/1 (adj. plate)	-	19	0.10	0.58	65.0	1.90E+17	1.59E+17	0.149	9.7	4.8	0.0	38.4
Nozzle Welds	LPCI Nozzle W179	001-01205	SMAW	-40	0.02	0.51	27.0	2.77E+17	2.09E+17	0.177	4.8	2.4	0.0	-30.5
	LPCI Nozzle W179	519-01205	SMAW	-49	0.01	0.53	20.0	2.77E+17	2.09E+17	0.177	3.5	1.8	0.0	-41.9
	LPCI Nozzle W179	504-01205	SMAW	-31	0.01	0.51	20.0	2.77E+17	2.09E+17	0.177	3.5	1.8	0.0	-23.9
ISP	Surveillance Plate	5K3238/1	-	7	0.09	0.64	{{ }}	8.86E+17	6.15E+17	0.327	16.1	8.0	0.0	39.1
	Surveillance Weld	**D53040**	**SAW**	**-30**	**0.07**	**0.57**	**{{ }}**	**7.75E+17**	**5.43E+17**	**0.306**	**64.5**	**28.0**	**0.0**	**90.5**

REDACTED EPRI PROPRIETARY INFORMATION [16]

(such information is marked with double braces "{{ }}" and a bar in the right-hand margin)

