CP&L
A Progress Energy Company

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10 CFR 50.90
10 CFR 50.12

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

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 AND 50-324/LICENSE NOS. DPR-71 AND DPR-62
REQUEST FOR LICENSE AMENDMENTS – CHANGES TO REACTOR COOLANT SYSTEM PRESSURE-TEMPERATURE LIMITS AND REQUEST FOR EXEMPTION FROM 10 CFR 50, APPENDIX G, REQUIREMENTS

Gentlemen:

In accordance with the Code of Federal Regulations, Title 10, Parts 50.90 and 2.101, Carolina Power & Light (CP&L) Company is requesting a revision to the Technical Specifications for the Brunswick Steam Electric Plant (BSEP), Unit Nos. 1 and 2. Technical Specification 3.4.9 includes reactor coolant system pressure-temperature limits curves that define acceptable regions for normal operation. The existing pressure-temperature limits curves for normal operation are valid up to 16 effective full power years (EFPY), and the existing pressure-temperature limits curves for hydrostatic and leak testing are valid up to 14 and 16 EFPY. The proposed license amendments replace the pressure-temperature limits curves for normal operation and hydrostatic/leak tests with curves that will be valid up to 32 EFPY.

Paragraph (IV)(A)(2)(b) of 10 CFR Part 50, Appendix G, requires that pressure-temperature limits be at least as conservative as limits obtained by following the methods of analysis and the margins of safety of Appendix G of Section XI of the ASME Code. The revised pressure-temperature limits curves rely on American Society of Mechanical Engineers (ASME) Code Case N-640, "Alternative Reference Fracture Toughness for Development of P-T Limit Curves for ASME Section XI, Division 1," as an alternate method for determining the fracture toughness of reactor pressure vessel materials for use in pressure-temperature limits curves. Pressure-temperature limits obtained using ASME Code Case N-640 do not meet the requirements in paragraph (IV)(A)(2)(b). Therefore, in accordance with 10 CFR 50.12(a), CP&L is requesting an exemption from the requirements of 10 CFR Part 50, Appendix G, paragraph (IV)(A)(2)(b), to use ASME Code Case N-640 to support the license amendment request.

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The requirements of 10 CFR 50.12 are satisfied because special circumstances are present, as described in 10 CFR 50.12(a)(2)(ii) and (iii), which warrant granting the exemption. The exemption is requested for the life of the facility. Similar exemptions have been approved for PECO Energy Company's Limerick Generating Station, Unit 1 (Accession Number ML0037400240); Commonwealth Edison's Dresden Nuclear Power Station, Units 2 and 3 (Accession Number ML0037457691) and Quad Cities Nuclear Power Station (Accession Number ML0036804410); and Southern Company's Edwin I. Hatch Nuclear Plant, Units 1 and 2 (Accession Number ML0037451810).

Marked-up Bases pages for the proposed BSEP, Unit 1 license amendment are included in Enclosure 11. These Bases pages are provided for information only and do not require issuance by the NRC.

In accordance with 10 CFR 50.91(b), CP&L is providing a copy of this license amendment application to Mr. Mel Fry of the State of North Carolina.

CP&L requests approval of the requested Technical Specification revisions by October 1, 2001. This date corresponds to the estimated time when the first BSEP unit (i.e., Unit 2) is expected to accumulate 16 EFPY of operation. In order to allow time for procedure revision and orderly incorporation into copies of the Technical Specifications, CP&L requests that the NRC allow 60 days for implementation of the license amendment.

Please refer any questions regarding this submittal to Mr. David C. DiCello, Manager - Regulatory Affairs, at (910) 457-2235.

Sincerely,

John S. Keenan

John S. Keenan

WRM/wrm

Enclosures:

1. Basis for Change Request
2. CP&L Calculation 0B11-0005, Revision 0
3. 10 CFR 50.92 Evaluation
4. Request For Exemption From 10 CFR 50, Appendix G, Paragraph (IV)(A)(2)(b)
5. Environmental Considerations
6. Page Change Instructions
7. Typed Technical Specification Pages - Unit No. 1
8. Typed Technical Specification Pages - Unit No. 2
9. Marked-up Technical Specification Pages - Unit No. 1
10. Marked-up Technical Specification Pages - Unit No. 2
11. Revised Technical Specification Bases Pages - Unit No. 1

John S. Keenan, having been first duly sworn, did depose and say that the information contained herein is true and correct to the best of his information, knowledge and belief; and the sources of his information are officers, employees, and agents of Carolina Power & Light Company.

Dean L. Mash
Notary (Seal)

My commission expires: August 29, 2004

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ENCLOSURE 1

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 AND 50-324/LICENSE NOS. DPR-71 AND DPR-62
REQUEST FOR LICENSE AMENDMENTS – CHANGES TO REACTOR PRESSURE VESSEL PRESSURE-TEMPERATURE LIMITS AND REQUEST FOR EXEMPTION FROM 10 CFR 50, APPENDIX G, REQUIREMENTS

Basis For Change Request

Introduction

In accordance with the Code of Federal Regulations, Title 10, Parts 50.90 and 2.101, Carolina Power & Light (CP&L) Company is requesting a revision to the Technical Specifications for the Brunswick Steam Electric Plant (BSEP), Unit Nos. 1 and 2. The existing pressure-temperature limits curves for normal operation are valid up to 16 effective full power years (EFPY), and the existing pressure-temperature limits curves for hydrostatic and leak testing are valid up to 14 and 16 EFPY. CP&L is requesting approval of revised pressure-temperature limits curves for normal operation and hydrostatic/leak tests that will be valid up to 32 EFPY.

Background

BSEP, Units 1 and 2 operated from initial plant start-up until 1990 using the original pressure-temperature limits curves. On February 15, 1990, CP&L received NRC approval of License Amendments 140 and 172 revising the pressure-temperature limits curves to incorporate changes made by the NRC to 10 CFR 50, Appendix G and through Regulatory Guide 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials." The revisions included normal operating limits curves (i.e., core critical and core not critical) which are valid up to 16 EFPY and hydrostatic and leak test limits curves which were valid up to 12 EFPY.

On October 7, 1997, CP&L received NRC approval of License Amendments 189 and 220 to delete the 8, 10, and 12 EFPY hydrostatic/leak test limits curves and incorporate new hydrostatic/leak test limits curves which are valid up to 14 and 16 EFPY. Due to the previous inadvertent transposition of the Unit 1 and Unit 2 pressure-temperature limits curves, these license amendments also exchanged the Unit 1 and Unit 2 limits curves. Transposition of the pressure-temperature limits curves was reported in Licensee Event Report 1-94-05, dated March 21, 1994, and supplemented April 29, 1994, and September 23, 1994.

Current Requirement

Technical Specification Figure 3.4.9-1 provides reactor coolant system pressure and temperature limits applicable to normal operation with the core not critical. Figure 3.4.9-2 provides reactor coolant system pressure and reactor coolant system temperature limits applicable to normal operation with the core critical. Figure 3.4.9-3 provides reactor coolant system pressure and

temperature limits applicable to hydrostatic and leak tests up to 14 EFPY. Figure 3.4.9-4 provides reactor coolant system pressure and temperature limits applicable to hydrostatic and leak tests up to 16 EFPY.

Technical Specification 3.4.9 states:

> RCS pressure, RCS temperature, RCS heatup and cooldown rates, and the recirculation pump starting temperature requirements shall be maintained within limits.

Surveillance Requirement 3.4.9.2.a, which is performed during reactor coolant system inservice hydrostatic and leak testing, requires the following action to be completed within 30 minutes:

> [Verify] RCS pressure and RCS temperature are within the applicable limits specified in Figure 3.4.9-3 or 3.4.9-4.

Proposed Change

Figure 3.4.9-1 is being revised to provide reactor coolant system pressure-temperature limits applicable to normal operation with the core not critical that are valid up to 32 EFPY. Figure 3.4.9-2 is being revised to provide reactor coolant system pressure-temperature limits applicable to normal operation with the core critical that are valid up to 32 EFPY. Figure 3.4.9-3 is being revised to provide reactor coolant system pressure-temperature limits applicable to hydrostatic and leak tests that are valid up to 32 EFPY. Figure 3.4.9-4 is being eliminated. To support the elimination of Figure 3.4.9-4, Surveillance Requirement 3.4.9.2.a is being revised to require completion of the following action within 30 minutes:

> [Verify] RCS pressure and RCS temperature are within the applicable limits specified in Figure 3.4.9-3.

Basis For Proposed Change

Components of the reactor coolant system have been designed to withstand the effects of cyclic loads resulting from system pressure and temperature changes. These cyclic loads are introduced by heatup and cooldown operations, power transients, and reactor trips. Technical Specification 5.5.5 requires monitoring of component cyclic occurrences. The various categories of load cycles used for the original design analysis are identified in Updated Final Safety Analysis Report, Table 5.3.3-2. The current licensing basis for cyclic loads is cumulative usage factor, which is tracked by the Reactor Pressure Vessel Fatigue Monitoring Program.

In accordance with 10 CFR 50, Appendix G, the BSEP Technical Specifications limit reactor coolant system pressure and temperature changes during heatup and cooldown to within the design assumptions and stress limits for cyclic operation. These limits are defined by the pressure-temperature limits curves for heatup, cooldown, and hydrostatic and leak testing. These curves are used during heatup and cooldown maneuvering, when pressure and temperature indications are monitored and compared to the applicable pressure-temperature limits curve to determine that operation is within the allowable limits.

The pressure-temperature limits curves in the BSEP Technical Specifications were established in accordance with 10 CFR 50, Appendix G, and the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, Appendix G, to provide adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. The reactor pressure vessel is the reactor coolant pressure boundary component that is most subject to brittle failure. As a result, the pressure-temperature limits apply primarily to the reactor pressure vessel.

Part of the analysis involved in developing the pressure-temperature limits curves accounts for neutron irradiation embrittlement effects in the beltline region of the reactor pressure vessel. Regulatory Guide 1.99, Revision 2, provides the general procedures that are acceptable to the NRC for calculating the effects of neutron embrittlement. Regulatory Guide 1.99, Revision 2, has been used to predict the shift in RT_{NDT}, as a function of neutron fluence, in the beltline region and to develop the pressure-temperature limits curves in the BSEP Technical Specifications.

Revised pressure-temperature limits curves are being requested which provide pressure-temperature limitations valid until 32 EFPY. Each revised pressure-temperature limits curve is represented by two curves, a beltline curve and a bottom head curve. The beltline curve is based on the N16A/B nozzles; the N16A/B nozzles are the limiting reactor pressure vessel material and are located in the beltline region. The bottom head curves define the pressure-temperature limits for the bottom head region of the reactor pressure vessel and accommodate cooldown rates as high as 882°F per hour and heatup rates up to 317°F in one minute. Technical Specification 3.4.9 provides limitations for the maximum rate of change in the reactor coolant temperature; however, these limitations are not being revised as part of this request.

The methods used for development of the revised pressure and temperature limits curves are described in CP&L Calculation 0B11-0005, Revision 0, a copy of which is provided in Enclosure 2 of this letter. The revised pressure-temperature limits being proposed for BSEP, Units 1 and 2, are based on ASME Code Case N-640, "Alternative Reference Fracture Toughness for Development of P-T Limit Curves for ASME Section XI, Division 1," as an alternative method for determining the fracture toughness of reactor pressure vessel materials for use in determining pressure-temperature limits. ASME Code Case N-640 permits the use of the K_{IC} fracture toughness curve of ASME Code, Section XI, Appendix A, Figure A-2200-1, in lieu of the K_{IA} fracture toughness curve from ASME Code, Section XI, Appendix G, Figure G-2200-1, as the lower bound for fracture toughness. In the development of pressure-temperature limits curves, use of the K_{IC} curve in determining the lower bound fracture toughness is more technically correct than the K_{IA} curve. The K_{IC} curve appropriately implements the use of static initiation fracture toughness behavior to evaluate the controlled heat-up and cooldown process of a reactor pressure vessel. The use of the initial conservatism of the K_{IA} curve, when the curve was codified in 1974, was necessary due to the limited knowledge of reactor pressure vessel materials. Since 1974, additional knowledge has been gained about reactor pressure vessel materials which demonstrates that the lower bound on fracture toughness provided by the K_{IA} curve is well beyond the margin of safety required to protect the public health and safety from potential reactor pressure vessel failure.

Use of the K_{IC} fracture toughness curve results in a reduction in allowable temperatures, for a given pressure, compared to allowable temperatures without the use of the code case. Pressure-temperature limits curves based on the K_{IC} curve will enhance overall plant safety by opening the pressure-temperature operating window, especially in the region of low temperature operations. Safety benefits during the pressure test include a reduction in challenges to plant operators in maintaining a high temperature in a limited operating window, personnel safety while conducting inspections in primary containment at elevated temperatures, and increased availability of plant systems, including the Residual Heat Removal system due to the reduction of the heatup and testing time.

The ASME Code Case N-640 was approved for use by the ASME on February 26, 1999; however, the code case has not yet received NRC approval for generic use. Nevertheless, license amendments using the code case have been approved by the NRC for PECO Energy Company's Limerick Generating Station, Unit 1 (Accession Number ML003745510); Commonwealth Edison's Dresden Nuclear Power Station, Units 2 and 3 (Accession Number ML003754512) and Quad Cities Nuclear Power Station (Accession Number ML003687959); and Southern Company's Edwin I. Hatch Nuclear Plant, Units 1 and 2 (Accession Number ML003746050).

Paragraph (IV)(A)(2)(b) of 10 CFR Part 50, Appendix G, requires that pressure-temperature limits be at least as conservative as limits obtained by following the methods of analysis and the margins of safety of Appendix G of Section XI of the ASME Code. Pressure-temperature limits obtained using ASME Code Case N-640 do not meet the requirements in paragraph (IV)(A)(2)(b). Because the revised pressure-temperature limits have been developed, in part, using ASME Code Case N-640, CP&L is requesting an exemption, in accordance with 10 CFR 50.12, from paragraph (IV)(A)(2)(b) of 10 CFR Part 50, Appendix G. The basis for the exemption request is further discussed in Enclosure 4 of this letter. The other margins involved with the ASME Code, Section XI, Appendix G, process of determining pressure-temperature limits remain unchanged.

Similar exemptions have been approved for PECO Energy Company's Limerick Generating Station, Unit 1 (Accession Number ML0037400240); Commonwealth Edison's Dresden Nuclear Power Station, Units 2 and 3 (Accession Number ML0037457691) and Quad Cities Nuclear Power Station (Accession Number ML0036804410); and Southern Company's Edwin I. Hatch Nuclear Plant, Units 1 and 2 (Accession Number ML0037451810).

Based on the above information, CP&L has concluded that the proposed changes to the pressure-temperature limits curves will not present an undue risk to the public health and safety.

References

1. U. S. Code of Federal Regulations, Chapter 10, Part 50, Appendix G, "Fracture Toughness Requirements," January 1, 1998 Edition.
2. ASME Boiler and Pressure Vessel Code, Section XI, "Rules For Inservice Inspection of Nuclear Power Plant Components," Nonmandatory Appendix G, "Fracture Toughness Criteria for Protection Against Failure," 1989 Edition, No Addenda.

3. ASME Code Case N-640, "Alternative Reference Fracture Toughness For Development of P-T Limit Curves, Section XI, Division 1," February 26, 1999.
4. CP&L Calculation 0B11-0005, Revision 0.

ENCLOSURE 2

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 AND 50-324/LICENSE NOS. DPR-71 AND DPR-62
REQUEST FOR LICENSE AMENDMENTS – CHANGES TO REACTOR PRESSURE VESSEL PRESSURE-TEMPERATURE LIMITS AND REQUEST FOR EXEMPTION FROM 10 CFR 50, APPENDIX G, REQUIREMENTS

CP&L Calculation 0B11-0005, Revision 0

SYSTEM#: 1005

CALC. TYPE: ESMISC

CATEGORY CODE: B

QUALITY CLASS: A

CAROLINA POWER & LIGHT COMPANY

0B11-0005

(CALCULATION #)

Development of RPV Pressure-Temperature Curves For BNP Units 1 & 2 For Up To 32 EFPY of Plant Operation

(TITLE INCLUDING STRUCTURE/SYSTEM/COMPONENT)

BRUNSWICK NUCLEAR POWER PLANT

UNITS 1 & 2

APPROVAL

Revision: 0

Prepared By: Philip Gore Date: 11-6-00

Reviewed By: Larry Jemma Date: 11-8-00

Design Supervisor: W Blum Wylie Date: 11-8-00

Revision Summary

Rev. #	Date	Revision Summary
0	11/06/00	Original issue of calculation.

List of Effective Pages

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1	0
2	0
3	0
4	0
5	0
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7	0
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Attachment 2	0
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1.0 PURPOSE

This calculation package documents the development of the revised set of RPV pressure-temperature (P-T) curves for Brunswick Steam Electric Plant Units 1 and 2 (BSEP -1 and BSEP-2). The P-T curves currently located in the BNP Unit 1 and Unit 2 Technical Specifications are valid through 16 effective full power years (EFPY) of operation. This new set of curves will be used in development of a Licensing Document Change Request (LDCR) to replace the existing curves prior to reaching the 16 EFPY threshold. The new set of curves includes curves for pressure test, core not critical, and core critical conditions for both units for up to 32 EFPY.

2.0 BACKGROUND

Brunswick Units 1 and 2 operated utilizing the original RPV P-T curves from startup of the units up to 1990. At that time, the company opted to revise the curves to incorporate changes which the NRC had made to Appendix G of 10CFR50 and Regulatory Guide 1.99 via revision 2 [6.6]. The submittal included normal operating curves (core critical and core not critical) which were valid through 16 EFPY and pressure test curves which were valid through 12 EFPY. The NRC approved this amendment request on February 15, 1990 [6.7], and the curves were subsequently incorporated into the site Technical Specifications.

On January 7, 1997, CP&L submitted another request for license amendments to the RPV pressure temperature curves [6.8]. This submittal requested the following changes:

- Exchange of the P-T curves located in the Unit 1 and Unit 2 Technical Specifications. In License Event Report 1-94-05, CP&L had reported that the Unit 1 and Unit 2 P-T curves had been inadvertently transposed. Engineering Evaluation 94-0084 [6.9] provides additional information on the curve switch.
- Deletion of the 8, 10, and 12 EFPY hydrostatic test pressure temperature limits curves and incorporation of new 14 and 16 EFPY hydrostatic pressure temperature limits curves.

The NRC approved this amendment request on October 7, 1997 [6.10], and the changes were subsequently incorporated into the site Technical Specifications.

3.0 METHODOLOGY FOR P-T CURVE DEVELOPMENT

3.1 RT_{NDT} Determination

RT_{NDT} estimates were developed for the reactor pressure vessel materials in accordance with Regulatory Guide 1.99, Revision 2 [6.11]. Inputs for RT_{NDT} calculations were based on data documented in Reference [6.13]. The adjusted reference temperatures (ART_{NDT}) used in developing the P-T curves are documented in Table 1 Attachment 4. The 32 EFPY fluence values used in calculating the ART_{NDT} values have been adjusted to account for planned power up-rates. A fluence evaluation will be performed as part of each implemented power uprate to determine the impact on fluence. If the fluence evaluation determines that the calculated 32 EFPY fluence values are not bounding, then these fluence projections and the P-T curves will be revised as required.

3.2 Pressure-Temperature Curve Methodology

The methodology for development of the P-T curves outlined below was taken from Structural Integrity Associates (SIA) Report No. SIR-00-132 and SIA calculation CPL-54Q-303, Rev. 0 (included as Attachments 4 and 5). This methodology is based on the requirements of References [6.1] and [6.2] with the exception that K_{IC}

is used in lieu of K_{IA} for the allowable material stress intensity factor. This approach has recently been approved for use by the ASME Code as Code Case N-640 [6.5].

a. Assume a fluid temperature, T.

b. For the temperature, T, assumed in step (a), compute the temperature at the assumed flaw tip, $T_{1/4t}$ (i.e., 1/4t into the vessel wall). This is accomplished by adding a temperature drop term, $\Delta T_{1/4t}$, to T. The value of $\Delta T_{1/4t}$ is zero for the pressure test curves (e.g., these tests are essentially isothermal), and is determined via heat transfer analysis for the other curves.

c. Calculate the allowable stress intensity factor, K_{IC} (as allowed per reference [6.5], based on $T_{1/4t}$ using the following relationship:

$$K_{IC} = 20.734\, e^{[0.02(T-ART)]} + 33.2$$

where:	T	=	$T_{1/4t}$ (°F)
	ART	=	adjusted reference temperature for location under consideration and desired EFPY from Tables 1 (°F) of Attachment 4.
	K_{IC}	=	allowable stress intensity factor (ksi√inch)

d. Calculate the allowable pressure stress intensity factor, K_{IP}, using the appropriate relationship for the P-T curve under consideration:

$K_{IP} = K_{IC}/1.5$ For pressure test curves.

$K_{IP} = (K_{IC}-K_{IT})/2.0$ For core critical and core not critical curves.

where:	K_{IT}	=	thermal stress intensity factor (ksi√inch)
		=	$M_t \times \Delta T_W$ per figure G-2214-2 of Reference [6.1] for the beltline and bottom head regions.
		=	5.4 ksi√inch for the N16A/B nozzles based on finite element analysis.
	ΔT_W	=	through-wall temperature drop, determined by heat transfer analysis (°F).
	M_t	=	factor from Figure G-2214-2 of Reference [6.1].
	K_{IP}	=	allowable pressure stress intensity factor (ksi√inch).

e. Compute the pressure, P. The relationship for the pressure, P, to the allowable pressure intensity factor, K_{IP}, is as follows:

$$K_{IP} = M_m\sigma_m + M_b\sigma_b$$

where:

M_m	=	membrane stress correction factor from Figure G-2214-1 of Reference [6.1].
σ_m	=	membrane stress due to pressure (ksi).
	=	PR/t for the beltline region.
	=	3.0PR/(2t) = 1.5PR/t for the spherical bottom head assuming a stress concentration factor of 3.0 for the bottom head penetrations.
		For the N16A/B nozzles, K_{IP} was determined directly based on finite element results as shown below:
P	=	pressure (ksi).
R	=	maximum vessel radius (inches)
t	=	minimum vessel wall thickness (inches)
M_b	=	bending stress correction factor = $(2/3)M_m$
σ_b	=	bending stress due to pressure (ksi)
	=	0 for a thin-walled vessel

Thus,

$P = K_{IP}t/(RM_m)$ for the beltline region

$P = K_{IP}t/(1.5RM_m)$ for the bottom head region

$P = 21.53\ K_{IP}$ for the N16A/B nozzles based on finite element analysis.

f. Repeat steps (a) through (e) for other temperatures to generate a series of P-T points for each region.

g. Subtract any applicable instrument errors for temperature and pressure from T and P, respectively. The resulting pressure and temperature series constitutes the P-T curve. The P-T curve relates the minimum required reactor fluid temperature to the reactor pressure for each region.

The following additional requirements were used to define the lower portion of the limiting (beltline) P-T curves. These limits are established by the discontinuity regions of the vessel (i.e., flanges), and are specified in Reference [6.2]:

For Pressure Test Conditions:

- Thermal stresses were assumed to be negligible during the pressure test condition and were therefore not considered.

- If P is greater than 20% of the pre-service hydrostatic test pressure, the temperature must be greater than the RT_{NDT} of the limiting flange material + 90°F. The pre-service hydro test pressure was 1563 psig.

- If P is less than or equal to 20% of the pre-service hydro test pressure, the minimum temperature is typically greater than or equal to the RT_{NDT} of the limiting flange material + 60°F. The additional 60°F margin above that recommended in Reference 6.2 has been a standard recommendation by GE for the BWR industry. For the BSEP flange material, this minimum temperature would be 76°F (i.e., 16°F + 60°F) for Unit 1 and 70°F (i.e., 10°F + 60°F) for Unit 2. Since the 60°F margin is only a recommendation, the minimum temperature for Unit 1 was set to 70°F to match Unit 2.

For Core Not Critical Conditions:

- If P 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 + 120°F.

- If P is less than or equal to 20% of the pre-service hydro test pressure, the minimum temperature is typically greater than or equal to the RT_{NDT} of the limiting flange material + 60°F. The additional 60°F margin above that recommended in Reference [6.2] has been a standard recommended by GE for the BWR industry. For the BSEP flange material, this minimum temperature is 70°F for Unit 1 and 70°F for Unit 2, as identified above.

For Core Critical Conditions:

- Per the requirements of Table 1 of Reference [6.2], the core critical P-T limits must be 40 °F above any Pressure Test or Core Not Critical curve limits. Core Not Critical conditions are more limiting than Pressure Test Conditions, so Core Critical conditions are equal to Core Not Critical conditions + 40°F.

- Another requirement of Table 1 of Reference [6.2] (or actually an allowance for the BWR), concerns minimum temperature for initial criticality in a startup. Given that water level is normal, BWRs are allowed initial criticality at the closure flange region temperature (RT_{NDT} + 60°F) if the pressure is below 20% of the pre-service hydro test pressure. This corresponds to 76°F for Unit 1 and 70°F for Unit 2, as identified above.

- Also per Table 1 of Reference [6.2], at pressures above 20% of the pre-service hydro test pressure, the Core Critical curve temperature must be at least that required for the pressure test (Pressure Test Curve at a conservative value of 1,100 psig). As a result of this requirement, the Core Critical curve must have a step at a pressure equal to 20% of the pre-service hydro pressure to the temperature required by the Pressure Test curve at 1,100 psig, or 40°F, whichever is greater.

3.3 Heat Transfer Analysis

A heat transfer analysis was performed by Structural Integrity Associates to estimate the ΔT_W and $\Delta T_{1/4t}$ used in the development of the new P-T curves. The results of that analysis are documented in Table 2 of Attachment 4.

4.0 ASSUMPTIONS

Assumptions are as noted throughout the calculation package.

5.0 CONCLUSIONS

Utilizing the above methodology, P-T limits curves were developed for Unit 1 and Unit 2 for

core critical, core not critical and pressure test conditions. The P-T limits in the Attachment 2 curves are represented by two curves, the bottom head curve and the N16A/B nozzle curve. The limiting curve (indicated by the solid line in the Attachment 2 curves) defines the P-T limits for the limiting RPV material. As documented in Table 1 of Attachment 4, the limiting materials of the BNP reactor vessels are the N16A/B nozzles which are located within the beltline region. The limiting curve bounds all vessel locations with respect to P-T limits. The bottom head curves (indicated by the broken line in the Attachment 1 curves) define the P-T limits specifically for the bottom head region of the vessel. The bottom head curves accommodate cooldown rates as high as 882°F/hr and step heatups up to 317°F in one minute and have been included to aid in the timely disposition of transient events that involve potential violation of the P-T limits. All of the curves included in Attachment 2 are valid through thirty-two (32) effective full power years (EFPY) of plant operation.

Spreadsheets used for the development of the P-T curves are included as Attachment 1. The completed P-T curves are included as Attachment 2.

6.0 REFERENCES

6.1 ASME Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, Nonmandatory Appendix G, "Fracture Toughness Criteria for Protection Against Failure," 1989 Edition, No Addenda.

6.2 U. S. Code of Federal Regulations, Chapter 10, Part 50, Appendix G, "Fracture Toughness Requirements," 1-1-98 Edition.

6.3 Structural Integrity Associates Calculation No. CPL-54Q-303, Revision 0, "Development of Updated P-T Curves For 32 EFPY," 10/19/00 (included as Attachment 5).

6.4 Structural Integrity Associates Report No. SIR-00-132, Revision 0, "Brunswick Pressure-Temperature Curves," October 2000 (included as Attachment 4).

6.5 ASME Code Case N-640, Alternative Reference Fracture Toughness for Development of P-T Limit Curves Section XI, Division 1," February 26, 1999.

6.6 CP&L Letter to United States Nuclear Regulatory Commission, Letter Serial Number NLS-88-104, "Request For License Amendment Reactor Coolant System Pressure/Temperature Limits," dated October 26, 1988.

6.7 Letter, Ngoc B. Le (NRC) to Lynn Eury (CP&L), "Issuance of Amendment No. 140 to Facility Operating License No. DPR-71 and Amendment No. 172 to Facility Operating License No. DPR-162, for Brunswick Steam Electric Plant (BSEP), Units 1 and 2, Regarding Staff Review of Pressure/Temperature Limits (TAC Nos. 71112 and 71113)" dated February 15, 1990.

6.8 CP&L Letter to United States Nuclear Regulatory Commission, Letter Serial Number BSEP 96-0344, "Request For License Amendments Pressure-Temperature Limits Curves," dated January 7, 1997.

6.9 EER 94-0084, "Evaluation of Brunswick Units 1 & 2 Pressure-Temperature Limit Curves," Revision 0.

6.10 Letter, David C. Trimble (NRC) to C. S. Hinnant (CP&L), "Issuance of Amendment No. 189 to Facility Operating License No. DPR-71 and Amendment No. 220 to Facility Operating License No. DPR-162 Correcting and Updating The Reactor Pressure Vessel Pressure-Temperature Limits - Brunswick Steam Electric Plant, Units 1 and 2, (TAC Nos. M97938 and M97939)" dated October 7, 1997.

6.11 USNRC Regulatory Guide 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials," U. S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, (Task ME 305-4), May, 1988.

6.12 ASME Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, Nonmandatory Appendix A, "Analysis of Flaws," 1995 Edition, No Addenda.

6.13 CP&L Letter to United States Nuclear Regulatory Commission, Letter Serial Number BSEP 95-0572, "Response to NRC Generic Letter 92-01, Revision 1, Supplement 1 Reactor Pressure Vessel Integrity," dated November 16, 1995.

ATTACHMENT 1

P-T Curve Spreadsheets
(following 10 pages)

	A	B	C	D	E	F	G	H
1			***Pressure-Temperature Curve Calculation***					
2			*(Core Not Critical)*					
3								
4	***Inputs:***		Plant =	**Brunswick 1**				
5			Component =	**N16 A/B**	(2" Instrument Nozzles)			
6			Vessel thickness, t =	**N/A**	inches (minimum)			
7			M_t =	**N/A**	(per Figure G-2214-2 of App. G, mod. for E, α)			
8			Vessel Radius, R =	**N/A**	inches (maximum)			
9			RT_{NDT} =	**114.2**	°F ======>	**32 EFPY**		
10			ΔT_w =	**N/A**	°F (temp. difference between inside and outside surfaces)			
11			K_{IT} =	**5.4**	ksi*inch$^{1/2}$			
12			$\Delta T_{1/4t}$ =	**20.1**	°F (temperature difference between fluid and crack tip)			
13			Stress Multiplier, F =	**N/A**				
14			Safety Factor =	**2.00**	(for heatup/cooldown)			
15			M_m =	**N/A**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)			
16			Temperature Instrument Error =	**0.0**	°F			
17			Pressure Instrument Error =	**15.0**	psig			
18			Hydro Test Pressure =	**1563**	psig			
19			Flange RT_{NDT} =	**10.0**	°F (use Unit 2 value to match Unit 2 results)			
20								
21		**Fluid**				**Calculated**	**Adjusted**	**Adjusted**
22		**Temperature**	**1/4t**			**Pressure**	**Temperature**	**Pressure for**
23		**T**	**Temperature**	K_{Ic}	K_{IP}	**P**	**for P-T Curve**	**P-T Curve**
24		**(°F)**	**(°F)**	**(ksi*inch$^{1/2}$)**	**(ksi*inch$^{1/2}$)**	**(psig)**	**(°F)**	**(psig)**
25		70	90.1	46.01	20.31	0	70	0
26		70	90.1	46.01	20.31	313	70	313
27		75	95.1	47.36	20.98	313	75	313
28		80	100.1	48.85	21.72	313	80	313
29		85	105.1	50.49	22.55	313	85	313
30		90	110.1	52.31	23.46	313	90	313
31		95	115.1	54.32	24.46	313	95	313
32		130	150.1	75.74	35.17	313	130	313
33		130	150.1	75.74	35.17	757	130	742
34		135	155.1	80.21	37.41	805	135	790
35		140	160.1	85.15	39.88	859	140	844
36		145	165.1	90.62	42.61	917	145	902
37		150	170.1	96.66	45.63	982	150	967
38		155	175.1	103.33	48.97	1054	155	1039
39		160	180.1	110.71	52.65	1134	160	1119
40		165	185.1	118.86	56.73	1221	165	1206
41		170	190.1	127.87	61.23	1318	170	1303
42		175	195.1	137.82	66.21	1426	175	1411
43		180	200.1	148.83	71.71	1544	180	1529

Pressure-Temperature Curve Calculation

(Core Not Critical)

Inputs:

Plant =	**Brunswick 1**	
Component =	**Bottom Head**	
Vessel thickness, t =	**5.400**	inches (minimum)
M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**110.59375**	inches (maximum)
RT_{NDT} =	**10.0**	°F ======> **All EFPYs**
ΔT_w =	**25.6**	°F (temp. difference between inside and outside surfaces)
K_{IT} =	**7.0**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**18.9**	°F (temperature difference between fluid and crack tip)
Stress Multiplier, F =	**1.50**	(for spherical bottom head with penetrations)
Safety Factor =	**2.00**	(for heatup/cooldown)
M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F (use Unit 2 value to match Unit 2 results)

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
0	18.9	57.97	25.49	0	70	0
5	23.9	60.58	26.79	363	70	348
10	28.9	63.46	28.23	383	70	368
15	33.9	66.64	29.82	404	70	389
20	38.9	70.16	31.58	428	70	413
25	43.9	74.04	33.52	455	70	440
30	48.9	78.34	35.67	484	70	469
35	53.9	83.09	38.04	516	70	501
40	58.9	88.33	40.67	552	70	537
45	63.9	94.13	43.57	591	70	576
50	68.9	100.54	46.77	634	70	619
55	73.9	107.62	50.31	682	70	667
60	78.9	115.45	54.23	735	70	720
65	83.9	124.10	58.55	794	70	779
70	88.9	133.66	63.33	859	70	844
75	93.9	144.23	68.61	931	75	916
80	98.9	155.90	74.45	1010	80	995
85	103.9	168.81	80.91	1097	85	1082
90	108.9	183.07	88.04	1194	90	1179
95	113.9	198.83	95.92	1301	95	1286
100	118.9	200.00	96.50	1309	100	1294

Pressure-Temperature Curve Calculation

(Core Critical = Curve C)

Inputs:

Plant =	**Brunswick 1**	
EFPY =	**32**	
Curve A Leak Test Temperature =	**152.4**	°F (at 1,100 psig)
Hydro Test Pressure =	**1,565**	psig
Flange RT_{NDT} =	**16.0**	°F

Curve B Temperature N16 Nozzle (°F)	Curve B Pressure for N16 Nozzle (psig)	Curve B Temperature Bottom Head (°F)	Curve B Pressure for Bottom Head (psig)	Curve C Temperature N16 Nozzle (°F)	Curve C Pressure N16 Nozzle (psig)	Curve C Temperature Bottom Head (°F)	Curve C Pressure Bottom Head (psig)
70.0	0	0.0	0	76.0	0	76.0	0
70.0	313	5.0	348	76.0	313	76.0	348
75.0	313	10.0	368	76.0	313	76.0	368
80.0	313	15.0	389	80.0	313	76.0	389
85.0	313	20.0	413	85.0	313	76.0	413
90.0	313	25.0	440	90.0	313	76.0	440
95.0	313	30.0	469	95.0	313	76.0	469
130.0	313	35.0	501	176.0	313	76.0	501
130.0	742	40.0	537	176.0	742	80.0	537
135.0	790	45.0	576	176.0	790	85.0	576
140.0	844	50.0	619	180.0	844	90.0	619
145.0	902	55.0	667	185.0	902	95.0	667
150.0	967	60.0	720	190.0	967	100.0	720
155.0	1039	65.0	779	195.0	1039	105.0	779
160.0	1119	70.0	844	200.0	1119	110.0	844
165.0	1206	75.0	916	205.0	1206	115.0	916
170.0	1303	80.0	995	210.0	1303	120.0	995
175.0	1411	85.0	1082	215.0	1411	125.0	1082
180.0	1529	90.0	1179	220.0	1529	130.0	1179
		95.0	1286			135.0	1286
		100.0	1294			140.0	1294

Pressure-Temperature Curve Calculation

(Pressure Test)

Inputs:

Plant =	**Brunswick 1**	
Component =	**N16 A/B**	(2" Instrument Nozzles)
Vessel thickness, t =	**N/A**	inches (minimum)
M_t =	**N/A**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**N/A**	inches (maximum)
RT_{NDT} =	**114.2**	°F ======> **32 EFPY**
ΔT_w =	**0.0**	°F (no thermal for pressure test)
K_{IT} =	**0.0**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**0.0**	°F (no thermal for pressure test)
Stress Multiplier, F =	**N/A**	
Safety Factor =	**1.50**	(for pressure test)
M_m =	**N/A**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F (use Unit 2 value to match Unit 2 results)

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	70.0	41.77	27.84	0	70	0
70	70.0	41.77	27.84	313	70	313
75	75.0	42.67	28.44	313	75	313
80	80.0	43.66	29.11	313	80	313
85	85.0	44.76	29.84	313	85	313
90	90.0	45.98	30.65	313	90	313
95	95.0	47.32	31.55	313	95	313
100	100.0	48.81	32.54	313	100	313
100	100.0	48.81	32.54	701	100	686
105	105.0	50.45	33.63	724	105	709
110	110.0	52.26	34.84	750	110	735
115	115.0	54.27	36.18	779	115	764
120	120.0	56.48	37.66	811	120	796
125	125.0	58.93	39.29	846	125	831
130	130.0	61.64	41.09	885	130	870
135	135.0	64.63	43.09	928	135	913
140	140.0	67.94	45.29	975	140	960
145	145.0	71.59	47.73	1028	145	1013
150	150.0	75.63	50.42	1085	150	1070
152.4	152.4	77.71	51.81	1115	152	1100
155	155.0	80.09	53.39	1150	155	1135
160	160.0	85.02	56.68	1220	160	1205
165	165.0	90.47	60.31	1299	165	1284
170	170.0	96.49	64.33	1385	170	1370
175	175.0	103.15	68.77	1481	175	1466
180	180.0	110.51	73.67	1586	180	1571

Pressure-Temperature Curve Calculation

(Pressure Test)

Inputs:

Plant =	**Brunswick 1**	
Component =	**Bottom Head**	
Vessel thickness, t =	**5.400**	inches (minimum)
M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**110.59375**	inches (maximum)
RT_{NDT} =	**10.0**	°F ======> **All EFPYs**
ΔT_w =	**0.0**	°F (no thermal for pressure test)
K_{IT} =	**0.0**	ksi•inch$^{1/2}$
$\Delta T_{1/4t}$ =	**0.0**	°F (no thermal for pressure test)
Stress Multiplier, F =	**1.50**	(for spherical bottom head with penetrations)
Safety Factor =	**1.50**	(for pressure test)
M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F (use Unit 2 value to match Unit 2 results)

Fluid Temperature T (°F)	**1/4t Temperature (°F)**	**K_{Ic} (ksi•inch$^{1/2}$)**	**K_{IP} (ksi•inch$^{1/2}$)**	**Calculated Pressure P (psig)**	**Adjusted Temperature for P-T Curve (°F)**	**Adjusted Pressure for P-T Curve (psig)**
70	70.0	102.04	68.03	0	70	0
70	70.0	102.04	68.03	923	70	908
75	75.0	109.28	72.85	988	75	973
80	80.0	117.28	78.19	1060	80	1045
83.5	83.5	123.38	82.25	1116	84	1101
85	85.0	126.12	84.08	1140	85	1125
90	90.0	135.90	90.60	1229	90	1214
95	95.0	146.70	97.80	1326	95	1311
100	100.0	158.63	105.76	1434	100	1419
105	105.0	171.83	114.55	1554	105	1539

Pressure-Temperature Curve Calculation

(Core Not Critical)

Inputs:

Plant =	**Brunswick 2**	
Component =	**N16 A/B**	(2" Instrument Nozzles)
Vessel thickness, t =	**N/A**	inches (minimum)
M_t =	**N/A**	(per Figure G-2214-2 of App. G. mod. for E, α)
Vessel Radius, R =	**N/A**	inches (maximum)
RT_{NDT} =	**106.1**	°F ======> **32 EFPY**
ΔT_w =	**N/A**	°F (temp. difference between inside and outside surfaces)
K_{IT} =	**5.4**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**20.1**	°F (temperature difference between fluid and crack tip)
Stress Multiplier, F =	**N/A**	
Safety Factor =	**2.00**	(for heatup/cooldown)
M_m =	**N/A**	(per Figure G-2214-1 of App. G. assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	90.1	48.27	21.43	0	70	0
70	90.1	48.27	21.43	313	70	313
75	95.1	49.85	22.22	313	75	313
80	100.1	51.60	23.10	313	80	313
85	105.1	53.54	24.07	313	85	313
90	110.1	55.67	25.14	313	90	313
95	115.1	58.04	26.32	313	95	313
130	150.1	83.22	38.91	313	130	313
130	150.1	83.22	38.91	838	130	823
135	155.1	88.48	41.54	894	135	879
140	160.1	94.29	44.45	957	140	942
145	165.1	100.72	47.66	1026	145	1011
150	170.1	107.82	51.21	1103	150	1088
155	175.1	115.67	55.13	1187	155	1172
160	180.1	124.34	59.47	1280	160	1265
165	185.1	133.92	64.26	1384	165	1369
170	190.1	144.52	69.56	1498	170	1483
175	195.1	156.22	75.41	1624	175	1609

Pressure-Temperature Curve Calculation

(Core Not Critical)

Inputs:

Plant =	**Brunswick 2**	
Component =	**Bottom Head**	
Vessel thickness, t =	**5.420**	inches (minimum)
M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**110.3125**	inches (maximum)
RT_{NDT} =	**40.0**	°F ======> **All EFPYs**
ΔT_w =	**25.8**	°F (temp. difference between inside and outside surfaces)
K_{IT} =	**7.1**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**19.1**	°F (temperature difference between fluid and crack tip)
Stress Multiplier, F =	**1.50**	(for spherical bottom head with penetrations)
Safety Factor =	**2.00**	(for heatup/cooldown)
M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
0	19.1	46.85	19.89	0	70	0
5	24.1	48.29	20.60	281	70	266
10	29.1	49.87	21.40	292	70	277
15	34.1	51.63	22.27	304	70	289
20	39.1	53.56	23.24	317	70	302
25	44.1	55.71	24.31	332	70	317
30	49.1	58.07	25.50	348	70	333
35	54.1	60.69	26.80	366	70	351
40	59.1	63.58	28.25	386	70	371
45	64.1	66.77	29.85	407	70	392
50	69.1	70.31	31.61	431	70	416
55	74.1	74.21	33.56	458	70	443
60	79.1	78.52	35.72	488	70	473
65	84.1	83.29	38.10	520	70	505
70	89.1	88.56	40.74	556	70	541
75	94.1	94.38	43.65	596	75	581
80	99.1	100.81	46.87	640	80	625
85	104.1	107.92	50.42	688	85	673
90	109.1	115.78	54.35	742	90	727
95	114.1	124.47	58.69	801	95	786
100	119.1	134.06	63.49	867	100	852
105	124.1	144.67	68.80	939	105	924
110	129.1	156.40	74.66	1019	110	1004
115	134.1	169.35	81.14	1107	115	1092
120	139.1	183.67	88.30	1205	120	1190
125	144.1	199.50	96.21	1313	125	1298
130	149.1	200.00	96.46	1316	130	1301

Pressure-Temperature Curve Calculation

(Core Critical = Curve C)

Inputs:

Plant =	**Brunswick 2**	
EFPY =	**32**	
Curve A Leak Test Temperature =	**144.3**	°F (at 1,100 psig)
Hydro Test Pressure =	**1,565**	psig
Flange RT_{NDT} =	**10.0**	°F

Curve B Temperature N16 Nozzle (°F)	Curve B Pressure for N16 Nozzle (psig)	Curve B Temperature Bottom Head (°F)	Curve B Pressure for Bottom Head (psig)	Curve C Temperature N16 Nozzle (°F)	Curve C Pressure N16 Nozzle (psig)	Curve C Temperature Bottom Head (°F)	Curve C Pressure Bottom Head (psig)
70.0	0	0.0	0	70.0	0	70.0	0
70.0	313	5.0	266	70.0	313	70.0	266
75.0	313	10.0	277	75.0	313	70.0	277
80.0	313	15.0	289	80.0	313	70.0	289
85.0	313	20.0	302	85.0	313	70.0	302
90.0	313	25.0	317	90.0	313	70.0	317
95.0	313	30.0	333	95.0	313	70.0	333
130.0	313	35.0	351	170.0	313	75.0	351
130.0	823	40.0	371	170.0	823	80.0	371
135.0	879	45.0	392	175.0	879	85.0	392
140.0	942	50.0	416	180.0	942	90.0	416
145.0	1011	55.0	443	185.0	1011	95.0	443
150.0	1088	60.0	473	190.0	1088	100.0	473
155.0	1172	65.0	505	195.0	1172	105.0	505
160.0	1265	70.0	541	200.0	1265	110.0	541
165.0	1369	75.0	581	205.0	1369	115.0	581
170.0	1483	80.0	625	210.0	1483	120.0	625
175.0	1609	85.0	673	215.0	1609	125.0	673
		90.0	727			130.0	727
		95.0	786			135.0	786
		100.0	852			140.0	852
		105.0	924			145.0	924
		110.0	1004			150.0	1004
		115.0	1092			155.0	1092
		120.0	1190			160.0	1190
		125.0	1298			165.0	1298
		130.0	1301			170.0	1301

Pressure-Temperature Curve Calculation

(Pressure Test)

Inputs:

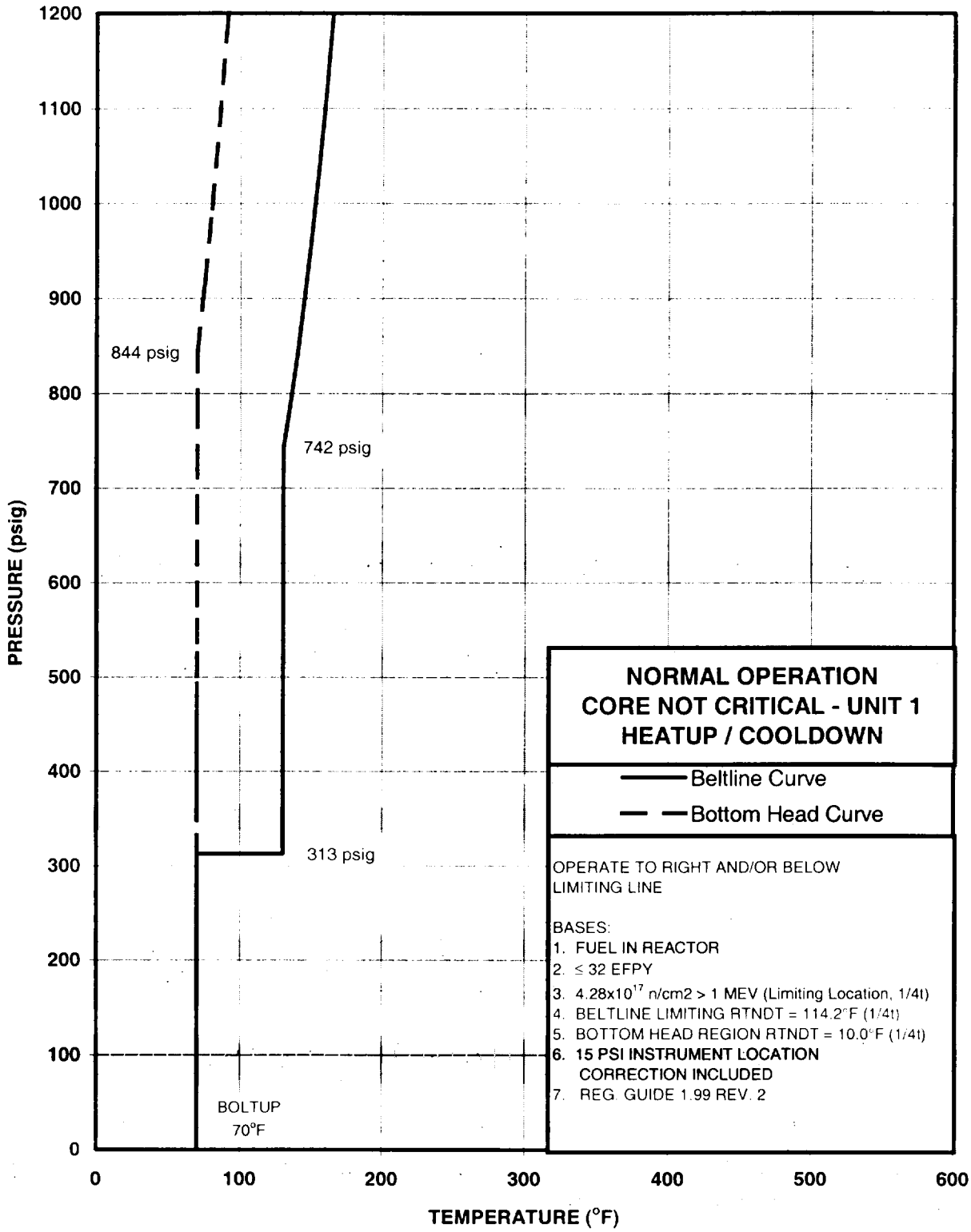
Plant =	**Brunswick 2**	
Component =	**N16 A/B**	(2" Instrument Nozzles)
Vessel thickness, t =	**N/A**	inches (minimum)
M_t =	**N/A**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**N/A**	inches (maximum)
RT_{NDT} =	**106.1**	°F ======> **32 EFPY**
ΔT_w =	**0.0**	°F (no thermal for pressure test)
K_{IT} =	**0.0**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**0.0**	°F (no thermal for pressure test)
Stress Multiplier, F =	**N/A**	
Safety Factor =	**1.50**	(for pressure test)
M_m =	**N/A**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F

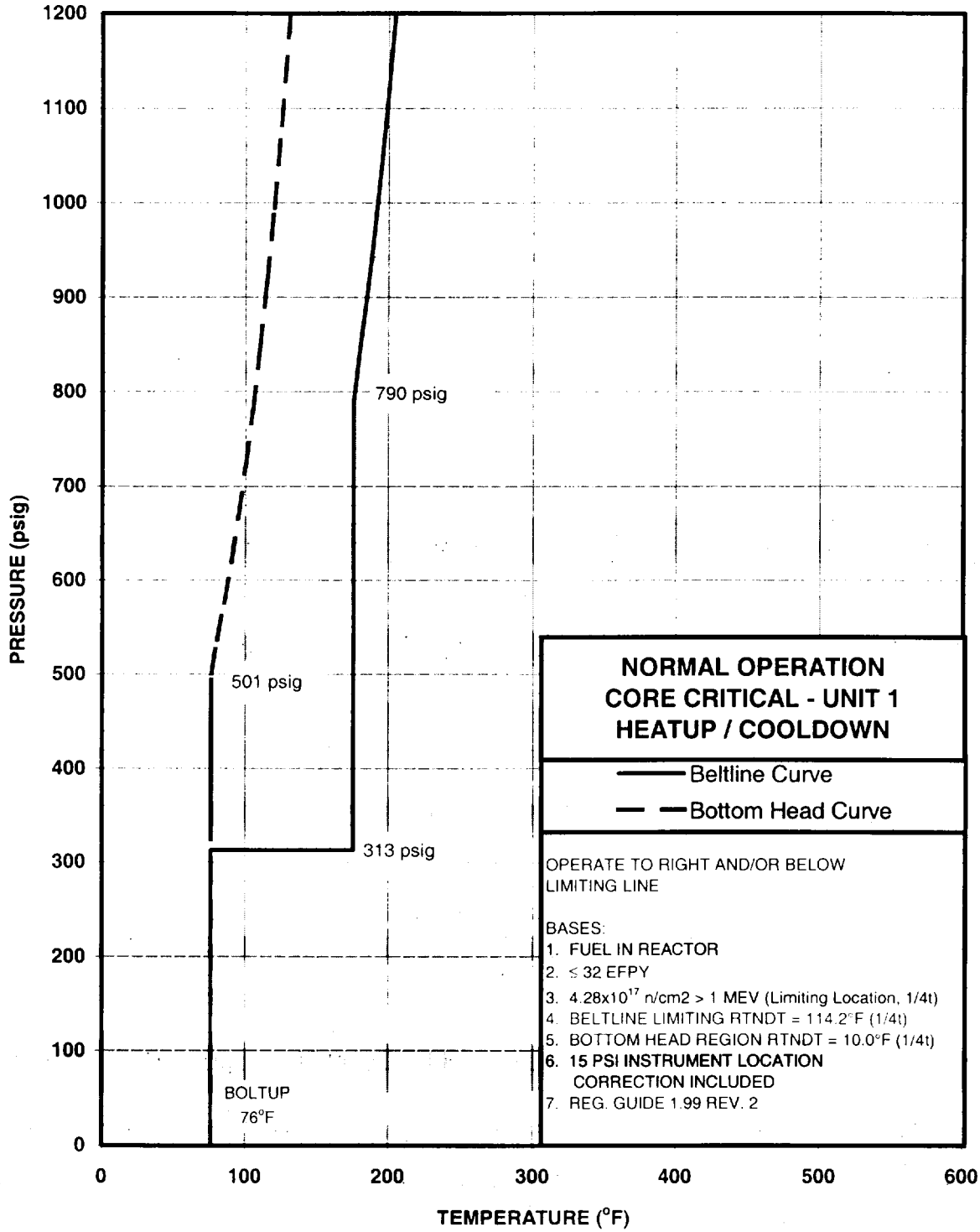
	Fluid Temperature T (°F)	**1/4t Temperature (°F)**	**K_{Ic} (ksi*inch$^{1/2}$)**	**K_{IP} (ksi*inch$^{1/2}$)**	**Calculated Pressure P (psig)**	**Adjusted Temperature for P-T Curve (°F)**	**Adjusted Pressure for P-T Curve (psig)**
25	70	70.0	43.27	28.85	0	70	0
26	70	70.0	43.27	28.85	313	70	313
27	75	75.0	44.33	29.55	313	75	313
28	80	80.0	45.50	30.33	313	80	313
29	85	85.0	46.80	31.20	313	85	313
30	90	90.0	48.23	32.15	313	90	313
31	95	95.0	49.81	33.20	313	95	313
32	100	100.0	51.55	34.37	313	100	313
33	100	100.0	51.55	34.37	740	100	725
34	105	105.0	53.48	35.66	768	105	753
35	110	110.0	55.62	37.08	798	110	783
36	115	115.0	57.97	38.65	832	115	817
37	120	120.0	60.58	40.39	870	120	855
38	125	125.0	63.46	42.31	911	125	896
39	130	130.0	66.64	44.43	957	130	942
40	135	135.0	70.16	46.77	1007	135	992
41	140	140.0	74.04	49.36	1063	140	1048
42	144.3	144.3	77.71	51.81	1115	144	1100
43	145	145.0	78.34	52.23	1124	145	1109
44	**150**	**150.0**	**83.09**	**55.39**	**1193**	**150**	**1178**
45	155	155.0	88.33	58.89	1268	155	1253
46	160	160.0	94.13	62.76	1351	160	1336
47	165	165.0	100.54	67.03	1443	165	1428
48	170	170.0	107.62	71.75	1545	170	1530

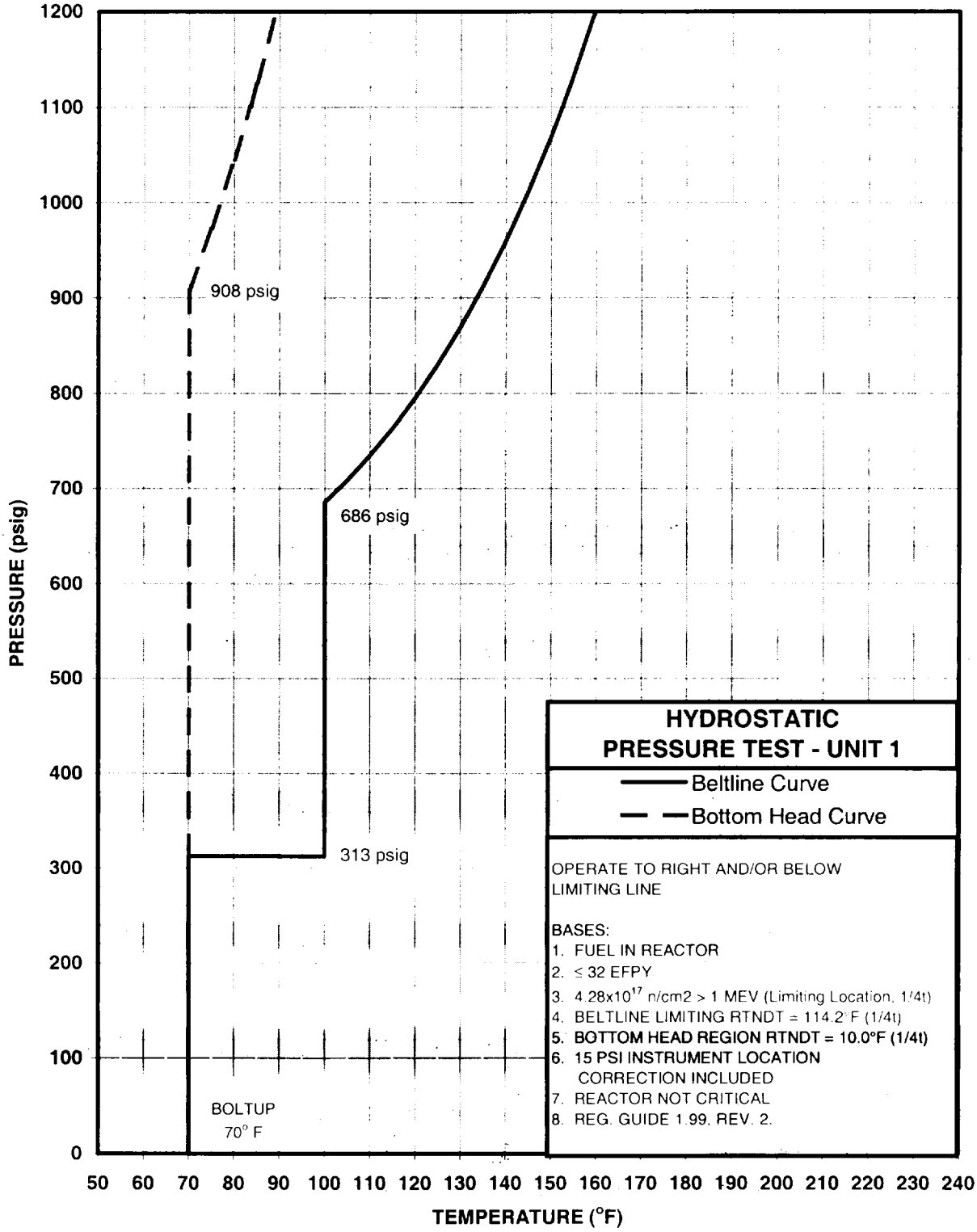
	A	B	C	D	E	F	G	H
1		***Pressure-Temperature Curve Calculation***						
2			*(Pressure Test)*					
3								
4	***Inputs:***		Plant =	**Brunswick 2**				
5			Component =	**Bottom Head**				
6		Vessel thickness, t =		**5.420**	inches (minimum)			
7			M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)			
8		Vessel Radius, R =		**110.3125**	inches (maximum)			
9			RT_{NDT} =	**40.0**	°F ======>	**All EFPYs**		
10			ΔT_w =	**0.0**	°F (no thermal for pressure test)			
11			K_{IT} =	**0.0**	ksi*inch$^{1/2}$			
12			$\Delta T_{1/4t}$ =	**0.0**	°F (no thermal for pressure test)			
13		Stress Multiplier, F =		**1.50**	(for spherical bottom head with penetrations)			
14			Safety Factor =	**1.50**	(for pressure test)			
15			M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)			
16		Temperature Instrument Error =		**0.0**	°F			
17		Pressure Instrument Error =		**15.0**	psig			
18		Hydro Test Pressure =		**1563**	psig			
19			Flange RT_{NDT} =	**10.0**	°F			
20								
21		**Fluid**				**Calculated**	**Adjusted**	**Adjusted**
22		**Temperature**	**1/4t**			**Pressure**	**Temperature**	**Pressure for**
23		**T**	**Temperature**	**K_{Ic}**	**K_{IP}**	**P**	**for P-T Curve**	**P-T Curve**
24		**(°F)**	**(°F)**	**(ksi*inch$^{1/2}$)**	**(ksi*inch$^{1/2}$)**	**(psig)**	**(°F)**	**(psig)**
25		70	70.0	70.98	47.32	0	70	0
26		70	70.0	70.98	47.32	646	70	631
27		75	75.0	74.95	49.97	682	75	667
28		80	80.0	79.34	52.90	722	80	707
29		85	85.0	84.20	56.13	766	85	751
30		90	90.0	89.56	59.71	815	90	800
31		95	95.0	95.49	63.66	869	95	854
32		100	100.0	102.04	68.03	928	100	913
33		105	105.0	109.28	72.85	994	105	979
34		110	110.0	117.28	78.19	1067	110	1052
35		113.1	113.1	122.66	81.77	1116	113	1101
36		115	115.0	126.12	84.08	1148	115	1133
37		120	120.0	135.90	90.60	1236	120	1221
38		125	125.0	146.70	97.80	1335	125	1320
39		130	130.0	158.63	105.76	1443	130	1428
40		135	135.0	171.83	114.55	1563	135	1548