Table 11: HCGS ART Calculations for 44 EFPY

	Description	Heat/Lot No.	Flux Type	Initial RT_{NDT} (°F)	Chemistry (wt%) Cu	Chemistry (wt%) Ni	Chemistry Factor, CF (°F)	Fluence at ID (n/cm^2)	Fluence at 1/4T (n/cm^2)	Fluence Factor, FF	Adjustments For 1/4T: ΔRT_{NDT} (°F)	Margin Terms σ_Δ (°F)	Margin Terms σ_i (°F)	ART (°F)
Plates	Intermediate Shell (3)	5K3025/1	-	19	0.15	0.71	112.8	4.38E+17	3.10E+17	0.224	25.2	12.6	0.0	69.5
	Intermediate Shell (3)	5K2608/1	-	19	0.09	0.58	58.0	4.38E+17	3.10E+17	0.224	13.0	6.5	0.0	45.0
	Intermediate Shell (3)	5K2698/1	-	19	0.10	0.58	65.0	4.38E+17	3.10E+17	0.224	14.6	7.3	0.0	48.1
	Lower Intermediate Shell (4)	5K2963/1	-	-10	0.07	0.58	44.0	1.27E+18	8.83E+17	0.392	17.3	8.6	0.0	24.5
	Lower Intermediate Shell (4)	5K2530/1	-	19	0.08	0.56	51.0	1.27E+18	8.83E+17	0.392	20.0	10.0	0.0	59.0
	Lower Intermediate Shell (4)	5K3238/1	-	7	0.09	0.64	58.0	1.27E+18	8.83E+17	0.392	22.8	11.4	0.0	52.5
	Lower Shell (5)	5K3230/1	-	-10	0.07	0.56	44.0	8.84E+17	6.17E+17	0.327	14.4	7.2	0.0	18.8
	Lower Shell (5)	6C35/1	-	-11	0.09	0.54	58.0	8.84E+17	6.17E+17	0.327	19.0	9.5	0.0	27.0
	Lower Shell (5)	6C45/1	-	1	0.08	0.57	51.0	8.84E+17	6.17E+17	0.327	16.7	8.3	0.0	34.4
Welds	Vertical W13	510-01205	SMAW	-40	0.09	0.54	108.7	4.33E+17	3.06E+17	0.222	24.1	12.1	0.0	8.3
	Vertical W13	D53040/1125-02205	SAW	-30	0.08	0.63	110.1	4.33E+17	3.06E+17	0.222	24.5	12.2	0.0	18.9
	Vertical W14	510-01205	SMAW	-40	0.09	0.54	108.7	1.11E+18	7.76E+17	0.368	40.0	20.0	0.0	40.0
	Vertical W14	D53040/1125-02205	SAW	-30	0.08	0.63	110.1	1.11E+18	7.76E+17	0.368	40.5	20.3	0.0	51.1
	Vertical W15	510-01205	SMAW	-40	0.09	0.54	108.7	7.70E+17	5.37E+17	0.304	33.0	16.5	0.0	26.1
	Vertical W15	D53040/1125-02205	SAW	-30	0.08	0.63	110.1	7.70E+17	5.37E+17	0.304	33.5	16.7	0.0	37.0
	Girth W6 (Shell 3-4)	519-01205	SMAW	-49	0.01	0.53	20.0	4.38E+17	3.10E+17	0.224	4.5	2.2	0.0	-40.0
	Girth W6 (Shell 3-4)	504-01205	SMAW	-31	0.01	0.51	20.0	4.38E+17	3.10E+17	0.224	4.5	2.2	0.0	-22.0
	Girth W6 (Shell 3-4)	510-01205	SMAW	-40	0.09	0.54	108.7	4.38E+17	3.10E+17	0.224	24.3	12.2	0.0	8.7
	Girth W6 (Shell 3-4)	D53040/1810-02205	SAW	-49	0.08	0.63	110.1	4.38E+17	3.10E+17	0.224	24.7	12.3	0.0	0.3
	Girth W6 (Shell 3-4)	D55733/1810-02205	SAW	-40	0.10	0.68	126.4	4.38E+17	3.10E+17	0.224	28.3	14.2	0.0	16.6
	Girth W7 (Shell 4-5)	510-01205	SMAW	-40	0.09	0.54	108.7	8.84E+17	6.17E+17	0.327	35.6	17.8	0.0	31.2
	Girth W7 (Shell 4-5)	D53040/1125-02205	SAW	-30	0.08	0.63	110.1	8.84E+17	6.17E+17	0.327	36.0	18.0	0.0	42.1
Nozzles	LPCI (N17; A-D)	19468/1	-	-20	0.12	0.80	86.0	1.35E+17	1.10E+17	0.117	10.1	5.0	0.0	0.1
	LPCI (N17; A-D)	10024/1	-	-20	0.14	0.82	105.1	1.35E+17	1.10E+17	0.117	12.3	6.2	0.0	4.6
	Instrument (N16; A, D)	5K3025/1 (adj. plate)	-	19	0.15	0.71	112.8	2.63E+17	2.22E+17	0.183	20.7	10.3	0.0	60.3
	Instrument (N16; B, C)	5K2698/1 (adj. plate)	-	19	0.10	0.58	65.0	2.63E+17	2.22E+17	0.183	11.9	6.0	0.0	42.8
Nozzle Welds	LPCI Nozzle W179	001-01205	SMAW	-40	0.02	0.51	27.0	3.81E+17	2.87E+17	0.214	5.8	2.9	0.0	-28.5
	LPCI Nozzle W179	519-01205	SMAW	-49	0.01	0.53	20.0	3.81E+17	2.87E+17	0.214	4.3	2.1	0.0	-40.4
	LPCI Nozzle W179	504-01205	SMAW	-31	0.01	0.51	20.0	3.81E+17	2.87E+17	0.214	4.3	2.1	0.0	-22.4
ISP	Surveillance Plate	5K3238/1	-	7	0.09	0.64	{{ }}	1.27E+18	8.83E+17	0.392	19.3	8.5	0.0	43.3
	Surveillance Weld	**D53040**	**SAW**	**-30**	**0.07**	**0.57**	**{{ }}**	**1.11E+18**	**7.76E+17**	**0.368**	**77.6**	**28.0**	**0.0**	**103.6**

REDACTED EPRI PROPRIETARY INFORMATION [16]

(such information is marked with double braces "{{ }}" and a bar in the right-hand margin)