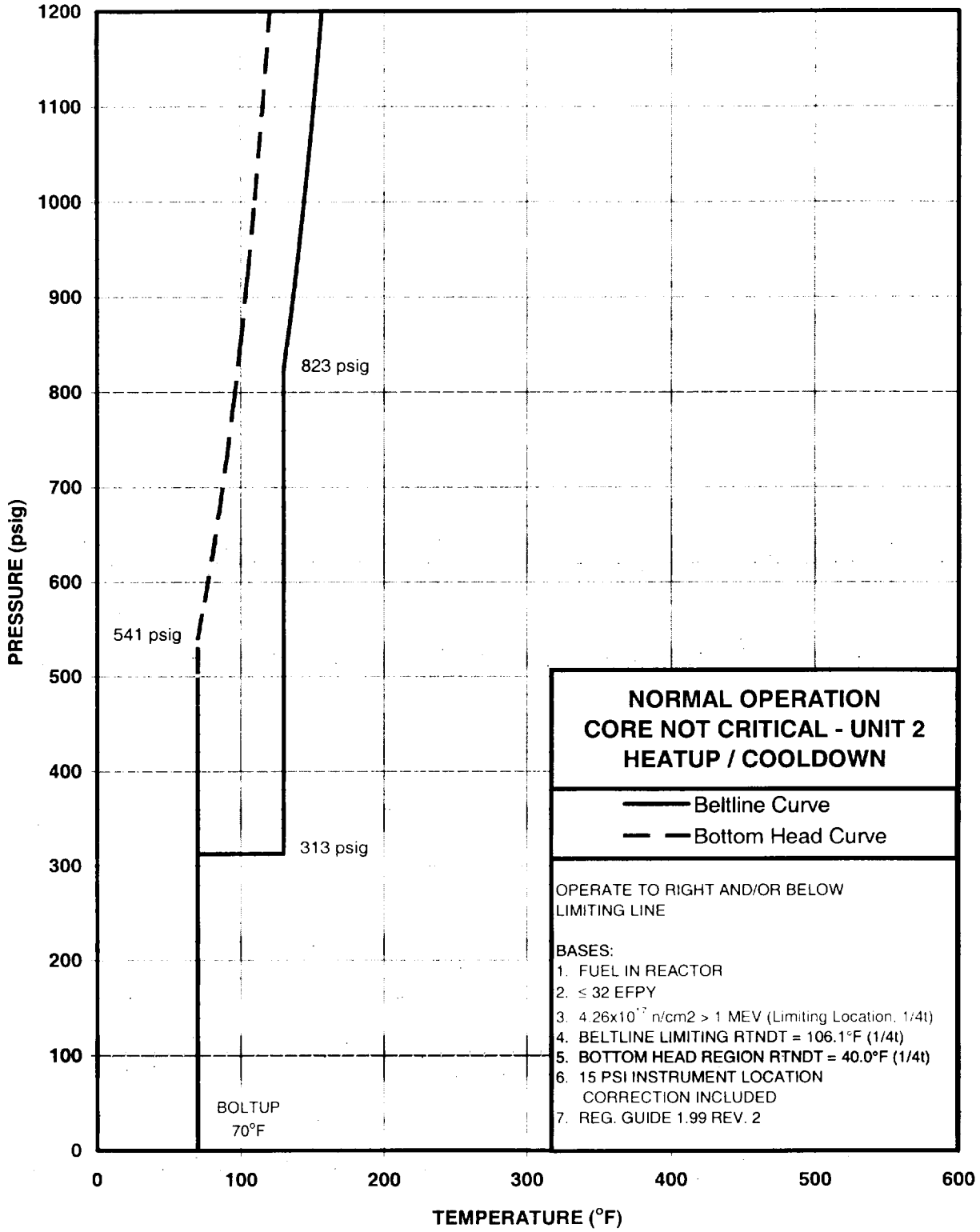
ATTACHMENT 2

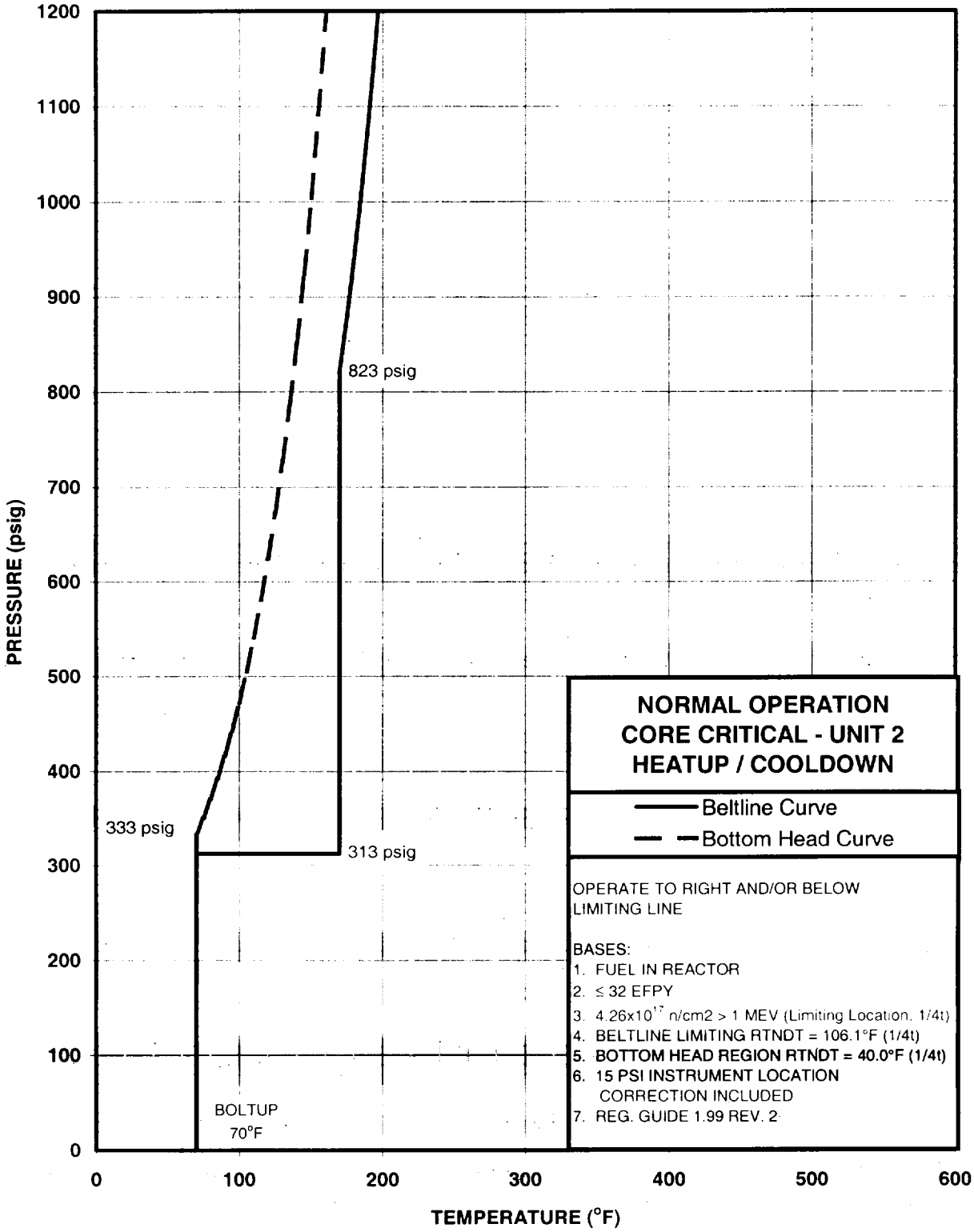
Pressure Temperature Curves
(following 6 pages)

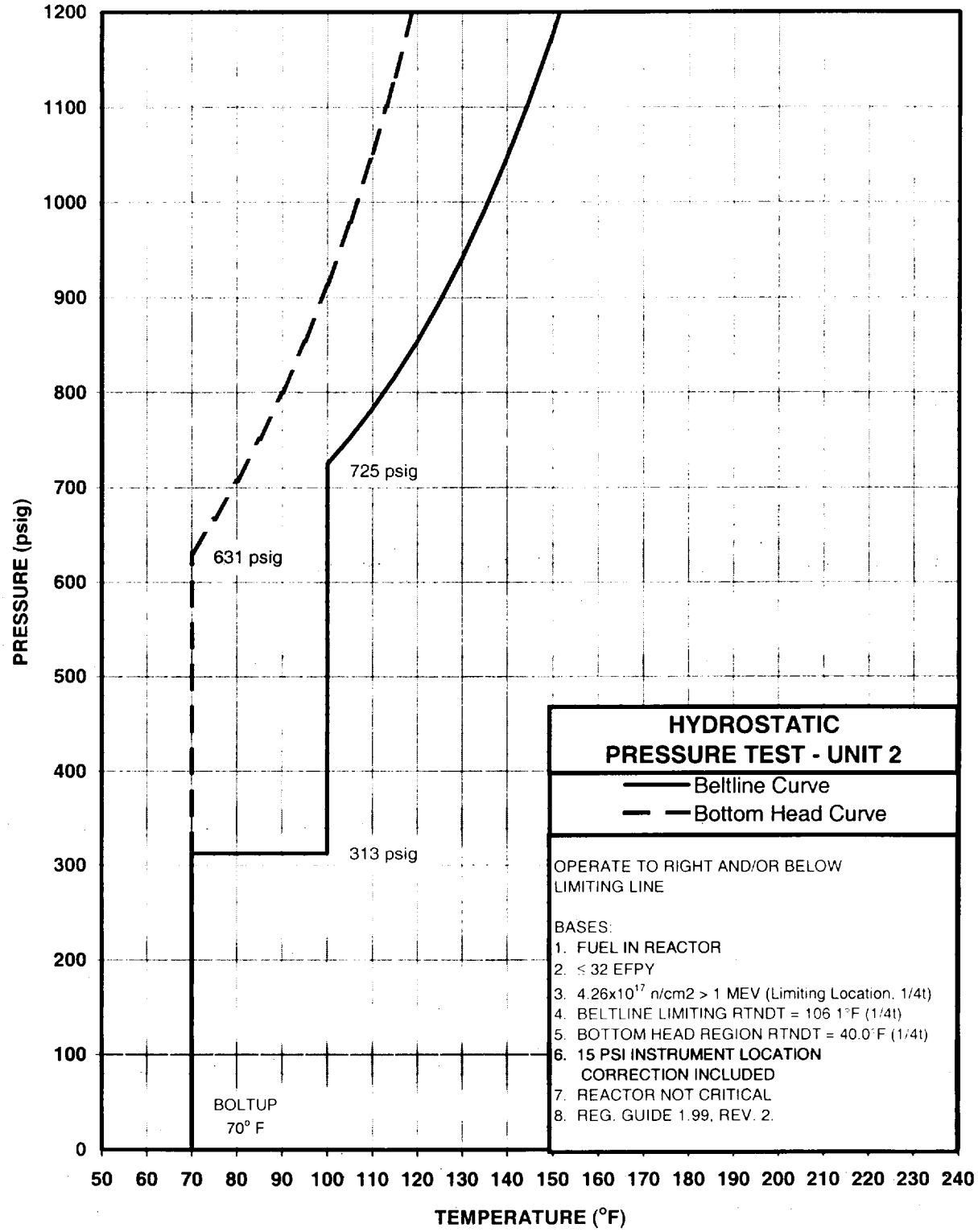

1200
1100
1000
900
800
700
600
500
400
300
200
100
0
PRESSURE (psig)
0
100
200
300
400
500
600
TEMPERATURE (°F)
844 psig
742 psig
313 psig
BOLTUP
70°F
NORMAL OPERATION
CORE NOT CRITICAL - UNIT 1
HEATUP / COOLDOWN
Beltline Curve
Bottom Head Curve
OPERATE TO RIGHT AND/OR BELOW
LIMITING LINE
BASES:
1. FUEL IN REACTOR
2. ≤ 32 EFPY
3. 4.28x10^17 n/cm2 > 1 MEV (Limiting Location, 1/4t)
4. BELTLINE LIMITING RTNDT = 114.2°F (1/4t)
5. BOTTOM HEAD REGION RTNDT = 10.0°F (1/4t)
6. 15 PSI INSTRUMENT LOCATION
CORRECTION INCLUDED
7. REG. GUIDE 1.99 REV. 2


1200
1100
1000
900
800
700
600
500
400
300
200
100
0
PRESSURE (psig)
0
100
200
300
400
500
600
TEMPERATURE (°F)
790 psig
501 psig
313 psig
BOLTUP
76°F
NORMAL OPERATION
CORE CRITICAL - UNIT 1
HEATUP / COOLDOWN
Beltline Curve
Bottom Head Curve
OPERATE TO RIGHT AND/OR BELOW
LIMITING LINE
BASES:
1. FUEL IN REACTOR
2. ≤ 32 EFPY
3. 4.28x10^17 n/cm2 > 1 MEV (Limiting Location, 1/4t)
4. BELTLINE LIMITING RTNDT = 114.2°F (1/4t)
5. BOTTOM HEAD REGION RTNDT = 10.0°F (1/4t)
6. 15 PSI INSTRUMENT LOCATION
CORRECTION INCLUDED
7. REG. GUIDE 1.99 REV. 2


1200
1100
1000
900
800
700
600
500
400
300
200
100
0
PRESSURE (psig)
908 psig
686 psig
313 psig
BOLTUP
70° F
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240
TEMPERATURE (°F)
HYDROSTATIC
PRESSURE TEST - UNIT 1
Beltline Curve
Bottom Head Curve
OPERATE TO RIGHT AND/OR BELOW
LIMITING LINE
BASES:
1. FUEL IN REACTOR
2. ≤ 32 EFPY
3. 4.28x10^17 n/cm2 > 1 MEV (Limiting Location, 1/4t)
4. BELTLINE LIMITING RTNDT = 114.2°F (1/4t)
5. BOTTOM HEAD REGION RTNDT = 10.0°F (1/4t)
6. 15 PSI INSTRUMENT LOCATION
CORRECTION INCLUDED
7. REACTOR NOT CRITICAL
8. REG. GUIDE 1.99, REV. 2.


1200
1100
1000
900
800
700
600
500
400
300
200
100
0
PRESSURE (psig)
0
100
200
300
400
500
600
TEMPERATURE (°F)
823 psig
541 psig
313 psig
BOLTUP
70°F
NORMAL OPERATION
CORE NOT CRITICAL - UNIT 2
HEATUP / COOLDOWN
Beltline Curve
Bottom Head Curve
OPERATE TO RIGHT AND/OR BELOW
LIMITING LINE
BASES:
1. FUEL IN REACTOR
2. ≤ 32 EFPY
3. 4.26x10^17 n/cm2 > 1 MEV (Limiting Location, 1/4t)
4. BELTLINE LIMITING RTNDT = 106.1°F (1/4t)
5. BOTTOM HEAD REGION RTNDT = 40.0°F (1/4t)
6. 15 PSI INSTRUMENT LOCATION
CORRECTION INCLUDED
7. REG. GUIDE 1.99 REV. 2


1200
1100
1000
900
800
700
600
500
400
300
200
100
0
PRESSURE (psig)
0
100
200
300
400
500
600
TEMPERATURE (°F)
823 psig
333 psig
313 psig
BOLTUP
70°F
NORMAL OPERATION
CORE CRITICAL - UNIT 2
HEATUP / COOLDOWN
Beltline Curve
Bottom Head Curve
OPERATE TO RIGHT AND/OR BELOW
LIMITING LINE
BASES:
1. FUEL IN REACTOR
2. ≤ 32 EFPY
3. 4.26x10^17 n/cm2 > 1 MEV (Limiting Location, 1/4t)
4. BELTLINE LIMITING RTNDT = 106.1°F (1/4t)
5. BOTTOM HEAD REGION RTNDT = 40.0°F (1/4t)
6. 15 PSI INSTRUMENT LOCATION
CORRECTION INCLUDED
7. REG. GUIDE 1.99 REV. 2


PRESSURE (psig)
TEMPERATURE (°F)
725 psig
631 psig
313 psig
BOLTUP
70° F
HYDROSTATIC
PRESSURE TEST - UNIT 2
Beltline Curve
Bottom Head Curve
OPERATE TO RIGHT AND/OR BELOW
LIMITING LINE
BASES:
1. FUEL IN REACTOR
2. ≤ 32 EFPY
3. 4.26x10^17 n/cm2 > 1 MEV (Limiting Location, 1/4t)
4. BELTLINE LIMITING RTNDT = 106.1°F (1/4t)
5. BOTTOM HEAD REGION RTNDT = 40.0°F (1/4t)
6. 15 PSI INSTRUMENT LOCATION
CORRECTION INCLUDED
7. REACTOR NOT CRITICAL
8. REG. GUIDE 1.99, REV. 2.

ATTACHMENT 3

Calculation Indexing Table
(following page)

CALCULATION INDEXING TABLE

FORM 0ENP-303-2 (11/99)

(For the purpose of creating cross references to documents in NRCS and equipment in EDBS)

Kind of Plant Document i.e. Calc, Drwg, EDBS, Procedure, Etc.	Document, Software or Tag Number	Input or Output	Description of Relationship to Subject Calc. (Basis for Cross-Reference)
Report	Structural Integrity Report No. SIR-00-132, Revision 0.	Input	This report summarizes the results of the calculations performed by Structural Integrity Associates in development of the Brunswick pressure-temperature curves.
Calculation	Structural Integrity Associates Calculation No. CPL-54Q-303, Revision 0.	Input	Development of Updated Pressure-Temperature Curves for 32 Effective Full Power Years (EFPY).
Calculation	Structural Integrity Associates Calculation No. CPL-36Q-306, Revision 0.	Input	Evaluation of BSEP Unit 1 P-T Curves for Heat-up and Cooldown.
Calculation	Structural Integrity Associates Calculation No. CPL-42Q-302, Revision 1.	Input	Brunswick Units 1 and 2 Hydro Test P-T Curve Development
Report	Structural Integrity Associates Report No. SIR-95-130, Revision 1.	Input	This report provided input for the determination of material RT_{NDTs} for Unit 2.
Calculation	Structural Integrity Associates Calculation No. CPL-36Q-305, Revision 0.	Input	Cool-down Temperature/Stress Analysis of the N16 Nozzle at Brunswick Unit 1.

ATTACHMENT 4

Structural Integrity Associates
Report No. SIR-00-132, Rev. 0
Brunswick Pressure-Temperature Curves
with Owner Review
(31 pages following)

Structural Integrity Associates, Inc.

6595 S. Dayton Street
Suite 2400
Englewood, CO 80111-6128
Phone 303-792-0077
Fax 303-792-2158
www.structint.com
gstevens@structint.com

October 19, 2000
GLS-00-072
SIR-00-132, Rev. 0

Mr. Blane Wilton
Brunswick Steam Electric Plant
Carolina Power & Light Company
P.O. Box 10429
Southport, NC 28461

Subject: Brunswick Pressure-Temperature Curves.

Dear Blane:

The Reference [1] calculation (attached) documents the revised set of pressure-temperature (P-T) curves developed for the Brunswick Steam Electric Plant, Units 1 and 2 (BSEP-1 and BSEP-2). This work was performed in accordance with the referenced contract, and includes a full set of updated P-T curves (i.e., pressure test, core not critical, and core critical conditions) for both BSEP units for 32 effective full power years (EFPY). The curves were developed in accordance with the 1989 ASME Code, Section XI, Appendix G [2] and ASME Code Case N-640 [3], which allows the use of K_{Ic} for the allowable material fracture toughness.

The inputs, methodology, and results for this effort are summarized in the sections that follow.

RT_{NDT} DETERMINATION

RT_{NDT} estimates were developed for the BSEP reactor pressure vessel (RPV) materials in accordance with Regulatory Guide 1.99, Revision 2 (RG 1.99) [4] for 32 EFPY, and are shown in Table 1 for both BSEP units. The inputs used for the calculations were based on the data documented in Reference [5]. The fluence estimates used in Table 1 have been scaled appropriately to account for future planned power uprates at both BSEP units.

P-T CURVE METHODOLOGY

The P-T curve methodology is based on the requirements of References [2], [3], [6], and [7]. The approach used for calculating the P-T curves is summarized below:

a. Assume a fluid temperature, T.

b. For the temperature, T, assumed in step (a), compute the temperature at the assumed flaw tip, $T_{1/4t}$ (i.e., 1/4t into the vessel wall). This is accomplished by

Charlotte, NC 704-573-1369 | N. Stonington, CT 860-599-6050 | Pompano Beach, FL 954-917-2781 | Rockville, MD 301-231-7746 | San Jose, CA 408-978-8200 | Uniontown, OH 330-899-9753

adding a temperature drop term, $\Delta T_{1/4t}$, to T. The value of $\Delta T_{1/4t}$ is zero for the pressure test P-T curves (e.g., these tests are essentially isothermal), and is determined via heat transfer analysis for the other curves.

c. Calculate the allowable stress intensity factor, K_{IC} (as allowed per Reference [3]), based on $T_{1/4t}$ using the following relationship:

$$K_{IC} = 20.734\, e^{[0.02\,(T-ART)]} + 33.2$$

where:

T	=	$T_{1/4t}$ (°F)
ART	=	adjusted reference temperature for location under consideration and desired EFPY from Table 1 (°F)
K_{IC}	=	allowable stress intensity factor (ksi√inch)

d. Calculate the allowable pressure stress intensity factor, K_{IP}, using the appropriate relationship for the P-T curve under consideration:

$K_{IP} = K_{IC}/1.5$	for Curve A (i.e., pressure-test curve)
$K_{IP} = (K_{IC}-K_{IT})/2.0$	for Curves B and C (i.e., core not critical and core critical curves)

where:

K_{IT}	=	thermal stress intensity factor (ksi√inch)
	=	$M_t \times \Delta T_w$ per Figure G-2214-2 of Reference [2] for the beltline and bottom head regions.
	=	5.4 ksi√inch for the N16A/B nozzles based on finite element analysis
ΔT_w	=	through-wall temperature drop, determined by heat transfer analysis (°F)
M_t	=	factor from Figure G-2214-2 of Reference [2]
K_{IP}	=	allowable pressure stress intensity factor (ksi√inch)

e. Compute the pressure, P. The relationship for the pressure, P, to the allowable pressure stress intensity factor, K_{IP}, is as follows:

$$K_{IP} = M_m\, \sigma_m + M_b\, \sigma_b$$

where:

M_m	=	membrane stress correction factor from Figure G-2214-1 of Reference [2]
σ_m	=	membrane stress due to pressure (ksi)
	=	PR/t for the beltline region.

	=	3.0PR/(2t) = 1.5PR/t for the spherical bottom head assuming a stress concentration factor of 3.0 for the bottom head penetrations. For the N16A/B nozzles, K_{IP} was determined directly based on finite element results, as shown below.
P	=	pressure (ksi)
R	=	maximum vessel radius (inches)
t	=	minimum vessel wall thickness (inches)
M_b	=	bending stress correction factor = $(2/3)M_m$
σ_b	=	bending stress due to pressure (ksi)
	=	0 for a thin-walled vessel

Thus, $P = K_{IP}t/(RM_m)$ for the beltline region
$P = K_{IP}t/(1.5RM_m)$ for the bottom head region
$P = 21.53\ K_{IP}$ for the N16A/B nozzles based on finite element analysis

f. Repeat steps (a) through (e) for other temperatures to generate a series of P-T points for each region.

g. Subtract any applicable instrument errors for temperature and pressure from T and P, respectively. The resulting pressure and temperature series constitutes the P-T curve. The P-T curve relates the minimum required reactor fluid temperature to the reactor pressure for each region.

The following additional requirements were used to define the lower portion of the P-T curves. These limits are established by the discontinuity regions of the vessel (i.e., flanges), and are specified in Reference [6]:

For Pressure Test Conditions:

- Thermal stresses were assumed to be negligible during the pressure test condition and were therefore not considered.
- If P is greater than 20% of the pre-service hydro test pressure, the temperature must be greater than RT_{NDT} of the limiting flange material + 90°F. The pre-service hydro test pressure was 1,563 psig.
- If P is less than or equal to 20% of the pre-service hydro test pressure, the minimum temperature is typically greater than or equal to the RT_{NDT} of the limiting flange material + 60°F. The additional 60°F margin above that recommended in Reference [6] has been a standard recommendation by GE for the BWR industry. For the BSEP flange material, this minimum temperature would be 76°F (i.e., 16 + 60°F) for Unit 1, and 70°F (i.e., 10 + 60°F) for Unit 2. Since the 60°F margin is only a recommendation,

the minimum temperature for Unit 1 was set to 70°F to match Unit 2 and be consistent with past work.

For Core Not Critical Conditions:

- If P is greater than 20% of the pre-service hydro test pressure, the temperature must be greater than RT_{NDT} of the limiting flange material + 120°F.
- If P is less than or equal to 20% of the pre-service hydro test pressure, the minimum temperature is typically greater than or equal to the RT_{NDT} of the limiting flange material + 60°F. The additional 60°F margin above that recommended in Reference [6] has been a standard recommendation by GE for the BWR industry. For the BSEP flange material, this minimum temperature is 70°F for Unit 1 and 70°F for Unit 2, as identified above.

For Core Critical Conditions:

- Per the requirements of Table 1 of Reference [6], the core critical P-T limits must be 40°F above any Pressure Test or Core Not Critical curve limits. Core Not Critical conditions are more limiting than Pressure Test conditions, so Core Critical conditions are equal to Core Not Critical conditions plus 40°F.
- Another requirement of Table 1 of Reference [6] (or actually an allowance for the BWR), concerns minimum temperature for initial criticality in a startup. Given that water level is normal, BWRs are allowed initial criticality at the closure flange region temperature (RT_{NDT} + 60°F) if the pressure is below 20% of the pre-service hydro test pressure. This corresponds to 76°F for Unit 1 and 70°F for Unit 2, as identified above.
- Also per Table 1 of Reference [6], at pressures above 20% of the pre-service hydro test pressure, the Core Critical curve temperature must be at least that required for the pressure test (Pressure Test Curve at a conservative value of 1,100 psig). As a result of this requirement, the Core Critical curve must have a step at a pressure equal to 20% of the pre-service hydro pressure to the temperature required by the Pressure Test curve at 1,100 psig, or 40°F, whichever is greater.

HEAT TRANSFER ANALYSIS

Heat transfer analysis was undertaken to estimate the ΔT_w and $\Delta T_{1/4t}$ terms identified above. The P-T curves are developed considering a 100°F/hr heatup/cooldown. Therefore, a 100°F/hr cooldown from 550°F to 120°F was evaluated. Material properties were taken from the ASME Code [8] at an approximate average temperature of 350°F. The results at the end of the cooldown were conservatively selected so that maximum steady state temperature differences were achieved.

The heat transfer analysis results for all regions, including those for the N16A/B nozzles, are shown in Table 2.

P-T CURVES

The resulting P-T curves and the detailed input and output are contained in Appendix A for BSEP-1, and Appendix B for BSEP-2. Only the limiting curves that represent both the N16A/B nozzles and beltline are plotted for all cases, as the N16A/B nozzles are limiting for the beltline region.

DEMONSTRATION OF BOUNDING ASSESSMENT FOR BOTTOM HEAD

Recent questions from the U. S. Nuclear Regulatory Commission (NRC) have indicated that updated P-T curves should bound any heatup/cooldown rate expected in the bottom head region during a transient event. The NRC bases their position on the definition of an "Anticipated Operational Occurrence" (AOO) in 10CFR50 Appendix A [9], which states: "Anticipated operational occurrences mean those conditions of normal operation which are expected to occur one or more times during the life of the nuclear power unit and include but are not limited to loss of power to all recirculation pumps, tripping of the turbine generator set, isolation of the main condenser, and loss of all offsite power."

Since Brunswick has experienced transient events in which the heatup\cooldown rate in the bottom head region exceeded 100°F/hr, these events may be considered by the NRC to be AOOs. Therefore, the bottom head P-T curves should be developed to account for the maximum heatup/cooldown rate expected. Therefore, an evaluation was performed to assess the adequacy of the 100°F/hr heatup/cooldown rate used in the development of the BSEP P-T curves with respect to AOOs in the bottom head region. The transient shown in Figure 1 was previously established as a bounding transient for the bottom head region for the BSEP reactors [10, 11], and was used as a basis for this evaluation.

In order to evaluate the alternate transient shown in Figure 1, two assessments were made: (1) an assessment for the bottom head region for pressure test conditions, and (2) assessment of transient conditions for the bottom head region for heatup/cooldown conditions.

Assessment of the BSEP-1 bottom head for pressure test conditions is shown in Figure 2, and for heatup/cooldown conditions is shown in Figure 3. In each figure, the existing Tech. Spec. P-T curve (labeled as "Tech Spec"), an independently derived version of the existing Tech. Spec. P-T curve (labeled as "Fixed-ID"), and a P-T curve developed using the alternate transient shown in Figure 1 (labeled as "Allow, ID") are included. Since these results are comparative in nature, the same conclusions are applicable for BSEP-2.

CONCLUSIONS

Based on the results shown in Figures 2 and 3, the following conclusions can be made:

- The P-T curves for a fixed rate of 100°F/hr are bounding compared to the alternate cooldown transient shown in Figure 1. These curves bound all expected operating conditions for the bottom head region, including the transient defined in Figure 1. The transient defined in Figure 1 was developed specifically to cover inadvertent cooldown events in the bottom head region, and to bound all actual operating conditions in the bottom head region.
- Referring to Figure 1, cooldown rates as high as 882°F/hr in the bottom head region have been accommodated. This rate is expected to cover all anticipated operating conditions. Step heatups of 317°F in one minute are also bounded by this assessment, as discussed in References [10] and [11]. Any events that exceed these rates, which is unlikely, are monitored via the Technical Specification pressure-temperature limit tracking procedures, coupled with ASME Code, Section XI, Appendix E evaluation procedures.
- These results are consistent with the conclusions in ASME Code, Section XI, Appendix G [2], where solutions are provided for heatup/cooldown rates of 100°F/hr or less. Appendix G states that "the results would be overly conservative if applied to rapid temperature changes."
- Revised P-T curves for both Brunswick units are contained in Appendices A and B. The bottom head curves for both Brunswick units bound all anticipated operating conditions.

This letter report completes all work associated with the Reference [12] contract. Please don't hesitate to call me if you have any questions.

Prepared By: Gary L. Stevens
Gary L. Stevens, P. E.
Vice President

Reviewed By: Julie A. Hofmann
J. A. Hofmann
Principal Engineer

Approved By: Gary L. Stevens
Gary L. Stevens, P. E.
Vice President

gls
Attachment
cc: CPL-54Q-106, -402

REFERENCES

1. Structural Integrity Associates Calculation No. CPL-54Q-303, Revision 0, "Re-Compilation of P-T Curves for Brunswick 1 and 2," 10/19/00.

2. ASME Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, Nonmandatory Appendix G, "Fracture Toughness Criteria for Protection Against Failure," 1989 Edition, No Addenda.

3. ASME Boiler and Pressure Vessel Code, Code Case N-640, "Alternative Reference Fracture Toughness for Development of P-T Limit Curves," Section XI, Division 1, Approved February 26, 1999.

4. USNRC Regulatory Guide 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials," U. S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, (Task ME 305-4), May 1988.

5. E-mail from Phil Gore (CP&L) to Gary Stevens (SI), "RE: Fluence Estimates for PT Curve Work.xls," 10/10/00, 11:31 AM, with attached Word Document "95-0572.doc" and Excel Spreadsheet "Fluence Estimates for PT Curve Work.xls," SI File No. CPL-54Q-201.

6. U. S. Code of Federal Regulations, Title 10, Part 50, Appendix G, "Fracture Toughness Requirements," 1-1-98 Edition.

7. WRC Bulletin 175, "PVRC Recommendations on Toughness Requirements for Ferritic Materials," PVRC Ad Hoc Group on Toughness Requirements, Welding Research Council, August 1972.

8. ASME Boiler and Pressure Vessel Code, Section III, Rules for Construction of Nuclear Power Plant Components, Appendices, 1989 Edition, No Addenda.

9. U. S. Code of Federal Regulations, Title 10, Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," 1/1/98.

10. Structural Integrity Associates Calculation No. CPL-40Q-305, Revision 1, "Fracture Toughness Assessment of Bottom Head."

11. Structural Integrity Associates Report No. SIR-96-010, Revision 0, "Justification to Relax Requirements for Recirculation Pump Restart Following a Scram Event Brunswick Steam Electric Plant Units 1 and 2," SI File No. CPL-40Q-401.

12. CP&L Purchase Order No. XTA 5000213, Amendment No. XTA 5000213A6, Task Work Authorization Letter No. 00045B, Revision 1, 10/9/2000.

Table 1
RT_{NDT} Estimates for BSEP

Brunswick Unit 1 Limiting RPV Material Summary

Part Name & Material	MK No.	Heat No.	Slab or Lot No.	Estimated Initial RT_{NDT} (°F)	Chemistry Cu (wt %)	Chemistry Ni (wt %)	Chemistry Factor (°F)	Adjustments For 1/4t: ΔRT_{NDT} (°F)	Margin Terms σ_Δ (°F)	Margin Terms σ_I (°F)	EFPY	ART_{NDT} (°F)
FLANGE REGION (Shell Flange)	600	BV-3085	AFB176	16	0.09	0.88	N/A	N/A	N/A	0.0	32.0	16.0
BOTTOM HEAD	101	C4654	3	10	NR	0.55	N/A	N/A	N/A	0.0	32.0	10.0
NOTE	The adjusted reference temperature values are the same for all EFPYs for the above locations since there are no significant irradiation effects											
BELTLINE (Lower Int. Shell)	351	B8496	1	10	0.19	0.58	139.8	62.3	17.0	0.0	32.0	106.3
BELTLINE (N16A/B Nozzles)	302	Q2Q1VW	247P-4A,4B	48	0.16	0.82	123.2	33.1	16.6	0.0	32.0	114.2

Fluence Information:

Location	Wall Thickness (inches) Full	Wall Thickness (inches) 1/4t	EFPY	Fluence at ID (n/cm²)	Attenuation, 1/4t $e^{-0.24x}$	Fluence @ 1/4t (n/cm²)	Fluence Factor, FF $f^{(0.28-0.10\log f)}$
(Lower Int. Shell)	5.496	1.374	32.0	1.60E+18	0.719	1.15E+18	0.446
(N16A/B Nozzles)	5.496	1.374	32.0	5.95E+17	0.719	4.28E+17	0.269

Brunswick Unit 2 Limiting RPV Material Summary

Part Name & Material	MK No.	Heat No.	Slab or Lot No.	Estimated Initial RT_{NDT} (°F)	Chemistry Cu (wt %)	Chemistry Ni (wt %)	Chemistry Factor (°F)	Adjustments For 1/4t: ΔRT_{NDT} (°F)	Margin Terms σ_Δ (°F)	Margin Terms σ_I (°F)	EFPY	ART_{NDT} (°F)
FLANGE REGION (Top Head Flange)	706	1L-3335	AYT-173	10	0.11	0.80	N/A	N/A	N/A	0.0	32.0	10.0
BOTTOM HEAD	102	C4890	1A	40	NR	0.56	N/A	N/A	N/A	0.0	32.0	40.0
NOTE	The adjusted reference temperature values are the same for all EFPYs for the above locations since there are no significant irradiation effects											
BELTLINE (Lower Shell)	201	C4500	2	10	0.15	0.54	106.7	41.1	17.0	0.0	32.0	85.1
BELTLINE (N16A/B Nozzles)	302	Q2Q1VW	247P-3A,3B	40	0.16	0.82	123.2	33.0	16.5	0.0	32.0	106.1

Fluence Information:

Location	Wall Thickness (inches) Full	Wall Thickness (inches) 1/4t	EFPY	Fluence at ID (n/cm²)	Attenuation, 1/4t $e^{-0.24x}$	Fluence @ 1/4t (n/cm²)	Fluence Factor, FF $f^{(0.28-0.10\log f)}$
(Lower Shell)	5.466	1.367	32.0	1.18E+18	0.720	8.50E+17	0.385
(N16A/B Nozzles)	5.466	1.367	32.0	5.91E+17	0.720	4.26E+17	0.268

Table 2
Results of Heat Transfer Analysis

Variable	Beltline	Bottom Head	N16A/B Nozzles
ΔT_w (1)	Unit 1: 154.3 - 127.8 = 26.5°F Unit 2: 154.0 - 127.8 = 26.2°F	Unit 1: 153.2 - 127.7 = 25.5°F Unit 2: 153.5 - 127.7 = 25.8°F	Not required -- finite element solution used.
$\Delta T_{1/4t}$ (2)	Unit 1: 139.5 - 120.0 = 19.5°F Unit 2: 139.3 - 120.0 = 19.3°F	Unit 1: 138.9 - 120.0 = 18.9°F Unit 2: 139.1 - 120.0 = 19.1°F	Unit 1: 20.13°F Unit 2: 20.13°F
K_{IT}	Calc. per ASME Code, Section XI, App. G	Calc. per ASME Code, Section XI, App. G	Unit 1: 5.4 ksi√inch Unit 2: 5.4 ksi√inch

Notes:
1. ΔT_w is the temperature drop across the vessel wall, i.e., outside surface temperature - inside surface temperature.
2. $\Delta T_{1/4t}$ is the temperature difference between the fluid and the 1/4t location.

Figure 1: Alternate Cooldown Transient for BSEP Bottom Head Region

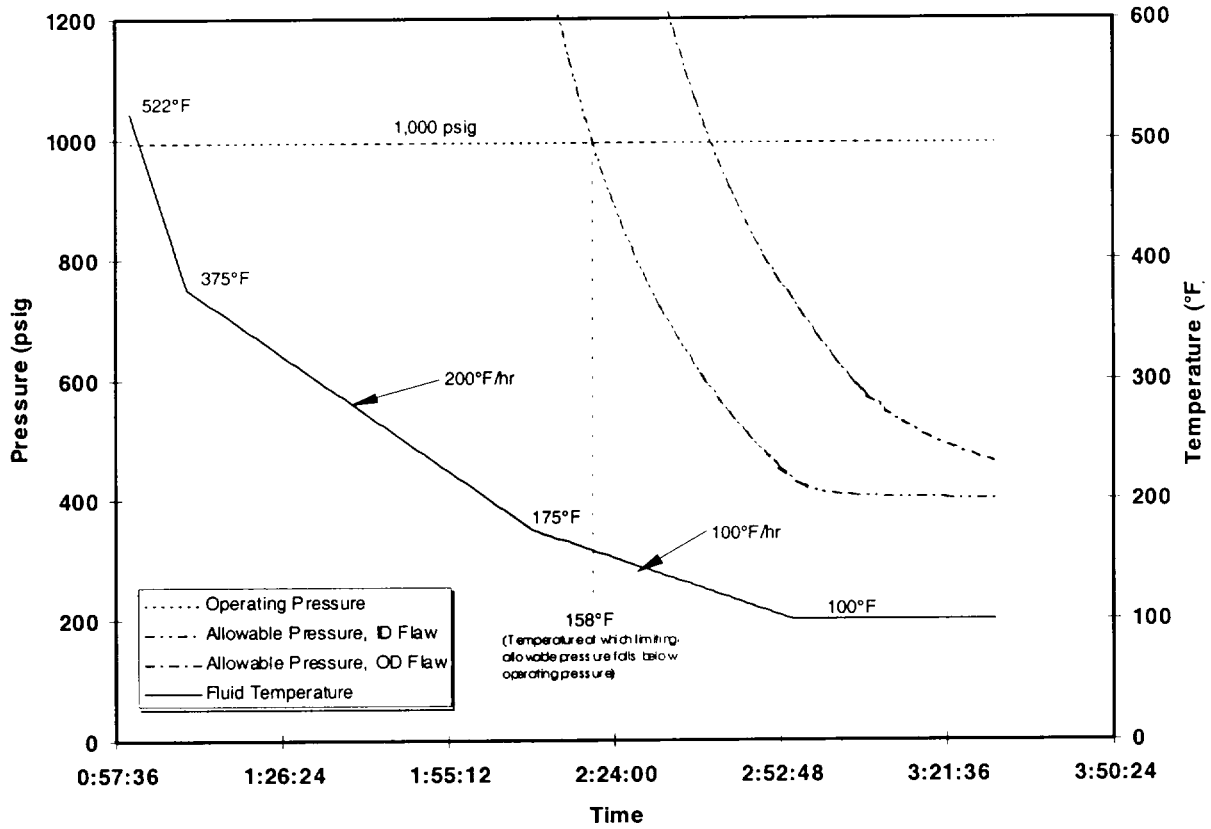


Figure 2: Pressure-Temperature Results for Pressure Test Conditions

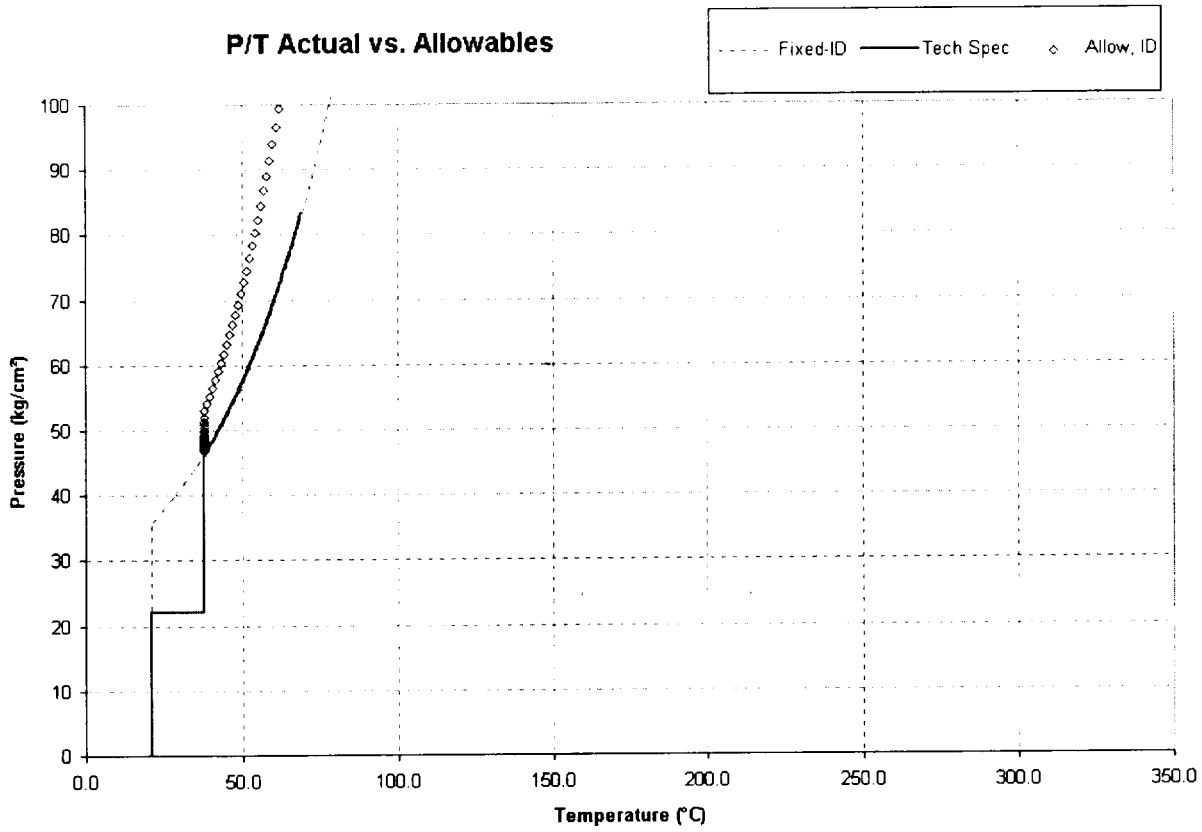
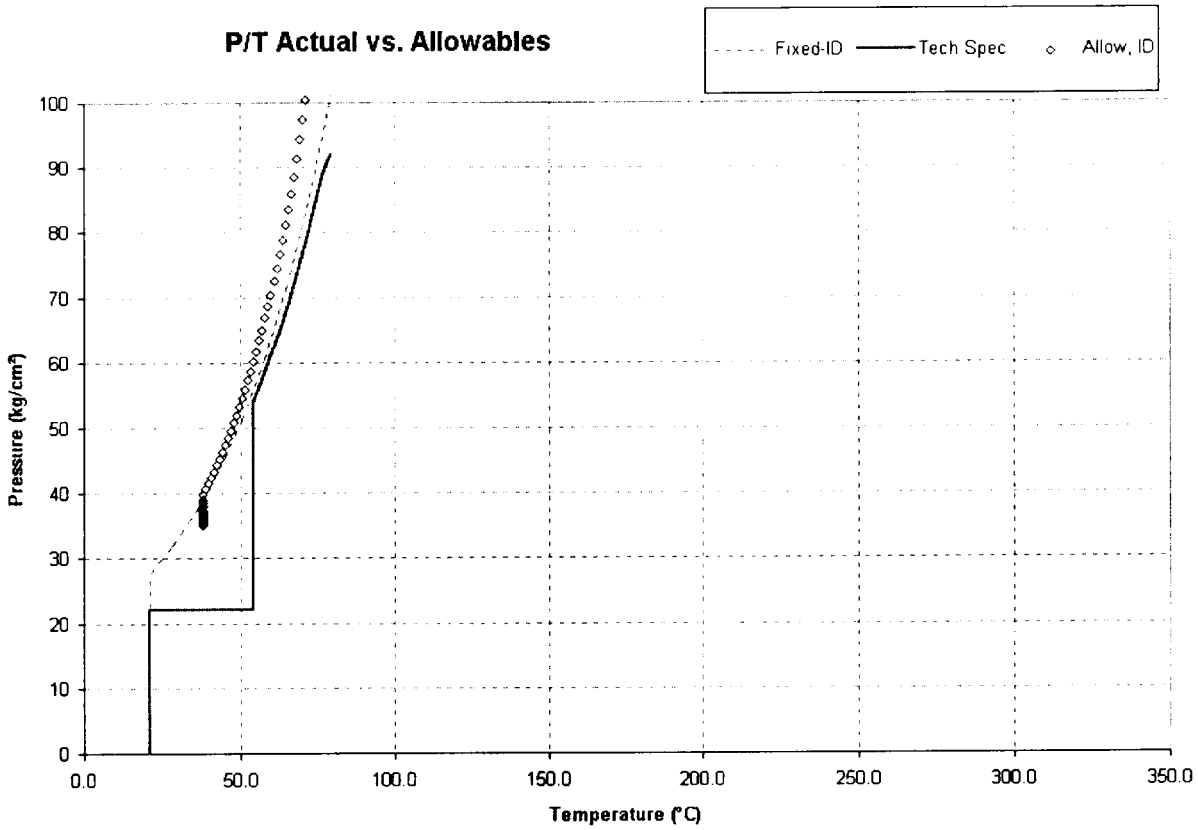


Figure 3: Pressure-Temperature Results for Heatup/Cooldown Conditions



Appendix A

Revised P-T Curves and Tabulated Values for BSEP-1

Table A-1. Tabulated Values for Bottom Head Curve A (BSEP-1, All EFPY)

Pressure-Temperature Curve Calculation

(Pressure Test)

Inputs:

Plant =	**Brunswick 1**	
Component =	**Bottom Head**	
Vessel thickness, t =	**5.400**	inches (minimum)
M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**110.59375**	inches (maximum)
RT_{NDT} =	**10.0**	°F ======> **All EFPYs**
ΔT_w =	**0.0**	°F (no thermal for pressure test)
K_{IT} =	**0.0**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**0.0**	°F (no thermal for pressure test)
Stress Multiplier, F =	**1.50**	(for spherical bottom head with penetrations)
Safety Factor =	**1.50**	(for pressure test)
M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F (use Unit 2 value to match Unit 2 results)

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	70.0	102.04	68.03	0	70	0
70	70.0	102.04	68.03	923	70	908
75	75.0	109.28	72.85	988	75	973
80	80.0	117.28	78.19	1060	80	1045
83.5	83.5	123.38	82.25	1116	84	1101
85	85.0	126.12	84.08	1140	85	1125
90	90.0	135.90	90.60	1229	90	1214
95	95.0	146.70	97.80	1326	95	1311
100	100.0	158.63	105.76	1434	100	1419
105	105.0	171.83	114.55	1554	105	1539

Table A-2. Tabulated Values for Beltline Curve A (BSEP-1, 32 EFPY)

Pressure-Temperature Curve Calculation

(Pressure Test)

Inputs:

Plant =	**Brunswick 1**	
Component =	**N16 A/B**	(2" Instrument Nozzles)
Vessel thickness, t =	**N/A**	inches (minimum)
M_t =	**N/A**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**N/A**	inches (maximum)
RT_{NDT} =	**114.2**	°F ======> **32 EFPY**
ΔT_w =	**0.0**	°F (no thermal for pressure test)
K_{IT} =	**0.0**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**0.0**	°F (no thermal for pressure test)
Stress Multiplier, F =	**N/A**	
Safety Factor =	**1.50**	(for pressure test)
M_m =	**N/A**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F (use Unit 2 value to match Unit 2 results)

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	70.0	41.77	27.84	0	70	0
70	70.0	41.77	27.84	313	70	313
75	75.0	42.67	28.44	313	75	313
80	80.0	43.66	29.11	313	80	313
85	85.0	44.76	29.84	313	85	313
90	90.0	45.98	30.65	313	90	313
95	95.0	47.32	31.55	313	95	313
100	100.0	48.81	32.54	313	100	313
100	100.0	48.81	32.54	701	100	686
105	105.0	50.45	33.63	724	105	709
110	110.0	52.26	34.84	750	110	735
115	115.0	54.27	36.18	779	115	764
120	120.0	56.48	37.66	811	120	796
125	125.0	58.93	39.29	846	125	831
130	130.0	61.64	41.09	885	130	870
135	135.0	64.63	43.09	928	135	913
140	140.0	67.94	45.29	975	140	960
145	145.0	71.59	47.73	1028	145	1013
150	150.0	75.63	50.42	1085	150	1070
152.4	152.4	77.71	51.81	1115	152	1100
155	155.0	80.09	53.39	1150	155	1135
160	160.0	85.02	56.68	1220	160	1205
165	165.0	90.47	60.31	1299	165	1284
170	170.0	96.49	64.33	1385	170	1370
175	175.0	103.15	68.77	1481	175	1466
180	180.0	110.51	73.67	1586	180	1571

Figure A-1. Curve A (BSEP-1, 32 EFPY)

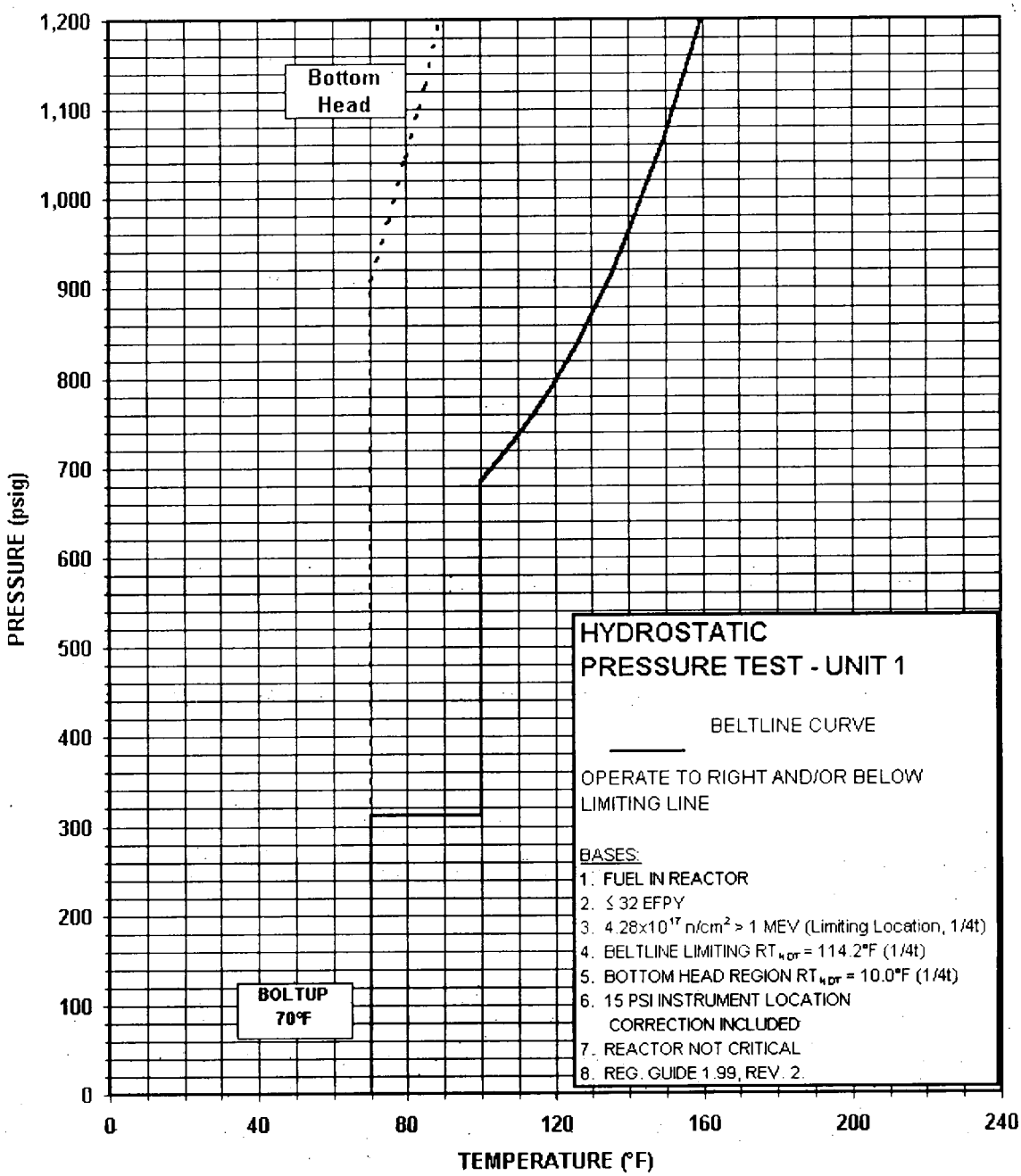


Figure x.x.x-x (page 1 of 1)
RCS Pressure and Temperature Limits
Hydrostatic and Leak Tests ≤ 32 EFPY

Table A-3. Tabulated Values for Bottom Head Curve B (BSEP-1, All EFPY)

Pressure-Temperature Curve Calculation

(Core Not Critical)

Inputs:

Plant =	**Brunswick 1**	
Component =	**Bottom Head**	
Vessel thickness, t =	**5.400**	inches (minimum)
M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**110.59375**	inches (maximum)
RT_{NDT} =	**10.0**	°F ======> **All EFPYs**
ΔT_w =	**25.5**	°F (temp. difference between inside and outside surfaces)
K_{IT} =	**7.0**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**18.9**	°F (temperature difference between fluid and crack tip)
Stress Multiplier, F =	**1.50**	(for spherical bottom head with penetrations)
Safety Factor =	**2.00**	(for heatup/cooldown)
M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F (use Unit 2 value to match Unit 2 results)

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	88.9	133.66	63.33	0	70	0
70	88.9	133.66	63.33	859	70	844
75	93.9	144.23	68.61	931	75	916
80	98.9	155.90	74.45	1010	80	995
85	103.9	168.81	80.91	1097	85	1082
90	108.9	183.07	88.04	1194	90	1179
95	113.9	198.83	95.92	1301	95	1286
130	148.9	200.00	96.50	1309	130	1294

Table A-4. Tabulated Values for Beltline Curve B (BSEP-1, 32 EFPY)

Pressure-Temperature Curve Calculation

(Core Not Critical)

Inputs:

Plant =	**Brunswick 1**	
Component =	**N16 A/B**	(2" Instrument Nozzles)
Vessel thickness, t =	**N/A**	inches (minimum)
M_t =	**N/A**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**N/A**	inches (maximum)
RT_{NDT} =	**114.2**	°F ======> **32 EFPY**
ΔT_w =	**N/A**	°F (temp. difference between inside and outside surfaces)
K_{IT} =	**5.4**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**20.1**	°F (temperature difference between fluid and crack tip)
Stress Multiplier, F =	**N/A**	
Safety Factor =	**2.00**	(for heatup/cooldown)
M_m =	**N/A**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F (use Unit 2 value to match Unit 2 results)

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	90.1	46.01	20.31	0	70	0
70	90.1	46.01	20.31	313	70	313
75	95.1	47.36	20.98	313	75	313
80	100.1	48.85	21.72	313	80	313
85	105.1	50.49	22.55	313	85	313
90	110.1	52.31	23.46	313	90	313
95	115.1	54.32	24.46	313	95	313
130	150.1	75.74	35.17	313	130	313
130	150.1	75.74	35.17	757	130	742
135	155.1	80.21	37.41	805	135	790
140	160.1	85.15	39.88	859	140	844
145	165.1	90.62	42.61	917	145	902
150	170.1	96.66	45.63	982	150	967
155	175.1	103.33	48.97	1054	155	1039
160	180.1	110.71	52.65	1134	160	1119
165	185.1	118.86	56.73	1221	165	1206
170	190.1	127.87	61.23	1318	170	1303
175	195.1	137.82	66.21	1426	175	1411
180	200.1	148.83	71.71	1544	180	1529

Figure A-2. Curve B (BSEP-1, 32 EFPY)

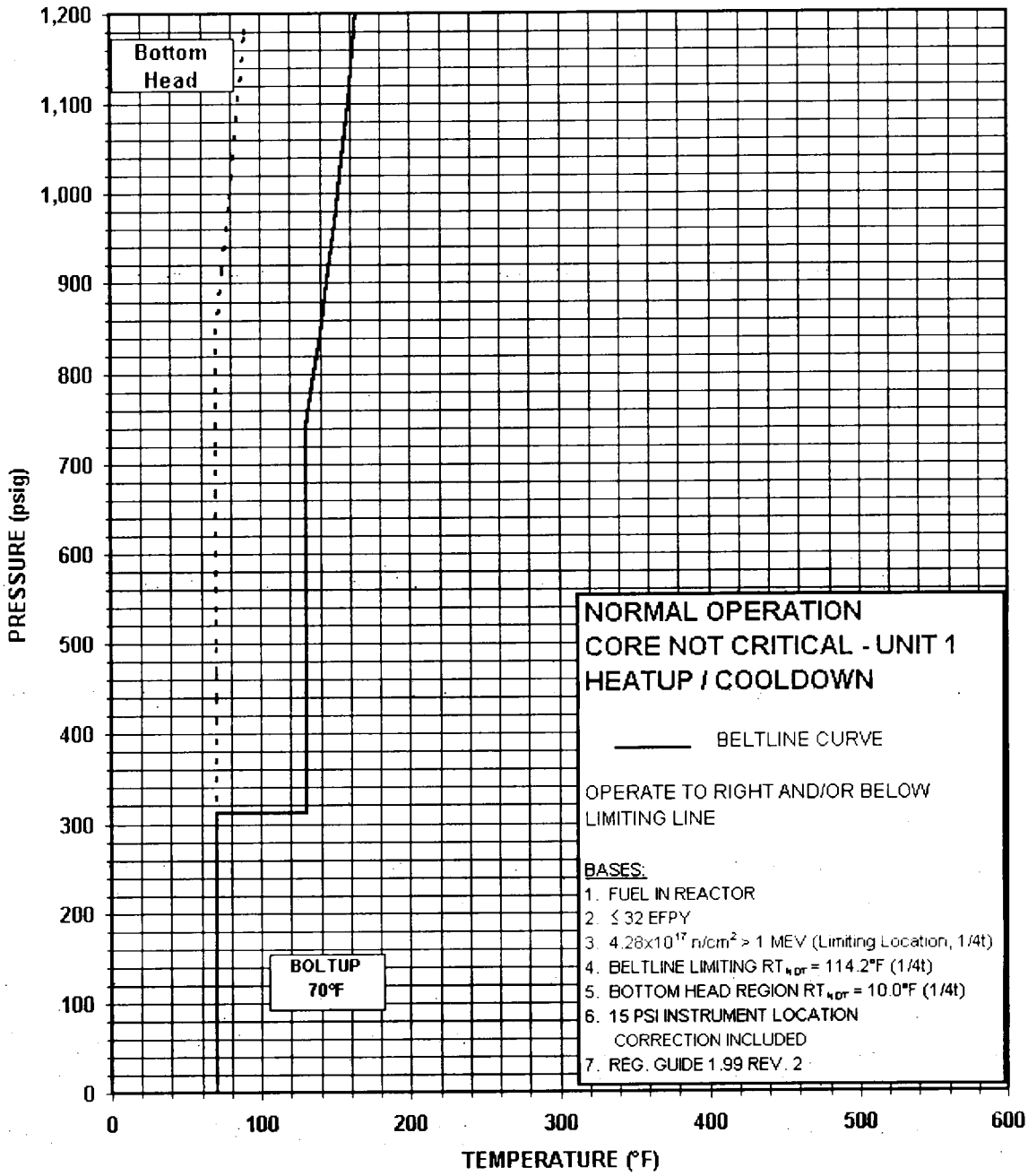


Figure x.x.x-x (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation With Core Not Critical ≤ 32 EFPY

Table A-5. Tabulated Values for Curve C (BSEP-1, 32 EFPY)

Pressure-Temperature Curve Calculation

(Core Critical = Curve C)

Inputs:

Plant =	**Brunswick 1**	
EFPY =	**32**	
Curve A Leak Test Temperature =	**152.4**	°F (at 1,100 psig)
Hydro Test Pressure =	**1,565**	psig
Flange RT_{NDT} =	**16.0**	°F

Curve B Temperature N16 Nozzle (°F)	Curve B Pressure for N16 Nozzle (psig)	Curve B Temperature Bottom Head (°F)	Curve B Pressure for Bottom Head (psig)	Curve C Temperature N16 Nozzle (°F)	Curve C Pressure N16 Nozzle (psig)	Curve C Temperature Bottom Head (°F)	Curve C Pressure Bottom Head (psig)
70.0	0	0.0	0	76.0	0	76.0	0
70.0	313	5.0	348	76.0	313	76.0	348
75.0	313	10.0	368	76.0	313	76.0	368
80.0	313	15.0	389	80.0	313	76.0	389
85.0	313	20.0	413	85.0	313	76.0	413
90.0	313	25.0	440	90.0	313	76.0	440
95.0	313	30.0	469	95.0	313	76.0	469
130.0	313	35.0	501	176.0	313	76.0	501
130.0	742	40.0	537	176.0	742	80.0	537
135.0	790	45.0	576	176.0	790	85.0	576
140.0	844	50.0	619	180.0	844	90.0	619
145.0	902	55.0	667	185.0	902	95.0	667
150.0	967	60.0	720	190.0	967	100.0	720
155.0	1039	65.0	779	195.0	1039	105.0	779
160.0	1119	70.0	844	200.0	1119	110.0	844
165.0	1206	75.0	916	205.0	1206	115.0	916
170.0	1303	80.0	995	210.0	1303	120.0	995
175.0	1411	85.0	1082	215.0	1411	125.0	1082
180.0	1529	90.0	1179	220.0	1529	130.0	1179
		95.0	1286			135.0	1286
		100.0	1294			140.0	1294

Figure A-3. Curve C (BSEP-1, 32 EFPY)

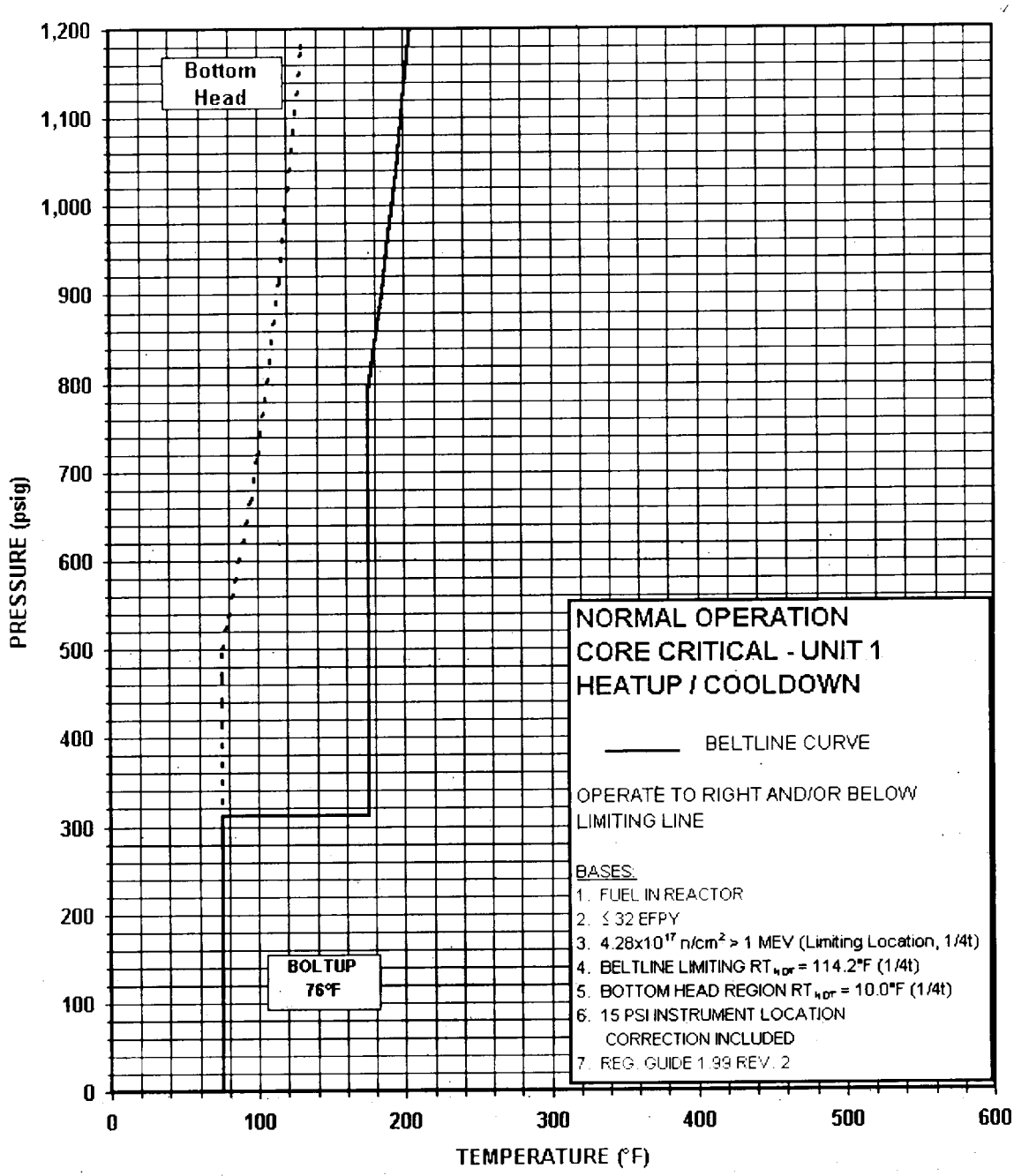


Figure x.x.x-x (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation With Core Critical ≤ 32 EFPY