Table 12: HCGS ART Calculations for 56 EFPY

	Description	Heat/Lot No.	Flux Type	Initial RT_{NDT} (°F)	Chemistry (wt%)		Chemistry Factor, CF (°F)	Fluence at ID (n/cm^2)	Fluence at 1/4T (n/cm^2)	Fluence Factor, FF	Adjustments For 1/4T			
					Cu	Ni					ΔRT_{NDT} (°F)	Margin Terms σ_Δ (°F)	Margin Terms σ_i (°F)	ART (°F)
Plates	Intermediate Shell (3)	5K3025/1	-	19	0.15	0.71	112.8	5.60E+17	3.97E+17	0.258	29.1	14.5	0.0	77.1
	Intermediate Shell (3)	5K2608/1	-	19	0.09	0.58	58.0	5.60E+17	3.97E+17	0.258	15.0	7.5	0.0	48.9
	Intermediate Shell (3)	5K2698/1	-	19	0.10	0.58	65.0	5.60E+17	3.97E+17	0.258	16.8	8.4	0.0	52.5
	Lower Intermediate Shell (4)	5K2963/1	-	-10	0.07	0.58	44.0	1.65E+18	1.15E+18	0.445	19.6	9.8	0.0	29.2
	Lower Intermediate Shell (4)	5K2530/1	-	19	0.08	0.56	51.0	1.65E+18	1.15E+18	0.445	22.7	11.4	0.0	64.4
	Lower Intermediate Shell (4)	5K3238/1	-	7	0.09	0.64	58.0	1.65E+18	1.15E+18	0.445	25.8	12.9	0.0	58.7
	Lower Shell (5)	5K3230/1	-	-10	0.07	0.56	44.0	1.16E+18	8.10E+17	0.376	16.5	8.3	0.0	23.1
	Lower Shell (5)	6C35/1	-	-11	0.09	0.54	58.0	1.16E+18	8.10E+17	0.376	21.8	10.9	0.0	32.6
	Lower Shell (5)	6C45/1	-	1	0.08	0.57	51.0	1.16E+18	8.10E+17	0.376	19.2	9.6	0.0	39.4
Welds	Vertical W13	510-01205	SMAW	-40	0.09	0.54	108.7	5.55E+17	3.92E+17	0.256	27.8	13.9	0.0	15.7
	Vertical W13	D53040/1125-02205	SAW	-30	0.08	0.63	110.1	5.55E+17	3.92E+17	0.256	28.2	14.1	0.0	26.4
	Vertical W14	510-01205	SMAW	-40	0.09	0.54	108.7	1.44E+18	1.01E+18	0.419	45.5	22.8	0.0	51.1
	Vertical W14	D53040/1125-02205	SAW	-30	0.08	0.63	110.1	1.44E+18	1.01E+18	0.419	46.1	23.1	0.0	62.3
	Vertical W15	510-01205	SMAW	-40	0.09	0.54	108.7	1.01E+18	7.04E+17	0.350	38.1	19.0	0.0	36.2
	Vertical W15	D53040/1125-02205	SAW	-30	0.08	0.63	110.1	1.01E+18	7.04E+17	0.350	38.6	19.3	0.0	47.2
	Girth W6 (Shell 3-4)	519-01205	SMAW	-49	0.01	0.53	20.0	5.60E+17	3.97E+17	0.258	5.2	2.6	0.0	-38.7
	Girth W6 (Shell 3-4)	504-01205	SMAW	-31	0.01	0.51	20.0	5.60E+17	3.97E+17	0.258	5.2	2.6	0.0	-20.7
	Girth W6 (Shell 3-4)	510-01205	SMAW	-40	0.09	0.54	108.7	5.60E+17	3.97E+17	0.258	28.0	14.0	0.0	16.1
	Girth W6 (Shell 3-4)	D53040/1810-02205	SAW	-49	0.08	0.63	110.1	5.60E+17	3.97E+17	0.258	28.4	14.2	0.0	7.8
	Girth W6 (Shell 3-4)	D55733/1810-02205	SAW	-40	0.10	0.68	126.4	5.60E+17	3.97E+17	0.258	32.6	16.3	0.0	25.2
	Girth W7 (Shell 4-5)	510-01205	SMAW	-40	0.09	0.54	108.7	1.16E+18	8.10E+17	0.376	40.9	20.4	0.0	41.8
	Girth W7 (Shell 4-5)	D53040/1125-02205	SAW	-30	0.08	0.63	110.1	1.16E+18	8.10E+17	0.376	41.4	20.7	0.0	52.8
Nozzles	LPCI (N17; A-D)	19468/1	-	-20	0.12	0.80	86.0	1.71E+17	1.40E+17	0.137	11.8	5.9	0.0	3.6
	LPCI (N17; A-D)	10024/1	-	-20	0.14	0.82	105.1	1.71E+17	1.40E+17	0.137	14.4	7.2	0.0	8.8
	Instrument (N16; A, D)	5K3025/1 (adj. plate)	-	19	0.15	0.71	112.8	3.37E+17	2.84E+17	0.213	24.0	12.0	0.0	67.0
	Instrument (N16; B, C)	5K2698/1 (adj. plate)	-	19	0.10	0.58	65.0	3.37E+17	2.84E+17	0.213	13.8	6.9	0.0	46.6
Nozzle Welds	LPCI Nozzle W179	001-01205	SMAW	-40	0.02	0.51	27.0	4.85E+17	3.65E+17	0.246	6.6	3.3	0.0	-26.7
	LPCI Nozzle W179	519-01205	SMAW	-49	0.01	0.53	20.0	4.85E+17	3.65E+17	0.246	4.9	2.5	0.0	-39.2
	LPCI Nozzle W179	504-01205	SMAW	-31	0.01	0.51	20.0	4.85E+17	3.65E+17	0.246	4.9	2.5	0.0	-21.2
ISP	Surveillance Plate	5K3238/1	-	7	0.09	0.64	{{ }}	1.65E+18	1.15E+18	0.445	21.9	8.5	0.0	45.9
	Surveillance Weld	**D53040**	**SAW**	**-30**	**0.07**	**0.57**	{{ }}	**1.44E+18**	**1.01E+18**	**0.419**	**88.3**	**28.0**	**0.0**	**114.3**