Appendix B

Revised P-T Curves and Tabulated Values for BSEP-2

Table B-1. Tabulated Values for Bottom Head Curve A (BSEP-2, All EFPY)

Pressure-Temperature Curve Calculation

(Pressure Test)

Inputs:

Plant =	**Brunswick 2**	
Component =	**Bottom Head**	
Vessel thickness, t =	**5.420**	inches (minimum)
M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**110.3125**	inches (maximum)
RT_{NDT} =	**40.0**	°F ====== **All EFPYs**
ΔT_w =	**0.0**	°F (no thermal for pressure test)
K_{IT} =	**0.0**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**0.0**	°F (no thermal for pressure test)
Stress Multiplier, F =	**1.50**	(for spherical bottom head with penetrations)
Safety Factor =	**1.50**	(for pressure test)
M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	70.0	70.98	47.32	0	70	0
70	70.0	70.98	47.32	646	70	631
75	75.0	74.95	49.97	682	75	667
80	80.0	79.34	52.90	722	80	707
85	85.0	84.20	56.13	766	85	751
90	90.0	89.56	59.71	815	90	800
95	95.0	95.49	63.66	869	95	854
100	100.0	102.04	68.03	928	100	913
105	105.0	109.28	72.85	994	105	979
110	110.0	117.28	78.19	1067	110	1052
113.1	113.1	122.66	81.77	1116	113	1101
115	115.0	126.12	84.08	1148	115	1133
120	120.0	135.90	90.60	1236	120	1221
125	125.0	146.70	97.80	1335	125	1320
130	130.0	158.63	105.76	1443	130	1428
135	135.0	171.83	114.55	1563	135	1548

Table B-2. Tabulated Values for Beltline Curve A (BSEP-2, 32 EFPY)

Pressure-Temperature Curve Calculation

(Pressure Test)

Inputs:

Plant =	**Brunswick 2**	
Component =	**N16 A/B**	(2" Instrument Nozzles)
Vessel thickness, t =	**N/A**	inches (minimum)
M_t =	**N/A**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**N/A**	inches (maximum)
RT_{NDT} =	**106.1**	°F ====== **32 EFPY**
ΔT_w =	**0.0**	°F (no thermal for pressure test)
K_{IT} =	**0.0**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**0.0**	°F (no thermal for pressure test)
Stress Multiplier, F =	**N/A**	
Safety Factor =	**1.50**	(for pressure test)
M_m =	**N/A**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	70.0	43.27	28.85	0	70	0
70	70.0	43.27	28.85	313	70	313
75	75.0	44.33	29.55	313	75	313
80	80.0	45.50	30.33	313	80	313
85	85.0	46.80	31.20	313	85	313
90	90.0	48.23	32.15	313	90	313
95	95.0	49.81	33.20	313	95	313
100	100.0	51.55	34.37	313	100	313
100	100.0	51.55	34.37	740	100	725
105	105.0	53.48	35.66	768	105	753
110	110.0	55.62	37.08	798	110	783
115	115.0	57.97	38.65	832	115	817
120	120.0	60.58	40.39	870	120	855
125	125.0	63.46	42.31	911	125	896
130	130.0	66.64	44.43	957	130	942
135	135.0	70.16	46.77	1007	135	992
140	140.0	74.04	49.36	1063	140	1048
144.3	144.3	77.71	51.81	1115	144	1100
145	145.0	78.34	52.23	1124	145	1109
150	150.0	83.09	55.39	1193	150	1178
155	155.0	88.33	58.89	1268	155	1253
160	160.0	94.13	62.76	1351	160	1336
165	165.0	100.54	67.03	1443	165	1428
170	170.0	107.62	71.75	1545	170	1530

Figure B-1. Curve A (BSEP-2, 32 EFPY)

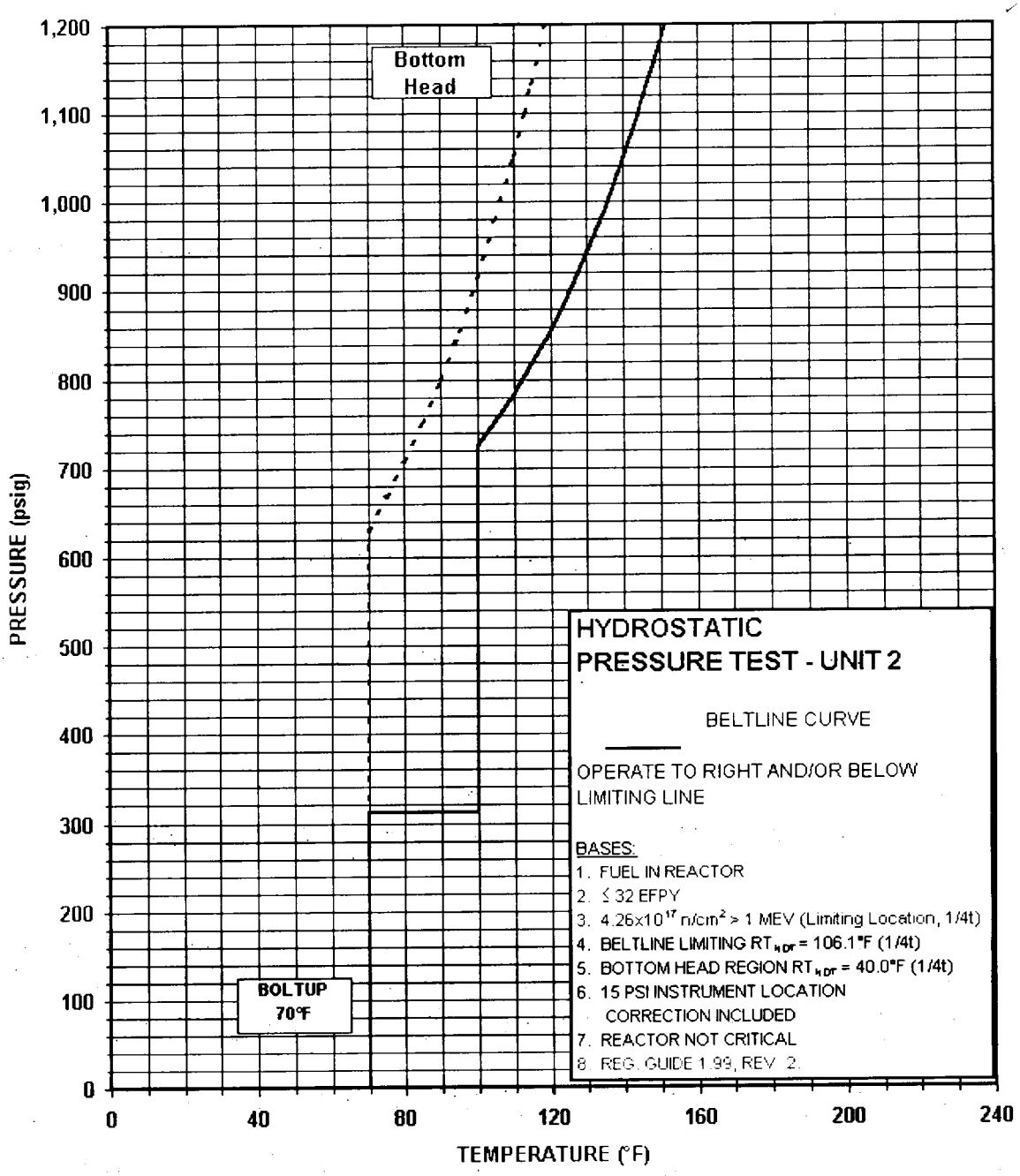


Figure x.x.x-x (page 1 of 1)
RCS Pressure and Temperature Limits
Hydrostatic and Leak Tests ≤ 32 EFPY

Table B-3. Tabulated Values for Bottom Head Curve B (BSEP-2, All EFPY)

Pressure-Temperature Curve Calculation

(Core Not Critical)

Inputs:

Plant =	**Brunswick 2**	
Component =	**Bottom Head**	
Vessel thickness, t =	**5.420**	inches (minimum)
M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**110.3125**	inches (maximum)
RT_{NDT} =	**40.0**	°F ====== **All EFPYs**
ΔT_w =	**25.8**	°F (temp. difference between inside and outside surfac
K_{IT} =	**7.1**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**19.1**	°F (temperature difference between fluid and crack tip)
Stress Multiplier, F =	**1.50**	(for spherical bottom head with penetrations)
Safety Factor =	**2.00**	(for heatup/cooldown)
M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
0	19.1	46.85	19.89	0	70	0
5	24.1	48.29	20.60	281	70	266
10	29.1	49.87	21.40	292	70	277
15	34.1	51.63	22.27	304	70	289
20	39.1	53.56	23.24	317	70	302
25	44.1	55.71	24.31	332	70	317
30	49.1	58.07	25.50	348	70	333
35	54.1	60.69	26.80	366	70	351
40	59.1	63.58	28.25	386	70	371
45	64.1	66.77	29.85	407	70	392
50	69.1	70.31	31.61	431	70	416
55	74.1	74.21	33.56	458	70	443
60	79.1	78.52	35.72	488	70	473
65	84.1	83.29	38.10	520	70	505
70	89.1	88.56	40.74	556	70	541
75	94.1	94.38	43.65	596	75	581
80	99.1	100.81	46.87	640	80	625
85	104.1	107.92	50.42	688	85	673
90	109.1	115.78	54.35	742	90	727
95	114.1	124.47	58.69	801	95	786
100	119.1	134.06	63.49	867	100	852
105	124.1	144.67	68.80	939	105	924
110	129.1	156.40	74.66	1019	110	1004
115	134.1	169.35	81.14	1107	115	1092
120	139.1	183.67	88.30	1205	120	1190
125	144.1	199.50	96.21	1313	125	1298
130	149.1	200.00	96.46	1316	130	1301

Table B-4. Tabulated Values for Beltline Curve B (BSEP-2, 32 EFPY)

Pressure-Temperature Curve Calculation

(Core Not Critical)

Inputs:

Plant =	**Brunswick 2**	
Component =	**N16 A/B**	(2" Instrument Nozzles)
Vessel thickness, t =	**N/A**	inches (minimum)
M_t =	**N/A**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**N/A**	inches (maximum)
RT_{NDT} =	**106.1**	°F ====== **32 EFPY**
ΔT_w =	**N/A**	°F (temp. difference between inside and outside surfac
K_{IT} =	**5.4**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**20.1**	°F (temperature difference between fluid and crack tip)
Stress Multiplier, F =	**N/A**	
Safety Factor =	**2.00**	(for heatup/cooldown)
M_m =	**N/A**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	90.1	48.27	21.43	0	70	0
70	90.1	48.27	21.43	313	70	313
75	95.1	49.85	22.22	313	75	313
80	100.1	51.60	23.10	313	80	313
85	105.1	53.54	24.07	313	85	313
90	110.1	55.67	25.14	313	90	313
95	115.1	58.04	26.32	313	95	313
130	150.1	83.22	38.91	313	130	313
130	150.1	83.22	38.91	838	130	823
135	155.1	88.48	41.54	894	135	879
140	160.1	94.29	44.45	957	140	942
145	165.1	100.72	47.66	1026	145	1011
150	170.1	107.82	51.21	1103	150	1088
155	175.1	115.67	55.13	1187	155	1172
160	180.1	124.34	59.47	1280	160	1265
165	185.1	133.92	64.26	1384	165	1369
170	190.1	144.52	69.56	1498	170	1483
175	195.1	156.22	75.41	1624	175	1609

Figure B-2. Curve B (BSEP-2, 32 EFPY)

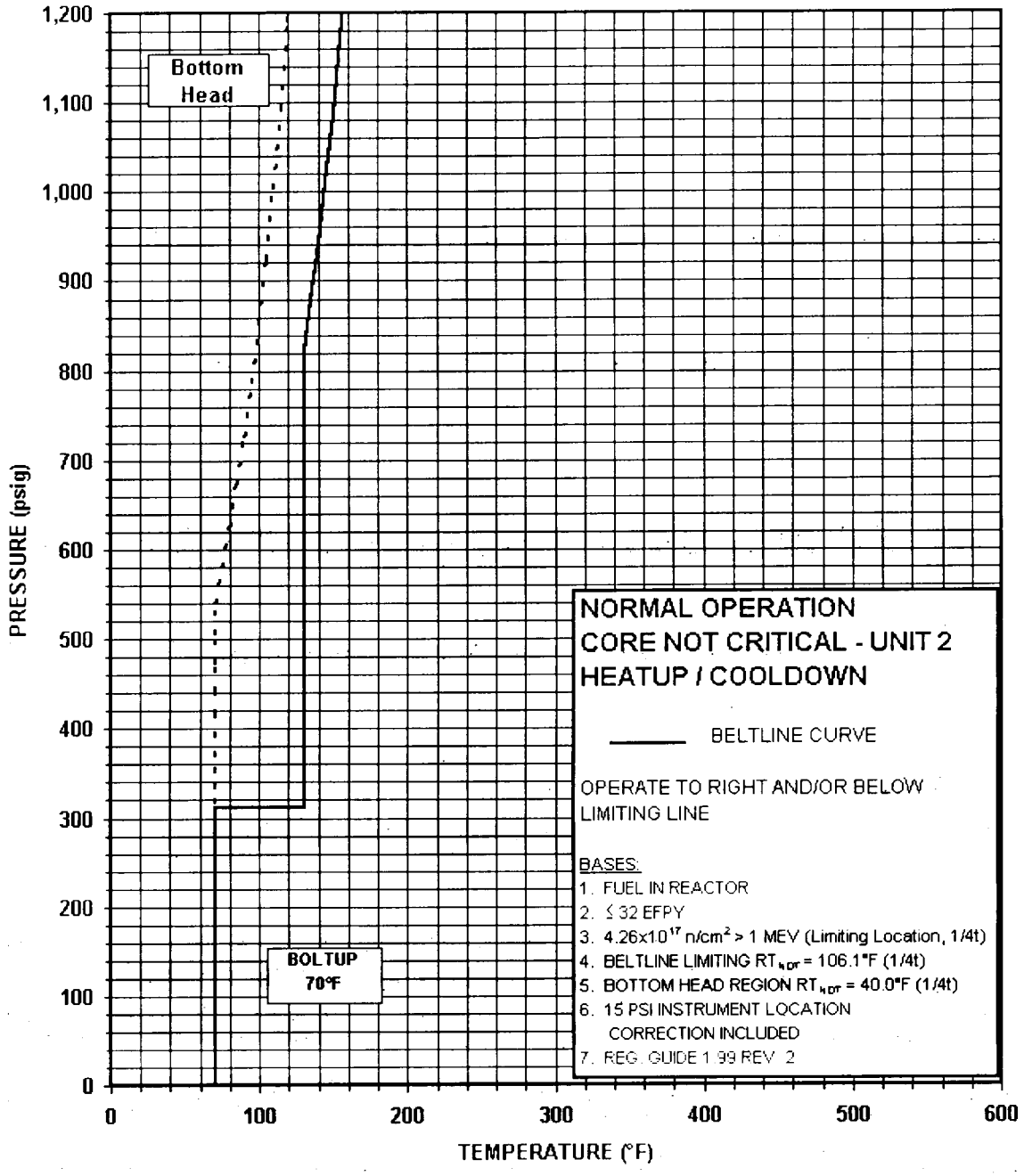


Figure x.x.x-x (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation With Core Not Critical ≤ 32 EFPY

Table B-5. Tabulated Values for Curve C (BSEP-2, 32 EFPY)

Pressure-Temperature Curve Calculation

(Core Critical = Curve C)

Inputs:

Plant =	**Brunswick 2**	
EFPY =	**32**	
Curve A Leak Test Temperature =	**144.3**	°F (at 1,100 psig)
Hydro Test Pressure =	**1,565**	psig
Flange RT_{NDT} =	**10.0**	°F

Curve B Temperature N16 Nozzle (°F)	Curve B Pressure for N16 Nozzle (psig)	Curve B Temperature Bottom Head (°F)	Curve B Pressure for Bottom Head (psig)	Curve C Temperature N16 Nozzle (°F)	Curve C Pressure N16 Nozzle (psig)	Curve C Temperature Bottom Head (°F)	Curve C Pressure Bottom Head (psig)
70.0	0	0.0	0	70.0	0	70.0	0
70.0	313	5.0	266	70.0	313	70.0	266
75.0	313	10.0	277	75.0	313	70.0	277
80.0	313	15.0	289	80.0	313	70.0	289
85.0	313	20.0	302	85.0	313	70.0	302
90.0	313	25.0	317	90.0	313	70.0	317
95.0	313	30.0	333	95.0	313	70.0	333
130.0	313	35.0	351	170.0	313	75.0	351
130.0	823	40.0	371	170.0	823	80.0	371
135.0	879	45.0	392	175.0	879	85.0	392
140.0	942	50.0	416	180.0	942	90.0	416
145.0	1011	55.0	443	185.0	1011	95.0	443
150.0	1088	60.0	473	190.0	1088	100.0	473
155.0	1172	65.0	505	195.0	1172	105.0	505
160.0	1265	70.0	541	200.0	1265	110.0	541
165.0	1369	75.0	581	205.0	1369	115.0	581
170.0	1483	80.0	625	210.0	1483	120.0	625
175.0	1609	85.0	673	215.0	1609	125.0	673
		90.0	727			130.0	727
		95.0	786			135.0	786
		100.0	852			140.0	852
		105.0	924			145.0	924
		110.0	1004			150.0	1004
		115.0	1092			155.0	1092
		120.0	1190			160.0	1190
		125.0	1298			165.0	1298
		130.0	1301			170.0	1301

Figure B-3. Curve C (BSEP-2, 32 EFPY)

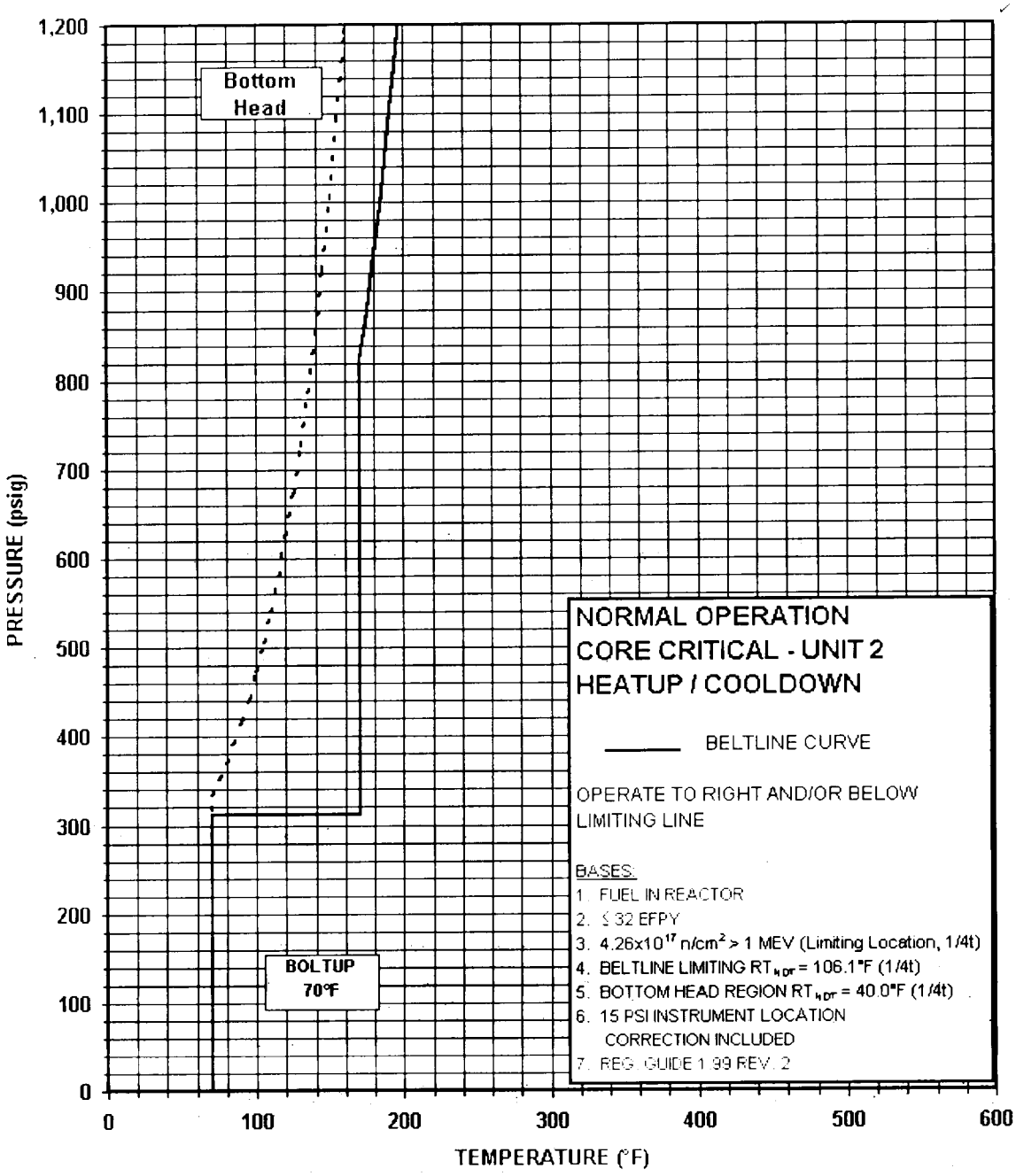


Figure x.x.x-x (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation With Core Critical ≤ 32 EFPY

ATTACHMENT 2
Sheet 1 of 1
Record of Lead Review

Design Structural Integrity Report SIR-00-132 **Revision** 0

The signature below of the Lead Reviewer records that:
- the review indicated below has been performed by the Lead Reviewer;
- appropriate reviews were performed and errors/deficiencies (for all reviews performed) have been resolved and these records are included in the design package;
- the review was performed in accordance with EGR-NGGC-0003.

☐ **Design Verification Review** ☐ **Engineering Review** ☑ **Owner's Review**
- ☐ Design Review
- ☐ Alternate Calculation
- ☐ Qualification Testing

☐ **Special Engineering Review**

☐ YES ☐ N/A **Other Records are attached.**

Phillip Gore / Phillip Gore — **Lead Reviewer (print/sign)**
Mech. — **Discipline**
10/31/00 — **Date**

Item No.	Deficiency	Resolution
	No comments	

FORM EGR-NGGC-0003-2-5
This form is a QA Record when completed and included with a completed design package. Owner's Reviews may be processed as stand alone QA records when Owner's Review is completed.

ATTACHMENT 5

Structural Integrity Associates
Calculation No. CPL-54Q-303, Rev. 0
Development of Updated P-T Curves For 32 EFPY
with Owner Review
(following 63 pages)

RECORD COPY

STRUCTURAL INTEGRITY Associates, Inc.	CALCULATION PACKAGE	FILE No: CPL-54Q-303 PROJECT No: CPL-55Q

PROJECT NAME: Re-Compilation of P-T Curves for Brunswick 1 and 2

CLIENT: Carolina Power & Light Company (CP&L)

CALCULATION TITLE: Development of Updated P-T Curves For 32 EFPY

PROBLEM STATEMENT OR OBJECTIVE OF THE CALCULATION:

Develop a full set of updated pressure-temperature (P-T) curves for both Brunswick Units for the beltline, bottom head and N16 nozzle regions for 32 effective full power years incorporating updated RT_{NDT} estimates, as well as the results of all previous worked performed on this subject.

Document Revision	Affected Pages	Revision Description	Project Mgr. Approval Signature & Date	Preparer(s) & Checker(s) Signatures & Date
0	1 - 23, A-1 - A-13, B-1 - B-13, C-1 - C-13 Files on Project CD-ROM	Original Issue	Gary L. Stevens Gary L. Stevens 10/19/00	Gary L. Stevens Gary L. Stevens 10/19/00 J. A. Hofmann Julia. Hofmann 10/19/00

1.0 INTRODUCTION

The purpose of this calculation is to develop a full set of updated pressure-temperature (P-T) curves for both units of the Brunswick Steam Electric Plant (BSEP) for the beltline, bottom head, and N16 nozzle regions for 32 effective full power years (EFPY). This includes pressure test, core not critical, and core critical conditions, and incorporates updated RT_{NDT} estimates, as well as the results of all previous worked performed on this subject.

2.0 RT_{NDT} DETERMINATION

Reference [1] provides updated RT_{NDT} estimates for the BSEP reactor pressure vessel (RPV) materials in accordance with Regulatory Guide 1.99, Revision 2 (RG 1.99) [2] for 32 EFPY including the effects of the various power uprates implemented or planned for the BSEP units. The results are summarized in this calculation in Table 1.

Table 1
RT_{NDT} Estimates for BSEP

Brunswick Unit 1 Limiting RPV Material Summary

Part Name & Material	MK No.	Heat No.	Slab or Lot No.	Estimated Initial RT_{NDT} (°F)	Chemistry Cu (wt %)	Chemistry Ni (wt %)	Chemistry Factor (°F)	Adjustments For 1/4t: ΔRT_{NDT} (°F)	Margin Terms σ_Δ (°F)	Margin Terms σ_I (°F)	EFPY	ART_{NDT} (°F)
FLANGE REGION (Shell Flange)	600	BV-3085	AFB176	16	0.09	0.88	N/A	N/A	N/A	0.0	32.0	16.0
BOTTOM HEAD	101	C4654	3	10	NR	0.55	N/A	N/A	N/A	0.0	32.0	10.0
NOTE: The adjusted reference temperature values are the same for all EFPYs for the above locations since there are no significant irradiation effects												
BELTLINE (Lower Int. Shell)	351	B8496	1	10	0.19	0.58	139.8	62.3	17.0	0.0	32.0	106.3
BELTLINE (N16A/B Nozzles)	302	Q2Q1VW	247P-4A,4B	48	0.16	0.82	123.2	33.1	16.6	0.0	32.0	114.2

Fluence Information:

Location	Wall Thickness (inches) Full	1/4t	EFPY	Fluence at ID (n/cm²)	Attenuation, 1/4t $e^{-0.24x}$	Fluence @ 1/4t (n/cm²)	Fluence Factor, FF $f^{(0.28-0.10\log f)}$
(Lower Int. Shell)	5.496	1.374	32.0	1.60E+18	0.719	1.15E+18	0.446
(N16A/B Nozzles)	5.496	1.374	32.0	5.95E+17	0.719	4.28E+17	0.269

Brunswick Unit 2 Limiting RPV Material Summary

Part Name & Material	MK No.	Heat No.	Slab or Lot No.	Estimated Initial RT_{NDT} (°F)	Chemistry Cu (wt %)	Chemistry Ni (wt %)	Chemistry Factor (°F)	Adjustments For 1/4t: ΔRT_{NDT} (°F)	Margin Terms σ_Δ (°F)	Margin Terms σ_I (°F)	EFPY	ART_{NDT} (°F)
FLANGE REGION (Top Head Flange)	706	1L-3335	AYT-173	10	0.11	0.80	N/A	N/A	N/A	0.0	32.0	10.0
BOTTOM HEAD	102	C4890	1A	40	NR	0.56	N/A	N/A	N/A	0.0	32.0	40.0
NOTE: The adjusted reference temperature values are the same for all EFPYs for the above locations since there are no significant irradiation effects												
BELTLINE (Lower Shell)	201	C4500	2	10	0.15	0.54	106.7	41.1	17.0	0.0	32.0	85.1
BELTLINE (N16A/B Nozzles)	302	Q2Q1VW	247P-3A,3B	40	0.16	0.82	123.2	33.0	16.5	0.0	32.0	106.1

Fluence Information:

Location	Wall Thickness (inches) Full	1/4t	EFPY	Fluence at ID (n/cm²)	Attenuation, 1/4t $e^{-0.24x}$	Fluence @ 1/4t (n/cm²)	Fluence Factor, FF $f^{(0.28-0.10\log f)}$
(Lower Shell)	5.466	1.367	32.0	1.18E+18	0.720	8.50E+17	0.385
(N16A/B Nozzles)	5.466	1.367	32.0	5.91E+17	0.720	4.26E+17	0.268

3.0 P-T CURVE METHODOLOGY

In this section, the methodology for calculating P-T curves is detailed. This methodology documents the equations used by the EXCEL spreadsheet developed for this work. The methodology is based on the requirements of References [3] through [6].

The approach used for calculating the P-T curves is summarized below:

a. Assume a fluid temperature, T.

b. For the temperature, T, assumed in step (a), compute the temperature at the assumed flaw tip, $T_{1/4t}$ (i.e., 1/4t into the vessel wall). This is accomplished by adding a temperature drop term, $\Delta T_{1/4t}$, to T. The value of $\Delta T_{1/4t}$ is zero for the pressure test P-T curves (e.g., thermal is neglected), and is determined via heat transfer analysis for the other curves.

c. Calculate the allowable stress intensity factor, K_{IC} (as allowed per Reference [6]), based on $T_{1/4t}$ using the following relationship:

$$K_{IC} = 20.734\, e^{[0.02\,(T-ART)]} + 33.2$$

where: T = $T_{1/4t}$ (°F)
ART = adjusted reference temperature for location under consideration, as shown in Table 1 (°F)
K_{IC} = allowable stress intensity factor (ksi√inch)

d. Calculate the allowable pressure stress intensity factor, K_{IP}, using the appropriate relationship for the P-T curve under consideration:

$K_{IP} = K_{IC}/1.5$ for Curve A (i.e., pressure-test curve)
$K_{IP} = (K_{IC}-K_{IT})/2.0$ for Curves B and C (i.e., core not critical and core critical curves)

where:
K_{IT} = thermal stress intensity factor (ksi√inch)
= M_t x ΔT_w per Figure G-2214-2 of Reference [3] for the beltline and bottom head regions.
= 5.4 ksi√inch for the N16A/B nozzles [7].
ΔT_w = through-wall temperature drop, determined by heat transfer analysis (°F)
M_t = factor from Figure G-2214-2 of Reference [3]
K_{IP} = allowable pressure stress intensity factor (ksi√inch)

e. Compute the pressure, P. The relationship for the pressure, P, to the allowable pressure stress intensity factor, K_{IP}, is as follows:

$$K_{IP} = M_m \sigma_m + M_b \sigma_b$$

where:

M_m	=	membrane stress correction factor from Figure G-2214-1 of Reference [3]. *The upper line for M_m in Figure G-2214-1 (corresponding to σ/σ_{ys} = 1.0) is conservatively used.*
σ_m	=	membrane stress due to pressure (ksi)
	=	PR/t for the beltline region.
	=	3.0PR/(2t) = 1.5PR/t for the spherical bottom head assuming a stress concentration factor of 3.0 for the bottom head penetrations. For the N16A/B nozzles, K_{IP} was determined directly based on finite element results, as shown below.
P	=	pressure (ksi)
R	=	maximum vessel radius (inches)
t	=	minimum vessel wall thickness (inches)
M_b	=	bending stress correction factor = $(2/3)M_m$
σ_b	=	bending stress due to pressure (ksi)
	=	0 for a thin-walled vessel

Thus,

$P = K_{IP}t/(RM_m)$ for the beltline region
$P = K_{IP}t/(1.5RM_m)$ for the bottom head region
$P = 21.53\ K_{IP}$ for the N16A/B nozzles [7]

f. Repeat steps (a) through (e) for other temperatures to generate a series of P-T points for each region.

g. Subtract any applicable instrument errors for temperature and pressure from T and P, respectively. The resulting pressure and temperature series constitutes the P-T curve. *Instrument errors were assumed to be zero for temperature and 15 psig for pressure consistent with past work and to account for the static head of water in a full vessel.* The P-T curve relates the minimum required reactor fluid temperature to the reactor pressure for each region.

The following additional requirements were used to define the lower portion of the P-T curves. These limits are established by the discontinuity regions of the vessel (i.e., flanges), and are specified in Reference [4]:

For Pressure Test Conditions:

- Thermal stresses were assumed to be negligible during the pressure test condition and were therefore not considered.
- If P is greater than 20% of the pre-service hydro test pressure, the upper vessel temperature must be greater than RT_{NDT} of the limiting flange material + 90°F. The pre-service hydro test pressure was 1,563 psig.
- If P is less than or equal to 20% of the pre-service hydro test pressure, the minimum temperature is typically greater than or equal to the RT_{NDT} of the limiting flange material + 60°F. The additional 60°F margin above that recommended in Reference [4] has been a standard recommendation by GE for the BWR industry. For the BSEP flange material, this minimum temperature would be 76°F (i.e., 16 + 60°F) for Unit 1, and 70°F (i.e., 10 + 60°F) for Unit 2. Since the 60°F margin is only a recommendation, the minimum temperature for Unit 1 was set to 70°F to match Unit 2 and be consistent with past work.

For Core Not Critical Conditions:

- If P is greater than 20% of the pre-service hydro test pressure, the upper vessel temperature must be greater than RT_{NDT} of the limiting flange material + 120°F.
- If P is less than or equal to 20% of the pre-service hydro test pressure, the minimum temperature is typically greater than or equal to the RT_{NDT} of the limiting flange material + 60°F. The additional 60°F margin above that recommended in Reference [4] has been a standard recommendation by GE for the BWR industry. For the BSEP flange material, this minimum temperature is 70°F for Unit 1 and 70°F for Unit 2, as identified above.

For Core Critical Conditions:

- Per the requirements of Table 1 of Reference [4], the core critical P-T limits must be 40°F above any Pressure Test or Core Not Critical curve limits. Core Not Critical conditions are more limiting than Pressure Test conditions, so Core Critical conditions are equal to Core Not Critical conditions plus 40°F.
- Another requirement of Table 1 of Reference [4] (or actually an allowance for the BWR), concerns minimum temperature for initial criticality in a startup. Given that water level is normal, BWRs are allowed initial criticality at the closure flange region temperature (RT_{NDT} + 60°F) if the pressure is below 20% of the pre-service hydro test pressure. This corresponds to 76°F for Unit 1 and 70°F for Unit 2, as identified above.
- Also per Table 1 of Reference [4], at pressures above 20% of the pre-service hydro test pressure, the Core Critical curve upper vessel temperature must be at least that required for the pressure test (Pressure Test Curve at 1,100 psig*). As a result of this requirement, the Core Critical curve for the beltline must have a step at a pressure equal to 20% of the pre-service hydro pressure to the temperature required by the Pressure Test curve at 1,100 psig, or 40°F, whichever is greater.

* NOTE: Per CP&L, the current pressure test requirement is 1,030 psig. For the purposes of P-T curve development, a pressure of 1,100 psig was conservatively used so that any potential future increases would be accommodated.

The vessel dimensions for the BSEP beltline, bottom head and N16A/B nozzle locations are documented in Reference [8].

4.0 HEAT TRANSFER ANALYSIS

Heat transfer analysis was undertaken to estimate the ΔT_w and $\Delta T_{1/4t}$ terms identified above. This was accomplished using the PIPE-TS2 computer code [9] for the beltline and bottom head regions. The analysis for the N16A/B nozzles was previously performed in Reference [10].

The P-T curves are developed considering a 100°F/hr heatup/cooldown. Therefore, a 100°F/hr cooldown from 550°F to 120°F was evaluated. The 550°F upper temperature was selected based on the approximate operating temperature (steam dome) for a BWR. The 120°F lower temperature was selected based upon the outside air temperature specified in Reference [10]. Material properties were taken from Reference [11] at an approximate average temperature of 350°F. Heat transfer coefficients and the outside air temperature were obtained from Reference [10]. Per Reference [8], the vessel material is SA-533 Gr. B Cl. 1. The results at the end of the cooldown, (T = 120°F, time = 3600*(550-120)/100 = 15,480 seconds) were conservatively selected so that maximum steady state temperature differences were achieved.

The PIPE-TS2 input files and the output file for t = 15,480 seconds are included in Appendix A for the beltline and bottom head regions for both BSEP units (4 cases total). The results for all regions, including those for the N16A/B nozzles from Reference [10], are shown in Table 2. These results are reflected in the P-T curve calculations contained in Appendices B and C.

Table 2
Results of Heat Transfer Analysis

Variable	Beltline [1]	Bottom Head [1]	N16A/B Nozzles [2]
ΔT_w [3]	Unit 1: 154.3 - 127.8 = 26.5°F Unit 2: 154.0 - 127.8 = 26.2°F	Unit 1: 153.2 - 127.7 = 25.5°F Unit 2: 153.5 - 127.7 = 25.8°F	Not required -- finite element solution used.
$\Delta T_{1/4t}$ [4]	Unit 1: 139.5 - 120.0 = 19.5°F Unit 2: 139.3 - 120.0 = 19.3°F	Unit 1: 138.9 - 120.0 = 18.9°F Unit 2: 139.1 - 120.0 = 19.1°F	Unit 1: 20.13°F [5] Unit 2: 20.13°F [5]
K_{IT}	Calc. per ASME Code, Section XI, App. G	Calc. per ASME Code, Section XI, App. G	Unit 1: 5.4 ksi√inch Unit 2: 5.4 ksi√inch

Notes:
1. Results are from PIPE-TS2 output contained in Appendix A.
2. Results are from References [7] and [10]. The Unit 2 nozzle results are assumed to be identical to those for Unit 1.
3. Per Reference [3], ΔT_w is the temperature drop across the vessel wall, i.e., outside surface temperature - inside surface temperature.
4. Since the P-T curves are being generated as a function of fluid temperature, $\Delta T_{1/4t}$ is the temperature difference between the fluid and the 1/4t location.
5. Reference [7] used a value of 9.53°F; however, per Reference [10], this corresponds to the temperature difference between the inside surface and the 1/4t location. Per Reference [10], the temperature difference between the fluid and the 1/4t location is 370.13 - 350 = 20.13°F at 7,200 seconds.

5.0 P-T CURVES

The resulting P-T curves and the detailed input and output are contained in Appendix B for BSEP-1, and Appendix C for BSEP-2. Only the limiting curves that represent both the N16A/B nozzles and beltline are plotted for all cases. The comparisons shown in Appendices B and C between the N16A/B nozzles and the beltline for 32 EFPY demonstrate that the N16A/B nozzles are limiting for the beltline region.

6.0 DEMONSTRATION OF BOUNDING ASSESSMENT FOR BOTTOM HEAD

Recent questions from the NRC have indicated that updated P-T curves should bound any heatup/cooldown rate expected in the bottom head region during a transient event. The NRC bases their position on the definition of an "Anticipated Operational Occurrence" (AOO) in 10CFR50 Appendix A [12], which states: "Anticipated operational occurrences mean those conditions of normal operation which are expected to occur one or more times during the life of the nuclear power unit and include but are not limited to loss of power to all recirculation pumps, tripping of

the turbine generator set, isolation of the main condenser, and loss of all offsite power."

Since Brunswick has had several transient events in which the heatup\cooldown rate in the bottom head region exceeded 100°F/hr, these events may be considered by the NRC to be AOOs. Therefore, the bottom head P-T curves should be developed to account for the maximum heatup/cooldown rate expected.

In this section, an evaluation is performed to assess the adequacy of the 100°F/hr heatup/cooldown rate used in the development of the BSEP P-T curves with respect to AOOs in the bottom head region.

6.1 METHODOLOGY

The SPHERE spreadsheet methodology used for the Reference [13] assessment will again be used for this work. A three-step process will be applied to investigate this problem: (1) reproduce the Reference [13] results to verify the proper functioning of the SPHERE spreadsheet for this project, (2) perform an assessment for the bottom head region for pressure test conditions using the SPHERE spreadsheet, and (3) perform an assessment of transient conditions for the bottom head region for heatup/cooldown conditions using the SPHERE spreadsheet. Each of these steps is described in detail in the subsections that follow.

6.2 STEP 1: REPRODUCE PREVIOUS RESULTS

Pages 25-28 of the Reference [13] calculation contain the alternate transient evaluation for Brunswick. The alternate transient, as defined in Figure 7-1 of Reference [14], is shown again here in Figure 1. The transient shown in Figure 1 was previously established as a bounding transient for the bottom head region for the Brunswick reactors.

The inputs to SPHERE, as identified in Figures 8, 9, and 18 of Reference [13], were again input to the spreadsheet, as shown in Figures 2 through 4, and a solution was obtained. The resulting pressure/temperature results are shown in Figure 5. Comparing these results to those from Figure 19 of Reference [13], it can be seen that identical results were achieved. Therefore, the SPHERE spreadsheet is considered to be verified and functioning correctly for the purposes of this assessment.

Figure 1: Alternate Cooldown Transient for Brunswick Bottom Head Region

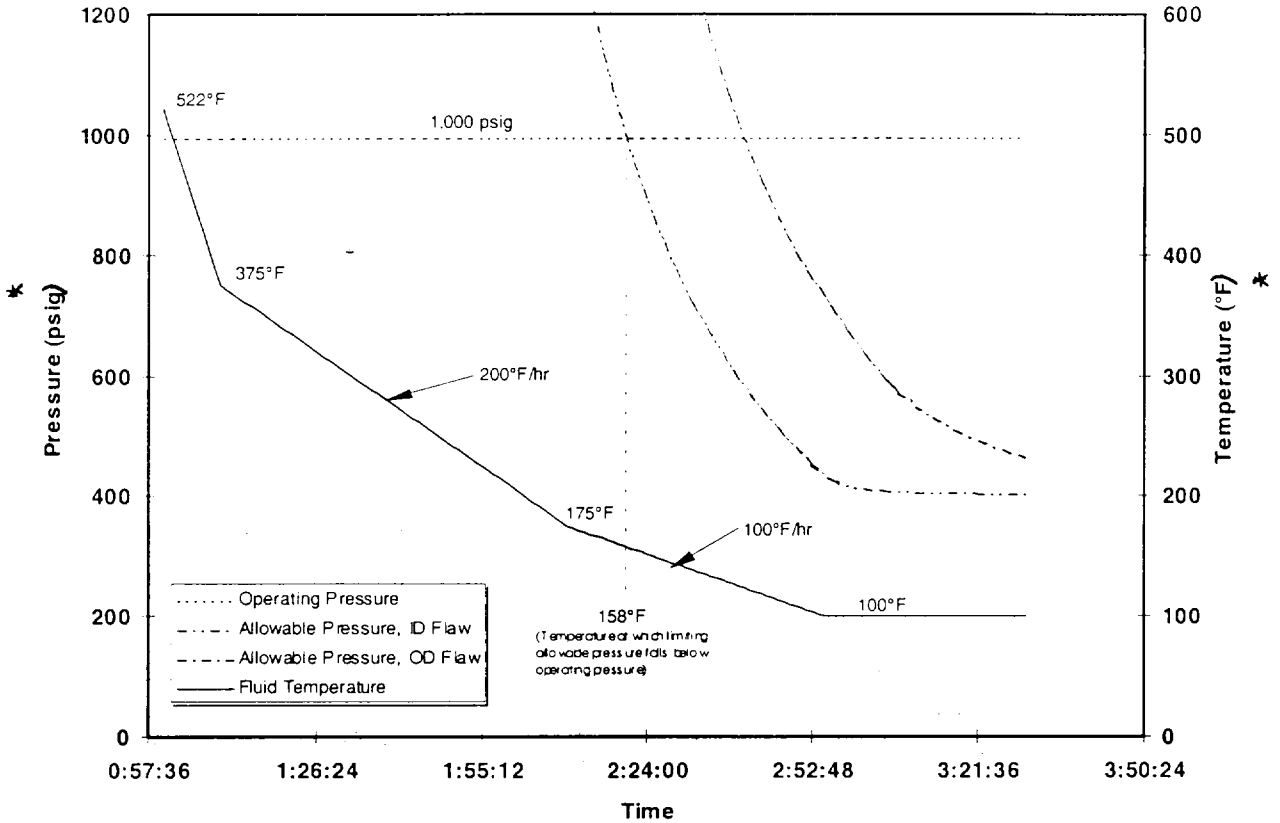


Figure 2: RPV Input Data for SPHERE
(Compares to Figure 18 of Reference [13])

RPV Input Data

Close

Erase Input

Input

*

Date	Time	Press (kg/cm²)	Temp (°C)	(°F)
12/15/95	1:00:00	70.30704	272.2222	522
12/15/95	1:10:00	70.30704	190.5556	375
12/15/95	2:10:00	70.30704	79.44444	175
12/15/95	2:55:00	70.30704	37.77778	100
12/15/95	3:30:00	70.30704	37.77778	100

* Hand changes to original calc. 10/19/00

Figure 3: User Variables Input Data for SPHERE
(Compares to Figure 8 of Reference [13])

User Variables

evnt_typ	C	Type of event: C=core critical, N=core not crit, P=pressure test
eval_typ	3	Kic evaluation: 1=JEAC 4206, 2=hybrid, 3=Section XI
~~matl_typ~~	~~BM~~	~~Material type: BM=base metal, WM=weld metal~~

*

~~pct_P~~	~~0.1~~	~~mass % of phosphorus in vessel material~~
~~pct_Cu~~	~~0.03~~	~~mass % of copper in vessel material~~
~~pct_Ni~~	~~0.54~~	~~mass % of nickel in vessel material~~
~~pct_Si~~	~~0.015~~	~~mass % of silicon in vessel material~~
~~CF~~	~~121.2505~~	~~Chemistry Factor, calculated = 121.2505~~
47,500 psi ys	3.28E+08	Material Yield Stress [N/m²]

*

~~T_init~~	~~21.11111~~	~~Minimum Boltup Temperature [°C]~~
~~T_o~~	~~125~~	~~Temperature Constant (JEAC 4206) [°C]~~
~~iRT_NDT~~	~~20~~	~~Initial Reference Temperature [°C]~~
~~Margin~~	~~0~~	~~Additional Temperature Shift [°C]~~

*

	1/4 T	3/4 T	
40°F ART	4.4	4.4	Adjusted Reference Temperature [°C]

*

~~EFPY~~	~~10~~	~~Effective Full Power Years [power years]~~
~~f_ao~~	~~10~~	~~irradiation fluence level at ID surface, actual~~
~~f_mo~~	~~12~~	~~irradiation fluence level at ID surface, Kic data~~

*

	1/4 T	3/4 T	
calculated a	42.8625	128.5875	crack depth [mm]
~~f_e~~	~~6.66977~~	~~2.96710~~	~~fluence at depth 'a', actual~~
~~f_m~~	~~8.00372~~	~~3.56852~~	~~fluence at depth 'a', Kic data~~
~~FF_e~~	~~1.62864~~	~~1.34293~~	~~fluence factor at depth 'a', actual~~
~~FF_m~~	~~1.69558~~	~~1.40531~~	~~fluence factor at depth 'a', Kic data~~
~~dT_Kic~~	~~8.1~~	~~7.6~~	~~temperature shift due to irradiation [°C]~~
~~RT_NDT~~	~~11.9~~	~~12.4~~	~~Final Reference Temperature [°C]~~

*

* Hand changes to original calc. → lined out items not used.

JAH 10/19/00

Figure 4: Location-Specific Input Data for SPHERE
(Compares to Figure 9 of Reference [13])

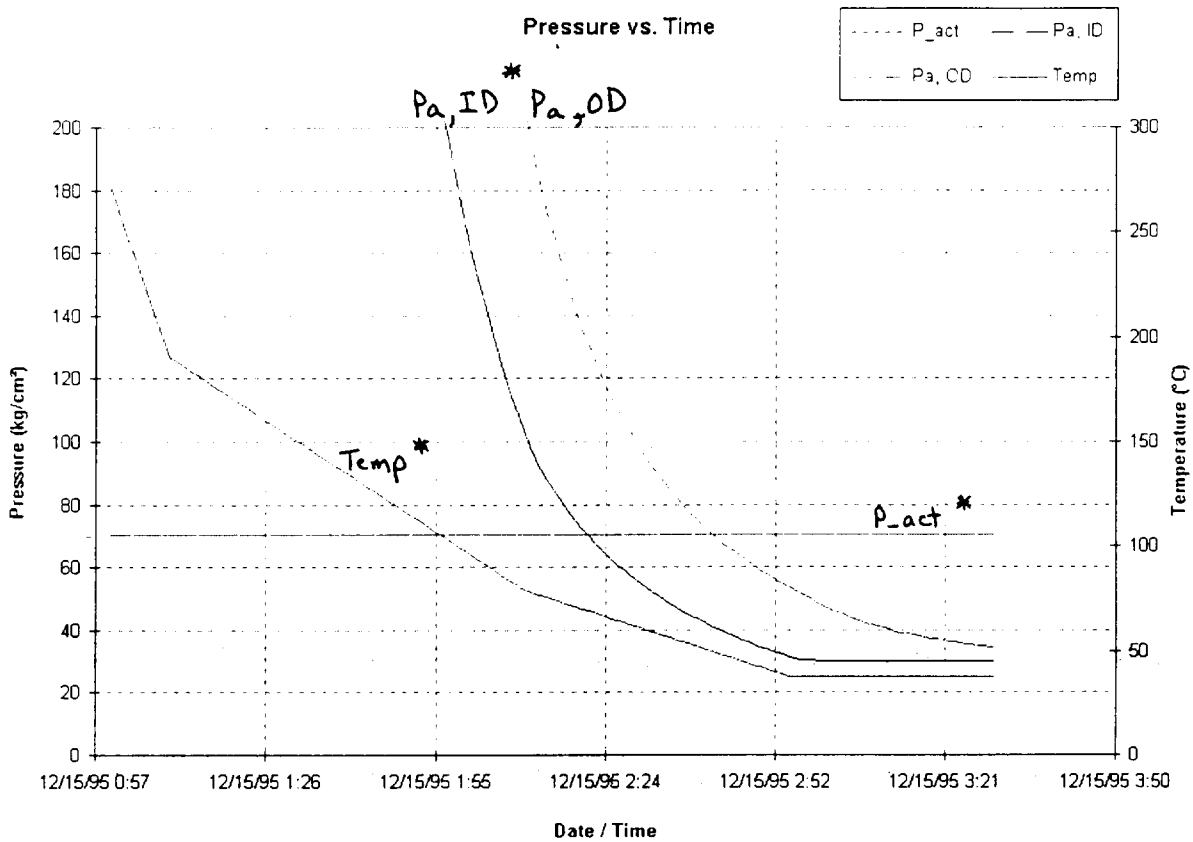
Location-Specific Data

title:	RPV Bottom Head		
outside radius:	2.9702125	[m]	= 110.1875" + 6.75"
wall thickness:	0.17145	[m]	= 6.75"
inside radius:	2.7987625	[m]	calculated
ID heat xfer coeff:	2011.43148	[W/m²·°C]	= 354 BTU/hr-ft²-°F
Material Properties:			
conductivity:	40.49838	[W/m·°C]	= 23.4 BTU/hr-ft-°F *
coeff. of thermal exp.:	1.31E-05	[1/°C]	= 7.25 x 10⁻⁶ in/in-°F
specific heat:	0.4814935	[kJ/kg·°C]	= 0.115 BTU/lb-°F
mass density:	7752.91703	[kg/m³]	= 0.2801 lb/in³
Young's modulus:	1.97E+11	[N/m²]	= 28.5 x 10⁶ psi
Poisson's ratio:	0.3		
Yield Strength	3.28E+08	[N/m²]	= 47,500 psi

* Hand changes to original calc.

10/19/00

Figure 5: Pressure/Temperature Results for Alternate Cooldown Transient
(Compares to Figure 19 of Reference [13])



* Hand changes made to original calc.
10/19/00

6.3 STEP 2: ASSESS TRANSIENT FOR PRESSURE TEST CONDITIONS

The P-T curves in this calculation were developed for a 100°F/hr cooldown rate. Because of the use of K_{IC}, the bottom head curves are primarily controlled by the 10 CFR 50 Appendix G temperature limits. Therefore, for the purposes of this evaluation, a more rigorous assessment can be provided by evaluating the P-T curves developed using K_{IA}.

The inputs for the Brunswick Unit 1 bottom head region were obtained from the Reference [13] calculation and input to SPHERE for pressure test conditions. A calculation was performed for pressure test conditions (i.e., no thermal), as well as the alternate transient shown in Figure 1. The inputs are shown in Figures 6 through 9, and the resulting P-T curves are shown in Figure 10.

The results shown in Figure 10 indicate that previous results obtained using K_{IA} were reproduced. Thus, a second level of verification is provided for the SPHERE spreadsheet, in that it was able to independently reproduce the previous P-T curve results.

Figure 6: RPV Input Data for SPHERE for Pressure Test Conditions

RPV Input Data

Close

Input

Erase Input

*

Date	Time	Press (kg/cm²)	Temp (°C)	(°F)
12/15/95	1:00:00	70.30704	272.2222	522
12/15/95	1:10:00	70.30704	190.5556	375
12/15/95	2:10:00	70.30704	79.44444	175
12/15/95	2:55:00	70.30704	37.77778	100
12/15/95	3:30:00	70.30704	37.77778	100

*

* Hand changes made to original calc.

10/19/00

Figure 7: User Variables Input Data for SPHERE for Pressure Test Conditions

User Variables

evnt_typ	P	Type of event: C=core critical, N=core not crit, P=pressure test
eval_typ	3	Kic evaluation: 1=JEAC 4206, 2=hybrid, 3=Section XI
~~matl_typ~~	~~BM~~	~~Material type: BM=base metal, WM=weld metal~~

*

~~pct_P~~	~~0.1~~	~~mass % of phosphorus in vessel material~~
~~pct_Cu~~	~~0.03~~	~~mass % of copper in vessel material~~
~~pct_Ni~~	~~0.54~~	~~mass % of nickel in vessel material~~
~~pct_Si~~	~~0.016~~	~~mass % of silicon in vessel material~~
~~CF~~	~~121.2505~~	~~Chemistry Factor, calculated = 121.2505~~
47,500 psi ys	3.28E+08	Material Yield Stress [N/m²]

*

~~T_init~~	~~21.11111~~	~~Minimum Boltup Temperature [°C]~~
~~T_o~~	~~125~~	~~Temperature Constant (JEAC 4206) [°C]~~
~~iRT_NDT~~	~~10~~	~~Initial Reference Temperature [°C]~~
~~Margin~~	~~0~~	~~Additional Temperature Shift [°C]~~

*

	1/4 T	3/4 T	
10°F ART	-12.2	-12.2	Adjusted Reference Temperature [°C]

*

~~EFPY~~	~~10~~	~~Effective Full Power Years [power years]~~
~~f_eo~~	~~10~~	~~irradiation fluence level at ID surface, actual~~
~~f_mo~~	~~12~~	~~irradiation fluence level at ID surface, Kic data~~

*

	1/4 T	3/4 T	
calculated a	34.29	102.87	crack depth [mm]
~~f_e~~	~~7.23250~~	~~3.78326~~	~~fluence at depth 'a', actual~~
~~f_m~~	~~8.67900~~	~~4.53991~~	~~fluence at depth 'a', Kic data~~
~~FF_e~~	~~1.65828~~	~~1.42634~~	~~fluence factor at depth 'a', actual~~
~~FF_m~~	~~1.72555~~	~~1.49031~~	~~fluence factor at depth 'a', Kic data~~
~~dT_Kic~~	~~-8.2~~	~~-7.8~~	~~temperature shift due to irradiation [°C]~~
~~RT_NDT~~	~~1.0~~	~~2.2~~	~~Final Reference Temperature [°C]~~

*

* Hand changes made to original calc. → lined-out items not used.

GLS 10/19/00

Figure 8: Location-Specific Input Data for SPHERE for Pressure Test Conditions

Location-Specific Data

title:	RPV Bottom Head		
outside radius:	2.94624125	[m]	= 110.59375" + 5.4" *
wall thickness:	0.13716	[m]	= 5.4" *
inside radius:	2.80908125	[m]	calculated *
ID heat xfer coeff:	2024.2783	[W/m²·°C]	= 356.5 BTU/hr-ft²-°F *
Material Properties:			
conductivity:	41.19066	[W/m·°C]	= 23.8 BTU/hr-ft-°F *
coeff. of thermal exp.:	1.35E-05	[1/°C]	= 7.5x10⁻⁶ in/in-°F *
specific heat:	0.51598686	[kJ/kg·°C]	= 0.1232384 BTU/lb-°F *
mass density:	7752.91703	[kg/m³]	= 0.2801 lb/in³ *
Young's modulus:	1.91E+11	[N/m²]	= 27.7 x 10⁶ psi *
Poisson's ratio:	0.3		✓
Yield Strength	3.28E+08	[N/m²]	= 47,500 psi *

Figure 9: Fixed P/T Curves Input Data for SPHERE for Pressure Test Conditions

Fixed P/T Curves:

* °F	Temp. T (°C)	* Allowable Pressures (kg/cm²) ~~Core Crit~~	* ~~Non-Crit~~	Pres.Test	* (psi)
70	21.1	~~8.0~~	~~8.0~~	0.0	0
70	21.1	~~22.0~~	~~22.0~~	22.0	313
75	23.9	~~22.0~~	~~22.0~~	22.0	
80	26.7	~~22.0~~	~~22.0~~	22.0	
85	29.4	~~22.0~~	~~22.0~~	22.0	
90	32.2	~~22.0~~	~~22.0~~	22.0	
95	35.0	~~22.0~~	~~22.0~~	22.0	
100	37.8	~~22.0~~	~~22.0~~	22.0	313
100	37.8	~~46.2~~	~~46.2~~	46.2	657
105	40.6	~~48.4~~	~~48.4~~	48.4	688
110	43.3	~~50.8~~	~~50.8~~	50.8	722
115	46.1	~~53.3~~	~~53.3~~	53.3	758
120	48.9	~~56.0~~	~~56.0~~	56.0	797
125	51.7	~~58.9~~	~~58.9~~	58.9	838
130	54.4	~~62.1~~	~~62.1~~	62.1	883
135	57.2	~~65.5~~	~~65.5~~	65.5	931
140	60.0	~~69.1~~	~~69.1~~	69.1	983
151	66.1	~~78.4~~	~~78.4~~	78.4	1115
156	68.9	~~83.0~~	~~83.0~~	83.0	1181

* Hand changes to original calc. → lined-out items not used.

10/19/00

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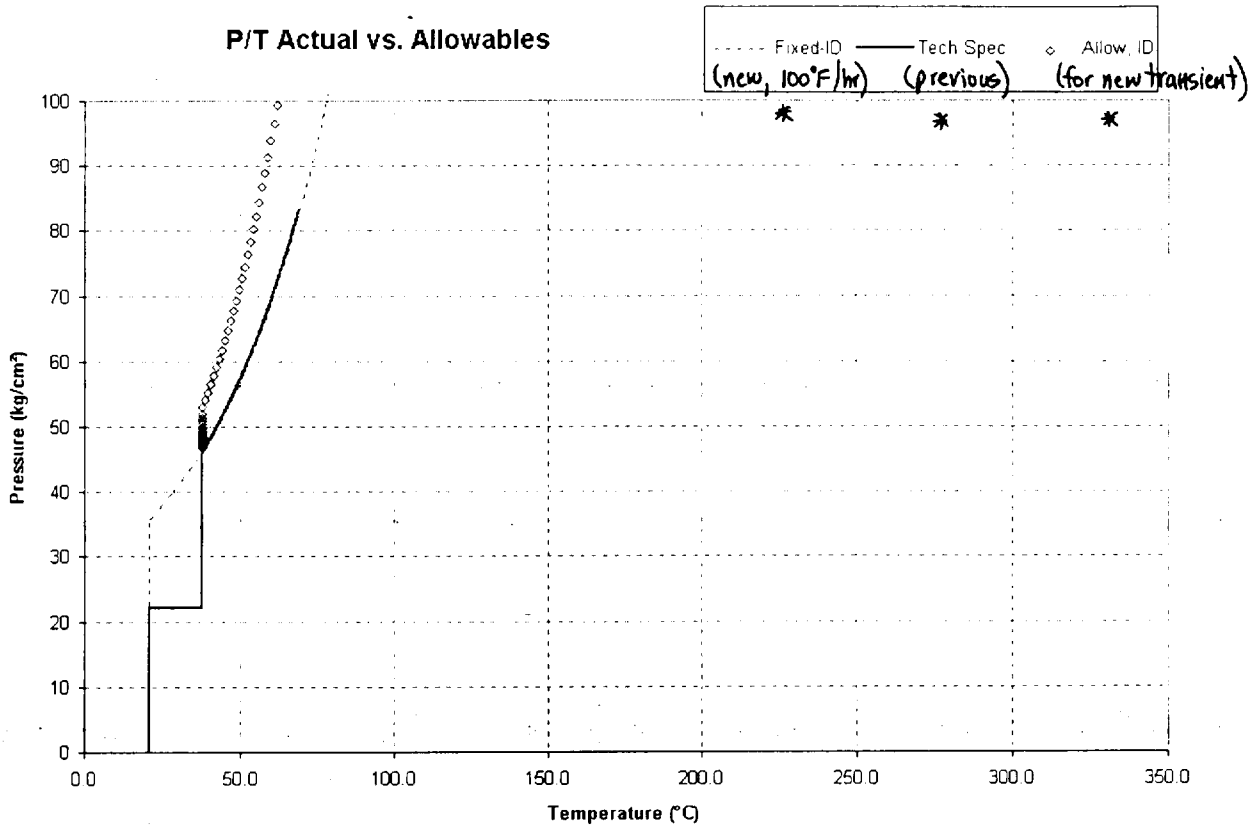
Checker/Date	JAH 10/19/00			
File No. CPL-54Q-303				**Page 16 of 23**

Figure 10: Pressure-Temperature Results for Pressure Test Conditions



* Hand changes made to original calc.

10/19/00

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	Preparer/Date	GLS 10/19/00			
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	File No. CPL-54Q-303				Page 17 of 23

6.4 STEP 5: ASSESS TRANSIENT FOR HEATUP/COOLDOWN CONDITIONS

The inputs for the Brunswick Unit 1 bottom head region were obtained from the Reference [13] calculation and input to SPHERE for heatup/cooldown conditions. A calculation was performed for heatup/cooldown conditions for a fixed cooldown rate of 100°F/hr, as well as the alternate transient shown in Figure 1. The inputs are shown in Figures 11 through 14, and the resulting P-T curves are shown in Figure 15.

The results shown in Figure 15 indicate that previous results obtained using K_{IA} were again essentially reproduced. The small differences in the curves are attributed to small differences in the thermal stress solution employed in SPHERE vs. the previous evaluation. Thus, a third level of verification is provided for the SPHERE spreadsheet, in that it was able to independently reproduce the previous P-T curve results.