REDACTED EPRI PROPRIETARY INFORMATION [16]

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Table 13: Nozzle Stress Intensity Factors

Nozzle	Applied Pressure, $K_{Ip\text{-}app}$	Thermal, K_{It}
Feedwater	78.46	41.85
Instrument (N16)	75.94	24.75

K_I in units of ksi-in$^{0.5}$

Appendix A

HOPE CREEK REACTOR VESSEL MATERIALS SURVEILLANCE PROGRAM

In accordance with 10 CFR 50, Appendix H, Reactor Vessel Material Surveillance Program Requirements [28], two surveillance capsules have been removed from the HCGS reactor vessel in 1994 after 6.01 EFPY [29] and in 2015 after 24.1 EFPY [30]. The surveillance capsules contained flux wires for neutron fluence measurement, Charpy V-Notch impact test specimens and uniaxial tensile test specimens fabricated using materials from the vessel materials within the core beltline region.

HCGS is currently committed to use the BWRVIP ISP, and has made a licensing commitment to use the ISP for HCGS during the period of extended operation. The BWRVIP ISP meets the requirements of 10 CFR 50, Appendix H, for Integrated Surveillance Programs, and has been approved by NRC. HCGS committed to use the ISP in place of its existing surveillance programs in the license amendment issued by the NRC regarding the implementation of the BWRVIP ISP, dated July 23, 2004 [12]. Under the ISP, a capsule was removed in 2015 after 24.1 EFPY [30]. HCGS continues to be a host plant under the ISP. One additional standby HCGS capsule is currently scheduled to be removed and tested under the ISP during the license renewal period in approximately 2036 at 40 EFPY [31].

EPRI Affidavit supporting the withholding of information in Enclosure 3 from public disclosure

ELECTRIC POWER RESEARCH INSTITUTE

NEIL WILMSHURST
Vice President and
Chief Nuclear Officer

Ref. EPRI Docket No. 99902016

May 15, 2018

Document Control Desk
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Request for Withholding of the following Proprietary Information Included in:

PSEG Nuclear LLC, Hope Creek Generating Station, titled:
"Pressure and Temperature Limits Report (PTLR)
for 32, 44, and 56 Effective Full Power Years (EFPY)",
Revision 1-P, dated September 2017

To Whom It May Concern:

This is a request under 10 C.F.R. §2.390(a)(4) that the U.S. Nuclear Regulatory Commission ("NRC") withhold from public disclosure the report identified in the enclosed Affidavit consisting of the proprietary information owned by Electric Power Research Institute, Inc. ("EPRI") identified above in the attached report. Proprietary and non-proprietary versions of the Report and the Affidavit in support of this request are enclosed.

EPRI desires to disclose the Proprietary Information in confidence to assist the NRC review of the enclosed submittal to the NRC by PSEG. The Proprietary Information is not to be divulged to anyone outside of the NRC or to any of its contractors, nor shall any copies be made of the Proprietary Information provided herein. EPRI welcomes any discussions and/or questions relating to the information enclosed.

If you have any questions about the legal aspects of this request for withholding, please do not hesitate to contact me at (704) 595-2732. Questions on the content of the Report should be directed to Andy McGehee of EPRI at (704) 502-6440.

Sincerely,

Attachment(s)

1300 West W.T. Harris Boulevard, Charlotte, NC 28262-8550 USA • 704.595.2732 • Mobile 704.490.2653 • nwilmshurst@epri.com

ELECTRIC POWER RESEARCH INSTITUTE

AFFIDAVIT

RE: Request for Withholding of the Following ProprietaryInformation Included In:

PSEG Nuclear LLC, Hope Creek Generating Station, titled:
"Pressure and Temperature Limits Report (PTLR)
for 32, 44, and 56 Effective Full Power Years (EFPY)",
Revision 1-P, dated September 2017

I, Neil Wilmshurst, being duly sworn, depose and state as follows:

I am the Vice President and Chief Nuclear Officer at Electric Power Research Institute, Inc. whose principal office is located at 3420 Hillview Avenue, Palo Alto, California ("EPRI") and I have been specifically delegated responsibility for the above-listed Report contains EPRI Proprietary Information that is sought under this Affidavit to be withheld "Proprietary Information". I am authorized to apply to the U.S. Nuclear Regulatory Commission ("NRC") for the withholding of the Proprietary Information on behalf of EPRI.

EPRI Proprietary Information is identified in the above referenced report with underlined text inside double brackets. Examples of such identification is as follows:

[[This sentence is an example{E}]]

Tables containing EPRI Proprietary Information are identified with double brackets before and after the object. In each case the superscript notation {E} refers to this affidavit and all the bases included below, which provide the reasons for the proprietary determination.

EPRI requests that the Proprietary Information be withheld from the public on the following bases:

Withholding Based Upon Privileged And Confidential Trade Secrets Or Commercial Or Financial Information (see e.g. 10 C.F.R. §2.390(a)(4))::

a. The Proprietary Information is owned by EPRI and has been held in confidence by EPRI. All entities accepting copies of the Proprietary Information do so subject to written agreements imposing an obligation upon the recipient to maintain the confidentiality of the Proprietary Information. The Proprietary Information is disclosed only to parties who agree, in writing, to preserve the confidentiality thereof.

b. EPRI considers the Proprietary Information contained therein to constitute trade secrets of EPRI. As such, EPRI holds the information in confidence and disclosure thereof is strictly limited to individuals and entities who have agreed, in writing, to maintain the confidentiality of the Information.

c. The information sought to be withheld is considered to be proprietary for the following reasons. EPRI made a substantial economic investment to develop the Proprietary Information and, by prohibiting public disclosure, EPRI derives an economic benefit in the form of licensing royalties and other additional fees from the confidential nature of the Proprietary Information. If the Proprietary Information were publicly available to consultants and/or other businesses providing services in the electric and/or nuclear power industry, they would be able to use the Proprietary Information for their own commercial benefit and profit and without expending the substantial economic resources required of EPRI to develop the Proprietary Information.

d. EPRI's classification of the Proprietary Information as trade secrets is justified by the Uniform Trade Secrets Act which California adopted in 1984 and a version of which has been adopted by over forty states. The California Uniform Trade Secrets Act, California Civil Code §§3426 – 3426.11, defines a "trade secret" as follows:

> "'Trade secret' means information, including a formula, pattern, compilation, program device, method, technique, or process, that:
>
> (1) Derives independent economic value, actual or potential, from not being generally known to the public or to other persons who can obtain economic value from its disclosure or use; and
>
> (2) Is the subject of efforts that are reasonable under the circumstances to maintain its secrecy."

e. The Proprietary Information contained therein are not generally known or available to the public. EPRI developed the Information only after making a determination that the Proprietary Information was not available from public sources. EPRI made a substantial investment of both money and employee hours in the development of the Propretary Information. EPRI was required to devote these resources and effort to derive the Proprietary Information. As a result of such effort and cost, both in terms of dollars spent and dedicated employee time, the Proprietary Information is highly valuable to EPRI.

f. A public disclosure of the Proprietary Information would be highly likely to cause substantial harm to EPRI's competitive position and the ability of EPRI to license the Proprietary Information both domestically and internationally. The Proprietary Information and Report can only be acquired and/or duplicated by others using an equivalent investment of time and effort.

I have read the foregoing and the matters stated herein are true and correct to the best of my knowledge, information and belief. I make this affidavit under penalty of perjury under the laws of the United States of America and under the laws of the State of California.

Executed at 1300 W WT Harris Blvd, Charlotte, NC being the premises and place of business of Electric Power Research Institute, Inc.

Date: May 15 2018.

[signature]

Neil Wilmshurst

(State of North Carolina)
(County of Mecklenburg)

Subscribed and sworn to (or affirmed) before me on this 15th day of May, 2018 by Neil Wilmshurst, proved to me on the basis of satisfactory evidence to be the person(s) who appeared before me.

Signature Deborah H. Rouse (Seal)

My Commission Expires 2nd day of April, 2021

DEBORAH H. ROUSE
NOTARY PUBLIC
CABARRUS
COUNTY
NORTH CAROLINA