Figure 11: RPV Input Data for SPHERE for Heatup/Cooldown Conditions

RPV Input Data

Close

Input

Erase Input

*

Date	Time	Press (kg/cm²)	Temp (°C)	°F
12/15/95	1:00:00	70.30704	272.2222	522
12/15/95	1:10:00	70.30704	190.5556	375
12/15/95	2:10:00	70.30704	79.44444	175
12/15/95	2:55:00	70.30704	37.77778	100
12/15/95	3:30:00	70.30704	37.77778	100

*

* Hand changes to original calc.

10/19/00

Figure 12: User Variables Input Data for SPHERE for Heatup/Cooldown Conditions

User Variables

evnt_typ	N	Type of event: C=core critical, N=core not crit, P=pressure test
eval_typ	3	Kic evaluation: 1=JEAC 4206, 2=hybrid, 3=Section XI
~~matl_typ~~	~~BM~~	~~Material type: BM=base metal, WM=weld metal~~

*

~~pct_P~~	~~0.1~~	~~mass % of phosphorus in vessel material~~
~~pct_Cu~~	~~0.03~~	~~mass % of copper in vessel material~~
~~pct_Ni~~	~~0.54~~	~~mass % of nickel in vessel material~~
~~pct_Si~~	~~0.016~~	~~mass % of silicon in vessel material~~
~~CF~~	~~121.2505~~	~~Chemistry Factor, calculated = 121.2505~~
47,500psi ys	3.28E+08	Material Yield Stress [N/m²]

*

~~T_init~~	~~21.11111~~	~~Minimum Boltup Temperature [°C]~~
~~T_o~~	~~125~~	~~Temperature Constant (JEAC 4206) [°C]~~
~~IRT_NDT~~	~~10~~	~~Initial Reference Temperature [°C]~~
~~Margin~~	~~0~~	~~Additional Temperature Shift [°C]~~

*

	1/4 T	3/4 T	
10°F ART	-12.2	-12.2	Adjusted Reference Temperature [°C]

*

~~EFPY~~	~~10~~	~~Effective Full-Power Years [power years]~~
~~f_eo~~	~~10~~	~~irradiation fluence level at ID surface, actual~~
~~f_mo~~	~~12~~	~~irradiation fluence level at ID surface, Kic data~~

*

	1/4 T	3/4 T	
calculated a	34.29	102.87	crack depth [mm]
~~f_e~~	~~7.23250~~	~~3.78326~~	~~fluence at depth 'a', actual~~
~~f_m~~	~~8.67900~~	~~4.53991~~	~~fluence at depth 'a', Kic data~~
~~FF_e~~	~~1.65828~~	~~1.42634~~	~~fluence factor at depth 'a', actual~~
~~FF_m~~	~~1.72555~~	~~1.49031~~	~~fluence factor at depth 'a', Kic data~~
~~dT_Kic~~	~~-8.2~~	~~-7.0~~	~~temperature shift due to irradiation [°C]~~
~~RT_NDT~~	~~1.8~~	~~2.2~~	~~Final Reference Temperature [°C]~~

*

* Hand changes made to original calc. → lined-out items not used.

10/19/00

Figure 13: Location-Specific Input Data for SPHERE for Heatup/Cooldown Conditions

Location-Specific Data

title:	RPV Bottom Head	
outside radius:	2.94624125	[m]
wall thickness:	0.13716	[m]
inside radius:	2.80908125	[m]
ID heat xfer coeff:	2024.2783	[W/m²·°C]
Material Properties:		
conductivity:	41.19066	[W/m·°C]
coeff. of thermal exp.:	1.35E-05	[1/°C]
specific heat:	0.51598686	[kJ/kg·°C]
mass density:	7752.91703	[kg/m³]
Young's modulus:	1.91E+11	[N/m²]
Poisson's ratio:	0.3	
Yield Strength	3.28E+08	[N/m²]

English units same as Figure 8 *

Figure 14: Fixed P/T Curves Input Data for SPHERE for Heatup/Cooldown Conditions

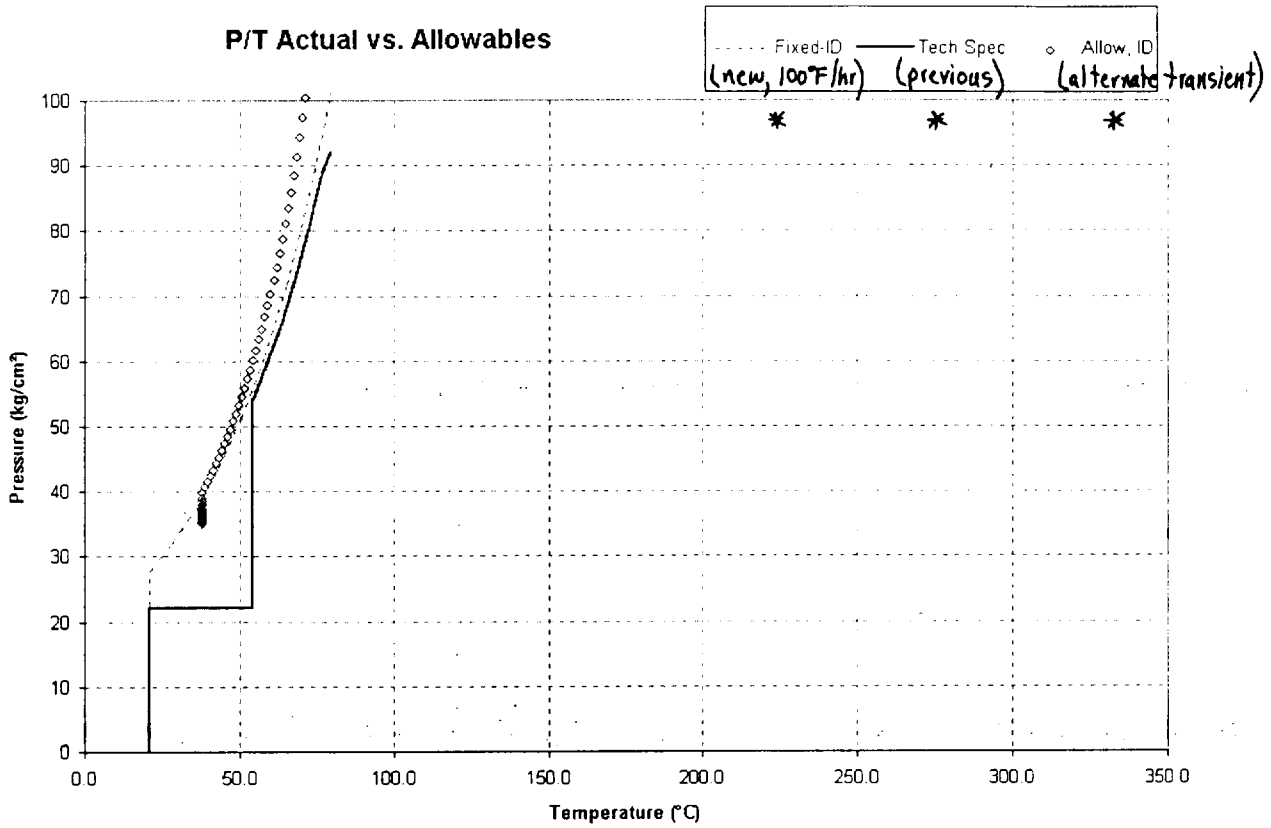
Fixed P/T Curves:

* °F	Temp. T (°C)	* Allowable Pressures (kg/cm²) ~~Core Crit~~	Non-Crit	~~Pres.Test~~	* (psi)
70	21.1	~~0.0~~	0.0	~~0.0~~	0
70	21.1	~~22.0~~	22.0	~~22.0~~	313
70	21.1	~~22.0~~	22.0	~~22.0~~	
75	23.9	~~22.0~~	22.0	~~22.0~~	
80	26.7	~~22.0~~	22.0	~~22.0~~	
85	29.4	~~22.0~~	22.0	~~22.0~~	
90	32.2	~~22.0~~	22.0	~~22.0~~	
95	35.0	~~22.0~~	22.0	~~22.0~~	
130	54.4	~~22.0~~	22.0	~~22.0~~	313
130	54.4	~~53.9~~	53.9	~~53.9~~	767
135	57.2	~~57.2~~	57.2	~~57.2~~	814
140	60.0	~~60.8~~	60.8	~~60.8~~	865
145	62.8	~~64.7~~	64.7	~~64.7~~	920
150	65.6	~~68.9~~	68.9	~~68.9~~	979
155	68.3	~~73.3~~	73.3	~~73.3~~	1043
160	71.1	~~78.1~~	78.1	~~78.1~~	1111
165	73.9	~~83.3~~	83.3	~~83.3~~	1185
170	76.7	~~88.8~~	88.8	~~88.8~~	1264
175	79.4	~~92.0~~	92.0	~~92.0~~	1309

* Hand changes to original calc. → lined-out items not used.

GLS 10/19/00

Figure 15: Pressure-Temperature Results for Heatup/Cooldown Conditions



* Hand changes made to original calc.

10/19/00

	Revision	0			
	Preparer/Date	GLS 10/19/00			
	Checker/Date	JAH 10/19/00			
	File No. CPL-54Q-303				Page 21 of 23

7.0 CONCLUSIONS

Based on the results shown in Figures 10 and 15, the following conclusions can be made:

- The P-T curves developed in this calculation for a fixed rate of 100°F/hr are bounding compared to the alternate cooldown transient shown in Figure 1. The alternate cooldown transient was developed specifically to bound all actual operating conditions in the bottom head region. Therefore, the P-T curves bound all expected operating conditions for the bottom head region, including the transient defined in Figure 1. The transient defined in Figure 1 was developed specifically to cover inadvertent cooldown events in the bottom head region, and to bound all actual operating conditions in the bottom head region.
- These results are consistent with the methodology in ASME Code, Section XI, Appendix G [3], where solutions are provided for heatup/cooldown rates of 100°F/hr or less. Appendix G states that "the results would be overly conservative if applied to rapid temperature changes."
- The conclusions shown here for Unit 1 also apply to Unit 2, since the same comparative results would be obtained for a different set of geometry/material inputs.

It is therefore concluded that the P-T curves included in Appendices B and C of this calculation for the bottom head region for both Brunswick units bound all anticipated operating conditions.

6.0 REFERENCES

1. E-mail from Phil Gore (CP&L) to Gary Stevens (SI), "RE: Fluence Estimates for PT Curve Work.xls," 10/10/00, 11:31 AM, with attached Word Document "95-0572.doc" and Excel Spreadsheet "Fluence Estimates for PT Curve Work.xls," SI File No. CPL-54Q-201.

2. USNRC Regulatory Guide 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials," U. S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, (Task ME 305-4), May 1988.

3. ASME Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, Nonmandatory Appendix G, "Fracture Toughness Criteria for Protection Against Failure," 1989 Edition, No Addenda.

4. U. S. Code of Federal Regulations, Title 10, Part 50, Appendix G, "Fracture Toughness Requirements," 1-1-98 Edition.

5. WRC Bulletin 175, "PVRC Recommendations on Toughness Requirements for Ferritic Materials," PVRC Ad Hoc Group on Toughness Requirements, Welding Research Council, August 1972.

6. ASME Boiler and Pressure Vessel Code, Code Case N-640, "Alternative Reference Fracture Toughness for Development of P-T Limit Curves," Section XI, Division 1, Approved February 26, 1999.

7. Structural Integrity Associates Calculation No. CPL-36Q-306, Revision 0, "Evaluation of BSEP Unit 1 P-T Curves for Heat-up and Cooldown," 5/16/95.

8. Structural Integrity Associates Calculation No. CPL-42Q-302, Revision 1, "Brunswick Units 1 and 2 Hydro Test P-T Curve Development," 8/22/96.

9. PIPE-TS2, "Program to Compute the Transient Thermal and Stress Response of an Axisymmetric Two-Material Cylinder," Version 1.01, Structural Integrity Associates.

10. Structural Integrity Associates Calculation No. CPL-36Q-305, Revision 0, "Cool-down Temperature/Stress Analysis of the N16 Nozzle at Brunswick Unit 1," 5/17/95.

11. ASME Boiler and Pressure Vessel Code, Section III, Rules for Construction of Nuclear Power Plant Components, Appendices, 1989 Edition, No Addenda.

12. U. S. Code of Federal Regulations, Title 10, Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," 1/1/98.

13. Structural Integrity Associates Calculation No. CPL-40Q-305, Revision 1, "Fracture Toughness Assessment of Bottom Head."

14. Structural Integrity Associates Report No. SIR-96-010, Revision 0, "Justification to Relax Requirements for Recirculation Pump Restart Following a Scram Event Brunswick Steam Electric Plant Units 1 and 2," SI File No. CPL-40Q-401.

Appendix A

PIPE-TS2 Input/Output Files for Heat Transfer Analysis of Beltline and Bottom Head Regions

File = "U1-BELT.IN"	[2 pages]
File = "15480.STP" (for Unit 1 beltline)	[1 page]
File = "U1-BOTHD.IN"	[2 pages]
File = "15480.STP" (for Unit 1 bottom head)	[1 page]
File = "U2-BELT.IN"	[2 pages]
File = "15480.STP" (for Unit 2 beltline)	[1 page]
File = "U2-BOTHD.IN"	[2 pages]
File = "15480.STP" (for Unit 2 bottom head)	[1 page]
Total =	[12 pages]

```
File   "[illegible]BELT.IN"

******  PIPE-TS2 INPUT FILE  =>  100f.in (TOP OF FILE)  ******
" Note that a blank line must preceed each line with ==> at start"

"==> Next 3 lines are CASE DESCRIPTIONS (or blanks) in parentheses"
"Cooldown Transient for Brunswick Unit 1"
"100F/hr, 550F to 120F"
"Vessel Shell Location"

"==> Next information is the pipe geometry"
"   First line is number of pipe nodes - 40 max"
"   Next line is inside radius (in.) and outside radius(in.)"
"   Next line is interface rad. (in.) / nodes in first material"
              40
              110.59375   116.08975
              110.73115   1

"==> Next line is initial pipe wall temperature"
              550

"==> Next series of lines is Inside Temperature history"
"    First entry is number of input data pairs - 40 Max"
"    Data pairs follow as   Time(sec)   Temperature(F)"
              3
              0             550
              15480         120
              16000         120

"==> Next series of lines is Inside Ht. Tx. Coefficient history"
"    First entry is number of input data pairs - 40 max"
"    Data pairs:  Time(sec)   Ht. Tx. Coefficient(Btu/hr-ft2-F)"
              2
              0            356.5
              16000        356.5

"==> Next series of lines is Outside Temperature history"
"    First entry is number of input data pairs - 40 Max"
"    Data pairs follow as   Time(sec)   Temperature(F)"
              2
              0             120
              16000         120

"==> Next series of lines is Outside Ht. Tx. Coefficient history"
"    First entry is number of input data pairs - 40 max"
"    Data pairs:  Time(sec)   Ht. Tx. Coefficient(Btu/hr-ft2-F)"
              2
              0             0.2
              16000         0.2

"==> Following are inner material properties (LAS, Clad is neglected) @350F ('89
Code)"
"    Thermal conductivity (Btu/Hr-Ft-F)"
              23.8
"    Density * Specific Heat (Btu/Ft3)"
              59.649
```

```
"    Modulus of Elasticity (ksi)"
              27.7e3
"    Coefficient of Thermal Expansion (per F)"
              7.50e-6
"    Poissons Ratio"
              .3

"==> Following are outer material properties (LAS) @350F ('89 Code)"
"    Thermal conductivity (Btu/Hr-Ft-F)"
              23.8
"    Density * Specific Heat (Btu/Ft3)"
              59.649
"    Modulus of Elasticity (ksi)"
              27.7e3
"    Coefficient of Thermal Expansion (per F)"
              7.50e-6
"    Poissons Ratio"
              .3

"==> Value of uniform temperature which is stress free in cylinder"
"    Stress-free temperature (F) may be any value"
              70

"==> Timestep and time control information (seconds)"
"     Timestep Max <= 0.5*{[(Ro-Ri)/nodes]^2/[k/RhoCp]}*3600"
"     Next line is number of time control intervals "
              1
"   end of interval - time step - print interval"
              16000          10.0          360
********************** END OF FILE  ******************
   CREATED   DATE:  12-18-1998       TIME:  09:30:00
```

1	110.5938	+5.29	+5.29	-0.00	+3.92	+3.94	127.8	132.3
2	110.7311	+4.89	+4.90	+0.01	+3.72	+3.74	129.1	133.0
3	110.8685	+4.50	+4.51	+0.01	+3.53	+3.55	130.4	133.7
4	111.0059	+4.13	+4.14	+0.02	+3.33	+3.35	131.7	134.3
5	111.1433	+3.76	+3.78	+0.02	+3.13	+3.16	132.9	135.0
6	111.2807	+3.40	+3.43	+0.03	+2.94	+2.96	134.1	135.6
7	111.4181	+3.06	+3.09	+0.03	+2.74	+2.77	135.2	136.3
8	111.5555	+2.72	+2.76	+0.03	+2.55	+2.57	136.3	136.9
9	111.6929	+2.40	+2.44	+0.04	+2.35	+2.38	137.4	137.6
10	111.8303	+2.08	+2.12	+0.04	+2.16	+2.18	138.5	138.3
11	111.9677	+1.78	+1.82	+0.04	+1.96	+1.99	139.5	138.9
12	112.1051	+1.49	+1.53	+0.04	+1.76	+1.79	140.4	139.6
13	112.2425	+1.21	+1.25	+0.05	+1.57	+1.60	141.4	140.2
14	112.3799	+0.93	+0.98	+0.05	+1.37	+1.40	142.3	140.9
15	112.5173	+0.67	+0.72	+0.05	+1.18	+1.20	143.2	141.6
16	112.6547	+0.42	+0.47	+0.05	+0.98	+1.01	144.0	142.2
17	112.7921	+0.18	+0.23	+0.05	+0.78	+0.81	144.8	142.9
18	112.9295	-0.05	-0.00	+0.05	+0.59	+0.62	145.6	143.5
19	113.0669	-0.27	-0.22	+0.05	+0.39	+0.42	146.4	144.2
20	113.2043	-0.48	-0.43	+0.05	+0.20	+0.23	147.1	144.8
21	113.3417	-0.68	-0.63	+0.05	+0.00	+0.03	147.7	145.5
22	113.4791	-0.87	-0.82	+0.05	-0.19	-0.16	148.4	146.2
23	113.6165	-1.05	-1.00	+0.05	-0.39	-0.36	149.0	146.8
24	113.7539	-1.22	-1.17	+0.04	-0.59	-0.55	149.6	147.5
25	113.8913	-1.38	-1.33	+0.04	-0.78	-0.75	150.1	148.1
26	114.0287	-1.53	-1.49	+0.04	-0.98	-0.94	150.6	148.8
27	114.1661	-1.66	-1.63	+0.04	-1.17	-1.14	151.1	149.5
28	114.3035	-1.79	-1.76	+0.04	-1.37	-1.33	151.5	150.1
29	114.4409	-1.91	-1.88	+0.03	-1.57	-1.53	151.9	150.8
30	114.5783	-2.02	-1.99	+0.03	-1.76	-1.73	152.3	151.4
31	114.7157	-2.12	-2.09	+0.03	-1.96	-1.92	152.7	152.1
32	114.8531	-2.21	-2.18	+0.03	-2.15	-2.12	153.0	152.8
33	114.9905	-2.29	-2.27	+0.02	-2.35	-2.31	153.2	153.4
34	115.1279	-2.36	-2.34	+0.02	-2.54	-2.51	153.5	154.1
35	115.2653	-2.42	-2.40	+0.02	-2.74	-2.70	153.7	154.7
36	115.4027	-2.47	-2.45	+0.02	-2.94	-2.90	153.9	155.4
37	115.5401	-2.51	-2.50	+0.01	-3.13	-3.09	154.0	156.0
38	115.6775	-2.54	-2.53	+0.01	-3.33	-3.29	154.1	156.7
39	115.8149	-2.56	-2.55	+0.01	-3.52	-3.48	154.2	157.4
40	115.9523	-2.57	-2.57	+0.00	-3.72	-3.68	154.3	158.0
41	116.0897	-2.57	-2.57	+0.00	-3.92	-3.87	154.3	158.7

15480

```
Filename: "100f.in"

******  PIPE-TSE INPUT FILE  =>  100f.in (TOP OF FILE)  ******
" Note that a blank line must preceed each line with ==> at start"

"==> Next 3 lines are CASE DESCRIPTIONS (or blanks) in parentheses"
"Cooldown Transient for Brunswick Unit 1"
"100F/hr, 550F to 120F"
"Bottom Head Location"

"==> Next information is the pipe geometry"
"   First line is number of pipe nodes - 40 max"
"   Next line is inside radius (in.) and outside radius(in.)"
"   Next line is interface rad. (in.) / nodes in first material"
              40
              110.59375   115.99375
              110.72875   1

"==> Next line is initial pipe wall temperature"
              550

"==> Next series of lines is Inside Temperature history"
"    First entry is number of input data pairs - 40 Max"
"    Data pairs follow as   Time(sec)   Temperature(F)"
              3
              0             550
              15480         120
              16000         120

"==> Next series of lines is Inside Ht. Tx. Coefficient history"
"    First entry is number of input data pairs - 40 max"
"    Data pairs:  Time(sec)   Ht. Tx. Coefficient(Btu/hr-ft2-F)"
              2
              0            356.5
              16000        356.5

"==> Next series of lines is Outside Temperature history"
"    First entry is number of input data pairs - 40 Max"
"    Data pairs follow as   Time(sec)   Temperature(F)"
              2
              0             120
              16000         120

"==> Next series of lines is Outside Ht. Tx. Coefficient history"
"    First entry is number of input data pairs - 40 max"
"    Data pairs:  Time(sec)   Ht. Tx. Coefficient(Btu/hr-ft2-F)"
              2
              0             0.2
              16000         0.2

"==> Following are inner material properties (LAS, Clad is neglected) @350F ('89
Code)"
"    Thermal conductivity (Btu/Hr-Ft-F)"
              23.8
"    Density * Specific Heat (Btu/Ft3)"
              59.649
"    Modulus of Elasticity (ksi)"
```

```
"    Coefficient of Thermal Expansion (per F)"
              7.50e-6
"    Poissons Ratio"
              .3

"==> Following are outer material properties (LAS) @350F ('89 Code)"
"    Thermal conductivity (Btu/Hr-Ft-F)"
              23.8
"    Density * Specific Heat (Btu/Ft3)"
              59.649
"    Modulus of Elasticity (ksi)"
              27.7e3
"    Coefficient of Thermal Expansion (per F)"
              7.50e-6
"    Poissons Ratio"
              .3

"==> Value of uniform temperature which is stress free in cylinder"
"    Stress-free temperature (F) may be any value"
              70

"==> Timestep and time control information (seconds)"
"     Timestep Max <= 0.5*{[(Ro-Ri)/nodes]^2/[k/RhoCp]}*3600"
"     Next line is number of time control intervals "
              1
"   end of interval - time step - print interval"
              16000         10.0            360
********************** END OF FILE  ********************
   CREATED   DATE:  12-18-1998       TIME:  09:30:00
```

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	110.5988	+5.10	+5.10	-0.00	+3.78	+3.80	127.7	132.0
2	110.7288	+4.72	+4.73	+0.01	+3.59	+3.62	128.9	132.7
3	110.8638	+4.35	+4.36	+0.01	+3.40	+3.43	130.2	133.3
4	110.9988	+3.98	+4.00	+0.02	+3.21	+3.24	131.4	133.9
5	111.1338	+3.63	+3.65	+0.02	+3.02	+3.05	132.6	134.6
6	111.2688	+3.28	+3.31	+0.03	+2.83	+2.86	133.7	135.2
7	111.4038	+2.95	+2.98	+0.03	+2.65	+2.67	134.8	135.9
8	111.5388	+2.63	+2.66	+0.03	+2.46	+2.48	135.9	136.5
9	111.6738	+2.32	+2.35	+0.04	+2.27	+2.29	136.9	137.1
10	111.8088	+2.01	+2.05	+0.04	+2.08	+2.11	137.9	137.8
11	111.9438	+1.72	+1.76	+0.04	+1.89	+1.92	138.9	138.4
12	112.0788	+1.44	+1.48	+0.04	+1.70	+1.73	139.9	139.0
13	112.2138	+1.17	+1.21	+0.04	+1.51	+1.54	140.8	139.7
14	112.3488	+0.90	+0.95	+0.04	+1.32	+1.35	141.7	140.3
15	112.4838	+0.65	+0.70	+0.05	+1.13	+1.16	142.5	140.9
16	112.6188	+0.41	+0.45	+0.05	+0.95	+0.97	143.3	141.6
17	112.7538	+0.18	+0.22	+0.05	+0.76	+0.79	144.1	142.2
18	112.8888	-0.05	-0.00	+0.05	+0.57	+0.60	144.9	142.8
19	113.0238	-0.26	-0.21	+0.05	+0.38	+0.41	145.6	143.5
20	113.1588	-0.46	-0.42	+0.05	+0.19	+0.22	146.3	144.1
21	113.2938	-0.66	-0.61	+0.05	+0.00	+0.03	146.9	144.7
22	113.4288	-0.84	-0.79	+0.04	-0.19	-0.16	147.5	145.4
23	113.5638	-1.01	-0.97	+0.04	-0.38	-0.35	148.1	146.0
24	113.6988	-1.17	-1.13	+0.04	-0.57	-0.53	148.7	146.7
25	113.8338	-1.33	-1.29	+0.04	-0.75	-0.72	149.2	147.3
26	113.9688	-1.47	-1.43	+0.04	-0.94	-0.91	149.7	147.9
27	114.1038	-1.61	-1.57	+0.04	-1.13	-1.10	150.1	148.6
28	114.2388	-1.73	-1.70	+0.03	-1.32	-1.29	150.6	149.2
29	114.3738	-1.85	-1.81	+0.03	-1.51	-1.48	151.0	149.8
30	114.5088	-1.95	-1.92	+0.03	-1.70	-1.67	151.3	150.5
31	114.6438	-2.05	-2.02	+0.03	-1.89	-1.86	151.7	151.1
32	114.7788	-2.13	-2.11	+0.03	-2.08	-2.04	152.0	151.7
33	114.9138	-2.21	-2.19	+0.02	-2.27	-2.23	152.2	152.4
34	115.0488	-2.28	-2.26	+0.02	-2.45	-2.42	152.5	153.0
35	115.1838	-2.33	-2.32	+0.02	-2.64	-2.61	152.7	153.6
36	115.3188	-2.38	-2.37	+0.01	-2.83	-2.80	152.8	154.3
37	115.4538	-2.42	-2.41	+0.01	-3.02	-2.99	153.0	154.9
38	115.5888	-2.45	-2.44	+0.01	-3.21	-3.18	153.1	155.6
39	115.7238	-2.47	-2.46	+0.01	-3.40	-3.36	153.2	156.2
40	115.8588	-2.48	-2.48	+0.00	-3.59	-3.55	153.2	156.8
41	115.9938	-2.48	-2.48	-0.00	-3.78	-3.74	153.2	157.5

15480

```
****** PIPE-TSI INPUT FILE => 100f.in (TOP OF FILE) ******
" Note that a blank line must preceed each line with ==> at start"

"==> Next 3 lines are CASE DESCRIPTIONS (or blanks) in parentheses"
"Cooldown Transient for Brunswick Unit 2"
"100F/hr, 550F to 120F"
"Vessel Shell Location"

"==> Next information is the pipe geometry"
"   First line is number of pipe nodes - 40 max"
"   Next line is inside radius (in.) and outside radius(in.)"
"   Next line is interface rad. (in.) / nodes in first material"
            40
            110.3125   115.7785
            110.44915   1

"==> Next line is initial pipe wall temperature"
            550

"==> Next series of lines is Inside Temperature history"
"    First entry is number of input data pairs - 40 Max"
"    Data pairs follow as   Time(sec)   Temperature(F)"
            3
            0              550
            15480          120
            16000          120

"==> Next series of lines is Inside Ht. Tx. Coefficient history"
"    First entry is number of input data pairs - 40 max"
"    Data pairs:  Time(sec)   Ht. Tx. Coefficient(Btu/hr-ft2-F)"
            2
            0             356.5
            16000         356.5

"==> Next series of lines is Outside Temperature history"
"    First entry is number of input data pairs - 40 Max"
"    Data pairs follow as   Time(sec)   Temperature(F)"
            2
            0              120
            16000          120

"==> Next series of lines is Outside Ht. Tx. Coefficient history"
"    First entry is number of input data pairs - 40 max"
"    Data pairs:  Time(sec)   Ht. Tx. Coefficient(Btu/hr-ft2-F)"
            2
            0              0.2
            16000          0.2

"==> Following are inner material properties (LAS, Clad is neglected) @350F ('89
Code)"
"    Thermal conductivity (Btu/Hr-Ft-F)"
            23.8
"    Density * Specific Heat (Btu/Ft3)"
            59.649
"    Modulus of Elasticity (ksi)"
```

```
"    Coefficient of Thermal Expansion (per F)"
              7.50e-6
"    Poissons Ratio"
              .3

"==> Following are outer material properties (LAS) @350F ('89 Code)"
"    Thermal conductivity (Btu/Hr-Ft-F)"
              23.8
"    Density * Specific Heat (Btu/Ft3)"
              59.649
"    Modulus of Elasticity (ksi)"
              27.7e3
"    Coefficient of Thermal Expansion (per F)"
              7.50e-6
"    Poissons Ratio"
              .3

"==> Value of uniform temperature which is stress free in cylinder"
"    Stress-free temperature (F) may be any value"
              70

"==> Timestep and time control information (seconds)"
"     Timestep Max <= 0.5*{[(Ro-Ri)/nodes]^2/[k/RhoCp]}*3600"
"     Next line is number of time control intervals "
              1
"   end of interval - time step - print interval"
              16000         10.0            360
********************** END OF FILE  ********************
   CREATED   DATE:  12-18-1998       TIME:  09:30:00
```

1	110.3125	+5.23	+5.23	+0.00	+3.88	+3.90	127.8	132.3
2	110.4492	+4.84	+4.85	+0.01	+3.68	+3.71	129.1	132.9
3	110.5858	+4.46	+4.47	+0.01	+3.49	+3.51	130.3	133.6
4	110.7225	+4.08	+4.10	+0.02	+3.29	+3.32	131.6	134.2
5	110.8591	+3.72	+3.74	+0.02	+3.10	+3.13	132.8	134.9
6	110.9958	+3.37	+3.39	+0.03	+2.91	+2.93	134.0	135.5
7	111.1324	+3.03	+3.06	+0.03	+2.71	+2.74	135.1	136.2
8	111.2691	+2.69	+2.73	+0.03	+2.52	+2.55	136.2	136.8
9	111.4057	+2.37	+2.41	+0.04	+2.33	+2.35	137.3	137.5
10	111.5424	+2.06	+2.10	+0.04	+2.13	+2.16	138.3	138.1
11	111.6790	+1.76	+1.80	+0.04	+1.94	+1.97	139.3	138.8
12	111.8157	+1.47	+1.52	+0.04	+1.74	+1.77	140.3	139.4
13	111.9523	+1.19	+1.24	+0.05	+1.55	+1.58	141.2	140.1
14	112.0890	+0.93	+0.97	+0.05	+1.36	+1.39	142.1	140.7
15	112.2256	+0.67	+0.71	+0.05	+1.16	+1.19	143.0	141.4
16	112.3623	+0.42	+0.47	+0.05	+0.97	+1.00	143.8	142.0
17	112.4989	+0.18	+0.23	+0.05	+0.78	+0.81	144.6	142.7
18	112.6356	-0.05	-0.00	+0.05	+0.58	+0.61	145.4	143.3
19	112.7722	-0.27	-0.22	+0.05	+0.39	+0.42	146.1	144.0
20	112.9089	-0.47	-0.43	+0.05	+0.19	+0.23	146.8	144.6
21	113.0455	-0.67	-0.63	+0.05	+0.00	+0.03	147.5	145.3
22	113.1822	-0.86	-0.81	+0.05	-0.19	-0.16	148.1	145.9
23	113.3188	-1.04	-0.99	+0.04	-0.39	-0.35	148.7	146.6
24	113.4555	-1.20	-1.16	+0.04	-0.58	-0.55	149.3	147.2
25	113.5921	-1.36	-1.32	+0.04	-0.77	-0.74	149.8	147.9
26	113.7288	-1.51	-1.47	+0.04	-0.97	-0.93	150.3	148.5
27	113.8654	-1.65	-1.61	+0.04	-1.16	-1.13	150.8	149.2
28	114.0021	-1.78	-1.74	+0.04	-1.35	-1.32	151.3	149.8
29	114.1387	-1.89	-1.86	+0.03	-1.55	-1.51	151.7	150.5
30	114.2754	-2.00	-1.97	+0.03	-1.74	-1.71	152.0	151.1
31	114.4120	-2.10	-2.07	+0.03	-1.94	-1.90	152.4	151.8
32	114.5487	-2.19	-2.16	+0.03	-2.13	-2.10	152.7	152.5
33	114.6853	-2.27	-2.24	+0.02	-2.32	-2.29	152.9	153.1
34	114.8220	-2.33	-2.31	+0.02	-2.52	-2.48	153.2	153.8
35	114.9586	-2.39	-2.38	+0.02	-2.71	-2.68	153.4	154.4
36	115.0953	-2.44	-2.43	+0.01	-2.90	-2.87	153.6	155.1
37	115.2319	-2.48	-2.47	+0.01	-3.10	-3.06	153.7	155.7
38	115.3686	-2.51	-2.50	+0.01	-3.29	-3.26	153.8	156.4
39	115.5052	-2.53	-2.53	+0.01	-3.49	-3.45	153.9	157.0
40	115.6419	-2.54	-2.54	+0.00	-3.68	-3.64	153.9	157.7
41	115.7785	-2.54	-2.54	+0.00	-3.87	-3.84	154.0	158.3

15480

```
****** PIPE-TS2 INPUT FILE => 100f.in (TOP OF FILE) ******
" Note that a blank line must preceed each line with ==> at start"

"==> Next 3 lines are CASE DESCRIPTIONS (or blanks) in parentheses"
"Cooldown Transient for Brunswick Unit 2"
"100F/hr, 550F to 120F"
"Bottom Head Location"

"==> Next information is the pipe geometry"
"   First line is number of pipe nodes - 40 max"
"   Next line is inside radius (in.) and outside radius(in.)"
"   Next line is interface rad. (in.) / nodes in first material"
            40
            110.3125   115.7325
            110.4480   1

"==> Next line is initial pipe wall temperature"
            550

"==> Next series of lines is Inside Temperature history"
"    First entry is number of input data pairs - 40 Max"
"    Data pairs follow as   Time(sec)   Temperature(F)"
            3
            0              550
            15480          120
            16000          120

"==> Next series of lines is Inside Ht. Tx. Coefficient history"
"    First entry is number of input data pairs - 40 max"
"    Data pairs:  Time(sec)   Ht. Tx. Coefficient(Btu/hr-ft2-F)"
            2
            0             356.5
            16000         356.5

"==> Next series of lines is Outside Temperature history"
"    First entry is number of input data pairs - 40 Max"
"    Data pairs follow as   Time(sec)   Temperature(F)"
            2
            0              120
            16000          120

"==> Next series of lines is Outside Ht. Tx. Coefficient history"
"    First entry is number of input data pairs - 40 max"
"    Data pairs:  Time(sec)   Ht. Tx. Coefficient(Btu/hr-ft2-F)"
            2
            0              0.2
            16000          0.2

"==> Following are inner material properties (LAS, Clad is neglected) @350F ('89
Code)"
"    Thermal conductivity (Btu/Hr-Ft-F)"
            23.8
"    Density * Specific Heat (Btu/Ft3)"
            59.649
"    Modulus of Elasticity (ksi)"
```

```
                27.7e3
"    Coefficient of Thermal Expansion (per F)"
                7.50e-6
"    Poissons Ratio"
                .3

"==> Following are outer material properties (LAS) @350F ('89 Code)"
"    Thermal conductivity (Btu/Hr-Ft-F)"
                23.8
"    Density * Specific Heat (Btu/Ft3)"
                59.649
"    Modulus of Elasticity (ksi)"
                27.7e3
"    Coefficient of Thermal Expansion (per F)"
                7.50e-6
"    Poissons Ratio"
                .3

"==> Value of uniform temperature which is stress free in cylinder"
"    Stress-free temperature (F) may be any value"
                70

"==> Timestep and time control information (seconds)"
"     Timestep Max <= 0.5*{[(Ro-Ri)/nodes]^2/[k/RhoCp]}*3600"
"     Next line is number of time control intervals "
                1
"   end of interval - time step - print interval"
                16000          10.0             360
********************** END OF FILE  ********************
   CREATED   DATE:  12-18-1998       TIME:  09:30:00
```

1	110.3125	+5.15	+5.15	+0.00	+3.82	+3.84	127.7	132.1
2	110.4480	+4.76	+4.77	+0.01	+3.63	+3.65	129.0	132.8
3	110.5835	+4.38	+4.40	+0.01	+3.43	+3.46	130.2	133.4
4	110.7190	+4.02	+4.03	+0.02	+3.24	+3.27	131.5	134.0
5	110.8545	+3.66	+3.68	+0.02	+3.05	+3.08	132.6	134.7
6	110.9900	+3.31	+3.34	+0.03	+2.86	+2.89	133.8	135.3
7	111.1255	+2.98	+3.01	+0.03	+2.67	+2.70	134.9	136.0
8	111.2610	+2.65	+2.68	+0.03	+2.48	+2.51	136.0	136.6
9	111.3965	+2.34	+2.37	+0.04	+2.29	+2.32	137.1	137.2
10	111.5320	+2.03	+2.07	+0.04	+2.10	+2.13	138.1	137.9
11	111.6675	+1.74	+1.78	+0.04	+1.91	+1.93	139.1	138.5
12	111.8030	+1.45	+1.49	+0.04	+1.72	+1.74	140.0	139.2
13	111.9385	+1.18	+1.22	+0.04	+1.53	+1.55	140.9	139.8
14	112.0740	+0.91	+0.96	+0.05	+1.34	+1.36	141.8	140.5
15	112.2095	+0.66	+0.70	+0.05	+1.15	+1.17	142.7	141.1
16	112.3450	+0.41	+0.46	+0.05	+0.95	+0.98	143.5	141.7
17	112.4805	+0.18	+0.22	+0.05	+0.76	+0.79	144.3	142.4
18	112.6160	-0.05	-0.00	+0.05	+0.57	+0.60	145.0	143.0
19	112.7515	-0.26	-0.22	+0.05	+0.38	+0.41	145.8	143.7
20	112.8870	-0.47	-0.42	+0.05	+0.19	+0.22	146.5	144.3
21	113.0225	-0.66	-0.62	+0.05	+0.00	+0.03	147.1	144.9
22	113.1580	-0.85	-0.80	+0.04	-0.19	-0.16	147.7	145.6
23	113.2935	-1.02	-0.98	+0.04	-0.38	-0.35	148.3	146.2
24	113.4290	-1.19	-1.14	+0.04	-0.57	-0.54	148.9	146.9
25	113.5645	-1.34	-1.30	+0.04	-0.76	-0.73	149.4	147.5
26	113.7000	-1.49	-1.45	+0.04	-0.95	-0.92	149.9	148.2
27	113.8354	-1.62	-1.58	+0.04	-1.14	-1.11	150.4	148.8
28	113.9709	-1.75	-1.71	+0.03	-1.33	-1.30	150.8	149.4
29	114.1064	-1.86	-1.83	+0.03	-1.52	-1.49	151.2	150.1
30	114.2419	-1.97	-1.94	+0.03	-1.72	-1.68	151.6	150.7
31	114.3774	-2.07	-2.04	+0.03	-1.91	-1.87	151.9	151.4
32	114.5129	-2.15	-2.13	+0.03	-2.10	-2.06	152.2	152.0
33	114.6484	-2.23	-2.21	+0.02	-2.29	-2.25	152.5	152.6
34	114.7839	-2.30	-2.28	+0.02	-2.48	-2.44	152.7	153.3
35	114.9194	-2.36	-2.34	+0.02	-2.67	-2.63	152.9	153.9
36	115.0549	-2.40	-2.39	+0.01	-2.86	-2.82	153.1	154.6
37	115.1904	-2.44	-2.43	+0.01	-3.05	-3.01	153.2	155.2
38	115.3259	-2.47	-2.46	+0.01	-3.24	-3.20	153.3	155.8
39	115.4614	-2.49	-2.49	+0.01	-3.43	-3.39	153.4	156.5
40	115.5969	-2.50	-2.50	+0.00	-3.62	-3.58	153.5	157.1
41	115.7324	-2.50	-2.50	+0.00	-3.81	-3.77	153.5	157.8

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Appendix B
P-T Curves for BSEP-1

File = "U1-PTEST.XLS" (Pressure Test Curves):

Sheet = "Beltline (32)" (for beltline @ 32 EFPY)	[1 page]
Sheet = "Bottom Head" (for bottom head)	[1 page]
Sheet = "N16 Nozzle (32)" (for N16 Nozzle @ 32 EFPY)	[1 page]
Plot = "Beltline vs. Nozzle" (shows nozzle is limiting)	[1 page]
Plot = "32 EFPY Curve" (P-T curve for 32 EFPY)	[1 page]

File = "U1-CNC.XLS" (Core Not Critical Curves):

Sheet = "Beltline (32)" (for beltline @ 32 EFPY)	[1 page]
Sheet = "Bottom Head" (for bottom head)	[1 page]
Sheet = "N16 Nozzle (32)" (for N16 Nozzle @ 32 EFPY)	[1 page]
Plot = "Beltline vs. Nozzle" (shows nozzle is limiting)	[1 page]
Plot = "32 EFPY CNC Curve" (P-T curve for 32 EFPY)	[1 page]

File = "U1-CC.XLS" (Core Critical Curves):

Sheet = "Curve C (32)" (for N16 Nozzle & Bottom Head @ 32 EFPY)	[1 page]
Plot = "32 EFPY CC Curve" (P-T curve for 32 EFPY)	[1 page]

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Total = [12 pages]

Pressure-Temperature Curve Calculation

(Pressure Test)

Inputs:

Plant =	**Brunswick 1**	
Component =	**Beltline**	
Vessel thickness, t =	**5.496**	inches (minimum)
M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**110.59375**	inches (maximum)
RT_{NDT} =	**106.3**	°F ======> **32 EFPY**
ΔT_w =	**0.0**	°F (no thermal for pressure test)
K_{IT} =	**0.0**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**0.0**	°F (no thermal for pressure test)
Stress Multiplier, F =	**1.00**	
Safety Factor =	**1.50**	(for pressure test)
M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F (use Unit 2 value to match Unit 2 results)

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	70.0	43.23	28.82	0	70	0
70	70.0	43.23	28.82	313	70	313
75	75.0	44.29	29.52	313	75	313
80	80.0	45.45	30.30	313	80	313
85	85.0	46.74	31.16	313	85	313
90	90.0	48.17	32.11	313	90	313
95	95.0	49.74	33.16	313	95	313
100	100.0	51.48	34.32	313	100	313
100	100.0	51.48	34.32	711	100	696
105	105.0	53.40	35.60	737	105	722
110	110.0	55.53	37.02	767	110	752
115	115.0	57.87	38.58	799	115	784
120	120.0	60.47	40.31	835	120	820
125	125.0	63.34	42.23	874	125	859
130	130.0	66.51	44.34	918	130	903
135	135.0	70.01	46.67	966	135	951
140	140.0	73.88	49.25	1020	140	1005
145	145.0	78.16	52.11	1079	145	1064
147.8	147.8	80.75	53.83	1115	148	1100
150	150.0	82.89	55.26	1144	150	1129
155	155.0	88.11	58.74	1216	155	1201
160	160.0	93.89	62.59	1296	160	1281
165	165.0	100.27	66.85	1384	165	1369
170	170.0	107.33	71.55	1482	170	1467
175	175.0	115.12	76.75	1589	175	1574

Pressure-Temperature Curve Calculation

(Pressure Test)

Inputs:

Plant =	**Brunswick 1**	
Component =	**Bottom Head**	
Vessel thickness, t =	**5.400**	inches (minimum)
M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**110.59375**	inches (maximum)
RT_{NDT} =	**10.0**	°F ======> **All EFPYs**
ΔT_w =	**0.0**	°F (no thermal for pressure test)
K_{IT} =	**0.0**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**0.0**	°F (no thermal for pressure test)
Stress Multiplier, F =	**1.50**	(for spherical bottom head with penetrations)
Safety Factor =	**1.50**	(for pressure test)
M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F (use Unit 2 value to match Unit 2 results)

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	70.0	102.04	68.03	0	70	0
70	70.0	102.04	68.03	923	70	908
75	75.0	109.28	72.85	988	75	973
80	80.0	117.28	78.19	1060	80	1045
83.5	83.5	123.38	82.25	1116	84	1101
85	85.0	126.12	84.08	1140	85	1125
90	90.0	135.90	90.60	1229	90	1214
95	95.0	146.70	97.80	1326	95	1311
100	100.0	158.63	105.76	1434	100	1419
105	105.0	171.83	114.55	1554	105	1539

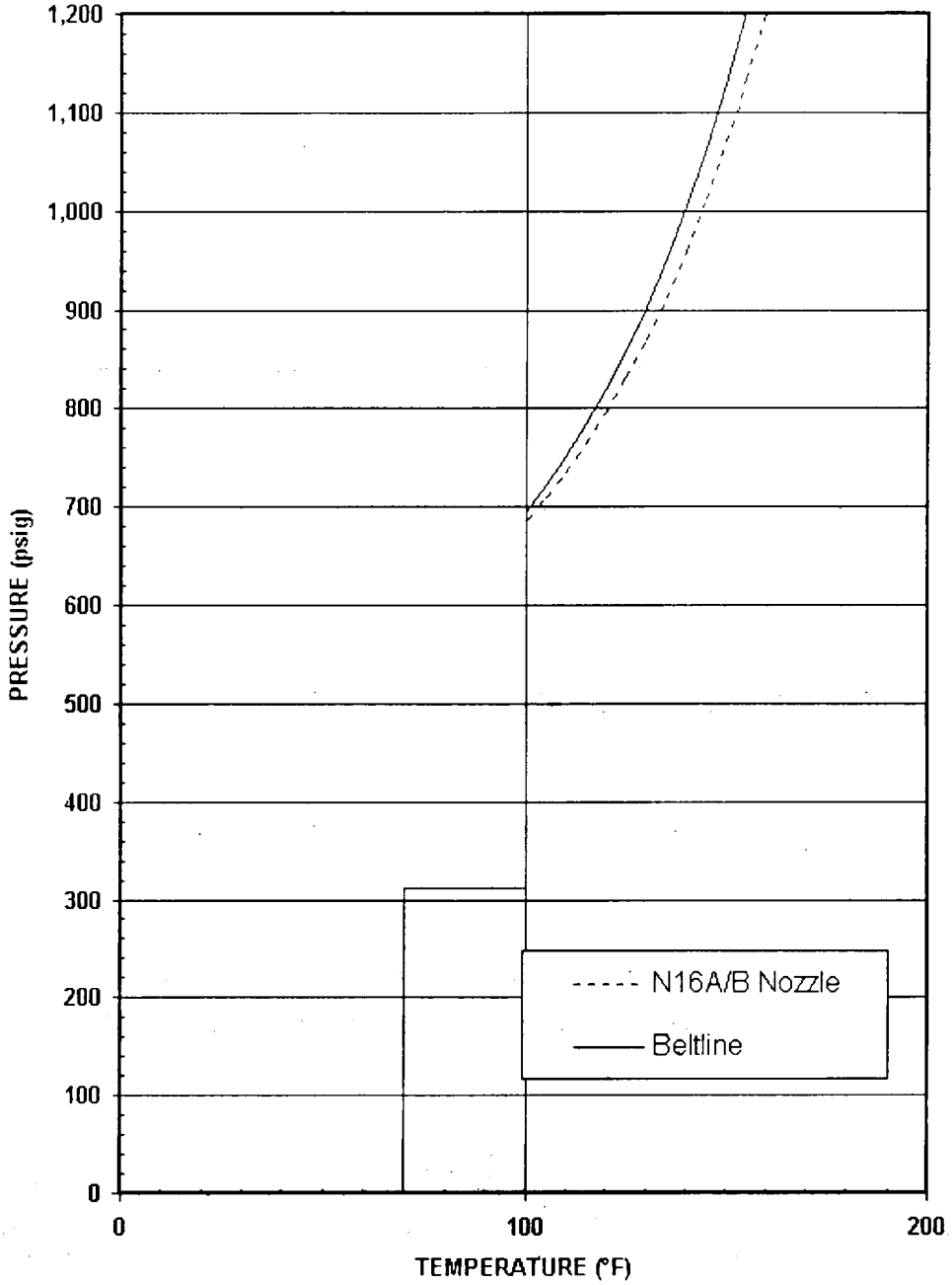
Pressure-Temperature Curve Calculation

(Pressure Test)

Inputs:

Plant =	**Brunswick 1**	
Component =	**N16 A/B**	(2" Instrument Nozzles)
Vessel thickness, t =	**N/A**	inches (minimum)
M_t =	**N/A**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**N/A**	inches (maximum)
RT_{NDT} =	**114.2**	°F ======> **32 EFPY**
ΔT_w =	**0.0**	°F (no thermal for pressure test)
K_{IT} =	**0.0**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**0.0**	°F (no thermal for pressure test)
Stress Multiplier, F =	**N/A**	
Safety Factor =	**1.50**	(for pressure test)
M_m =	**N/A**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F (use Unit 2 value to match Unit 2 results)

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	70.0	41.77	27.84	0	70	0
70	70.0	41.77	27.84	313	70	313
75	75.0	42.67	28.44	313	75	313
80	80.0	43.66	29.11	313	80	313
85	85.0	44.76	29.84	313	85	313
90	90.0	45.98	30.65	313	90	313
95	95.0	47.32	31.55	313	95	313
100	100.0	48.81	32.54	313	100	313
100	100.0	48.81	32.54	701	100	686
105	105.0	50.45	33.63	724	105	709
110	110.0	52.26	34.84	750	110	735
115	115.0	54.27	36.18	779	115	764
120	120.0	56.48	37.66	811	120	796
125	125.0	58.93	39.29	846	125	831
130	130.0	61.64	41.09	885	130	870
135	135.0	64.63	43.09	928	135	913
140	140.0	67.94	45.29	975	140	960
145	145.0	71.59	47.73	1028	145	1013
150	150.0	75.63	50.42	1085	150	1070
152.4	152.4	77.71	51.81	1115	152	1100
155	155.0	80.09	53.39	1150	155	1135
160	160.0	85.02	56.68	1220	160	1205
165	165.0	90.47	60.31	1299	165	1284
170	170.0	96.49	64.33	1385	170	1370
175	175.0	103.15	68.77	1481	175	1466
180	180.0	110.51	73.67	1586	180	1571



BELTLINE VS. N16A/B NOZZLE @ 32 EFPY
PRESSURE TEST CONDITIONS
(NOZZLE IS MORE LIMITING)

Revision	0			
Preparer/Date	GLS 10/19/00			
Checker/Date	JAH 10/19/00			
File No. CPL-54Q-303			**Page B-5 of B-13**	

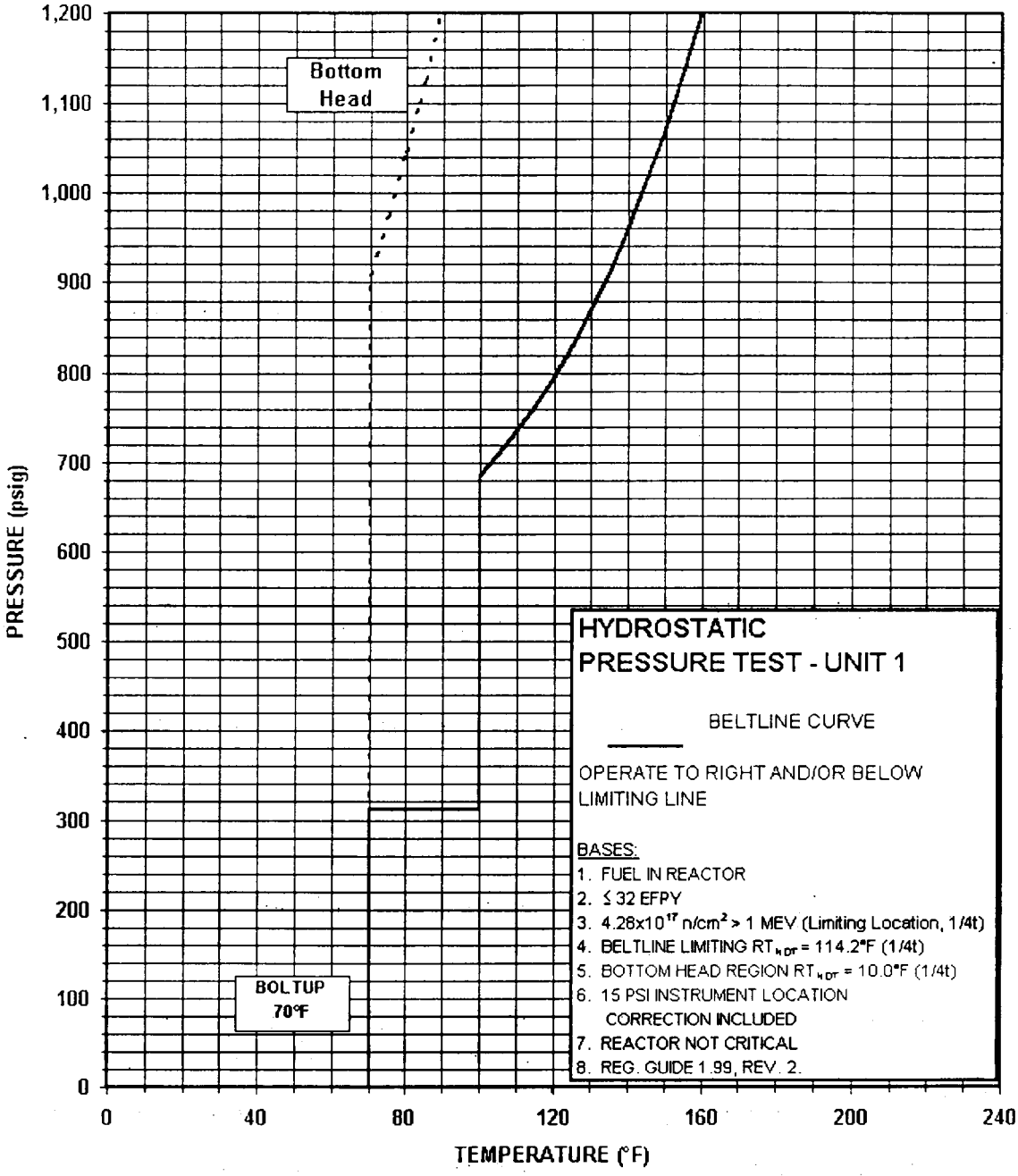


Figure x.x.x-x (page 1 of 1)
RCS Pressure and Temperature Limits
Hydrostatic and Leak Tests ≤ 32 EFPY

Pressure-Temperature Curve Calculation

(Core Not Critical)

Inputs:

Plant =	**Brunswick 1**	
Component =	**Beltline**	
Vessel thickness, t =	**5.496**	inches (minimum)
M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**110.59375**	inches (maximum)
RT_{NDT} =	**106.3**	°F ======> **32 EFPY**
ΔT_w =	**26.5**	°F (temp. difference between inside and outside surfaces)
K_{IT} =	**7.3**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**19.5**	°F (temperature difference between fluid and crack tip)
Stress Multiplier, F =	**1.00**	
Safety Factor =	**2.00**	(for heatup/cooldown)
M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F (use Unit 2 value to match Unit 2 results)

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	89.5	48.02	20.37	0	70	0
70	89.5	48.02	20.37	313	70	313
75	94.5	49.58	21.15	313	75	313
80	99.5	51.30	22.01	313	80	313
85	104.5	53.20	22.96	313	85	313
90	109.5	55.30	24.02	313	90	313
95	114.5	57.63	25.18	313	95	313
130	149.5	82.39	37.56	313	130	313
130	149.5	82.39	37.56	778	130	763
135	154.5	87.57	40.15	831	135	816
140	159.5	93.29	43.01	891	140	876
145	164.5	99.61	46.17	956	145	941
150	169.5	106.59	49.66	1028	150	1013
155	174.5	114.31	53.52	1108	155	1093
160	179.5	122.84	57.78	1196	160	1181
165	184.5	132.26	62.50	1294	165	1279
170	189.5	142.68	67.71	1402	170	1387
175	194.5	154.20	73.46	1521	175	1506

Pressure-Temperature Curve Calculation

(Core Not Critical)

Inputs:

Plant =	**Brunswick 1**	
Component =	**Bottom Head**	
Vessel thickness, t =	**5.400**	inches (minimum)
M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**110.59375**	inches (maximum)
RT_{NDT} =	**10.0**	°F ======> **All EFPYs**
ΔT_w =	**25.5**	°F (temp. difference between inside and outside surfaces)
K_{IT} =	**7.0**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**18.9**	°F (temperature difference between fluid and crack tip)
Stress Multiplier, F =	**1.50**	(for spherical bottom head with penetrations)
Safety Factor =	**2.00**	(for heatup/cooldown)
M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F (use Unit 2 value to match Unit 2 results)

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	88.9	133.66	63.33	0	70	0
70	88.9	133.66	63.33	859	70	844
75	93.9	144.23	68.61	931	75	916
80	98.9	155.90	74.45	1010	80	995
85	103.9	168.81	80.91	1097	85	1082
90	108.9	183.07	88.04	1194	90	1179
95	113.9	198.83	95.92	1301	95	1286
130	148.9	200.00	96.50	1309	130	1294

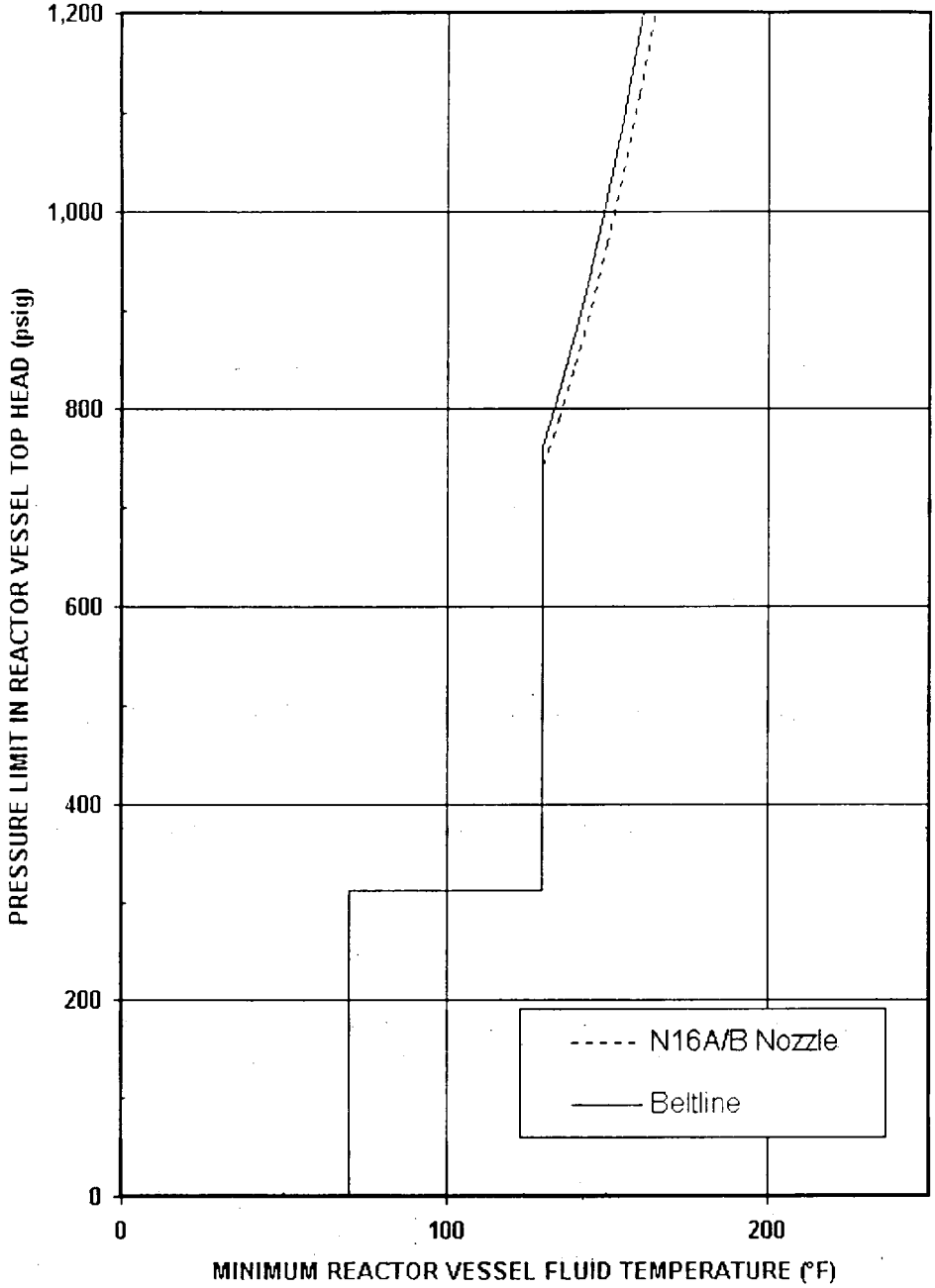
Pressure-Temperature Curve Calculation

(Core Not Critical)

Inputs:

Plant =	**Brunswick 1**	
Component =	**N16 A/B**	(2" Instrument Nozzles)
Vessel thickness, t =	**N/A**	inches (minimum)
M_t =	**N/A**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**N/A**	inches (maximum)
RT_{NDT} =	**114.2**	°F ======> **32 EFPY**
ΔT_w =	**N/A**	°F (temp. difference between inside and outside surfaces)
K_{IT} =	**5.4**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**20.1**	°F (temperature difference between fluid and crack tip)
Stress Multiplier, F =	**N/A**	
Safety Factor =	**2.00**	(for heatup/cooldown)
M_m =	**N/A**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F (use Unit 2 value to match Unit 2 results)

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	90.1	46.01	20.31	0	70	0
70	90.1	46.01	20.31	313	70	313
75	95.1	47.36	20.98	313	75	313
80	100.1	48.85	21.72	313	80	313
85	105.1	50.49	22.55	313	85	313
90	110.1	52.31	23.46	313	90	313
95	115.1	54.32	24.46	313	95	313
130	150.1	75.74	35.17	313	130	313
130	150.1	75.74	35.17	757	130	742
135	155.1	80.21	37.41	805	135	790
140	160.1	85.15	39.88	859	140	844
145	165.1	90.62	42.61	917	145	902
150	170.1	96.66	45.63	982	150	967
155	175.1	103.33	48.97	1054	155	1039
160	180.1	110.71	52.65	1134	160	1119
165	185.1	118.86	56.73	1221	165	1206
170	190.1	127.87	61.23	1318	170	1303
175	195.1	137.82	66.21	1426	175	1411
180	200.1	148.83	71.71	1544	180	1529



BELTLINE VS. N16A/B NOZZLE @ 32 EFPY
CORE NOT CRITICAL CONDITIONS
(NOZZLE IS MORE LIMITING)

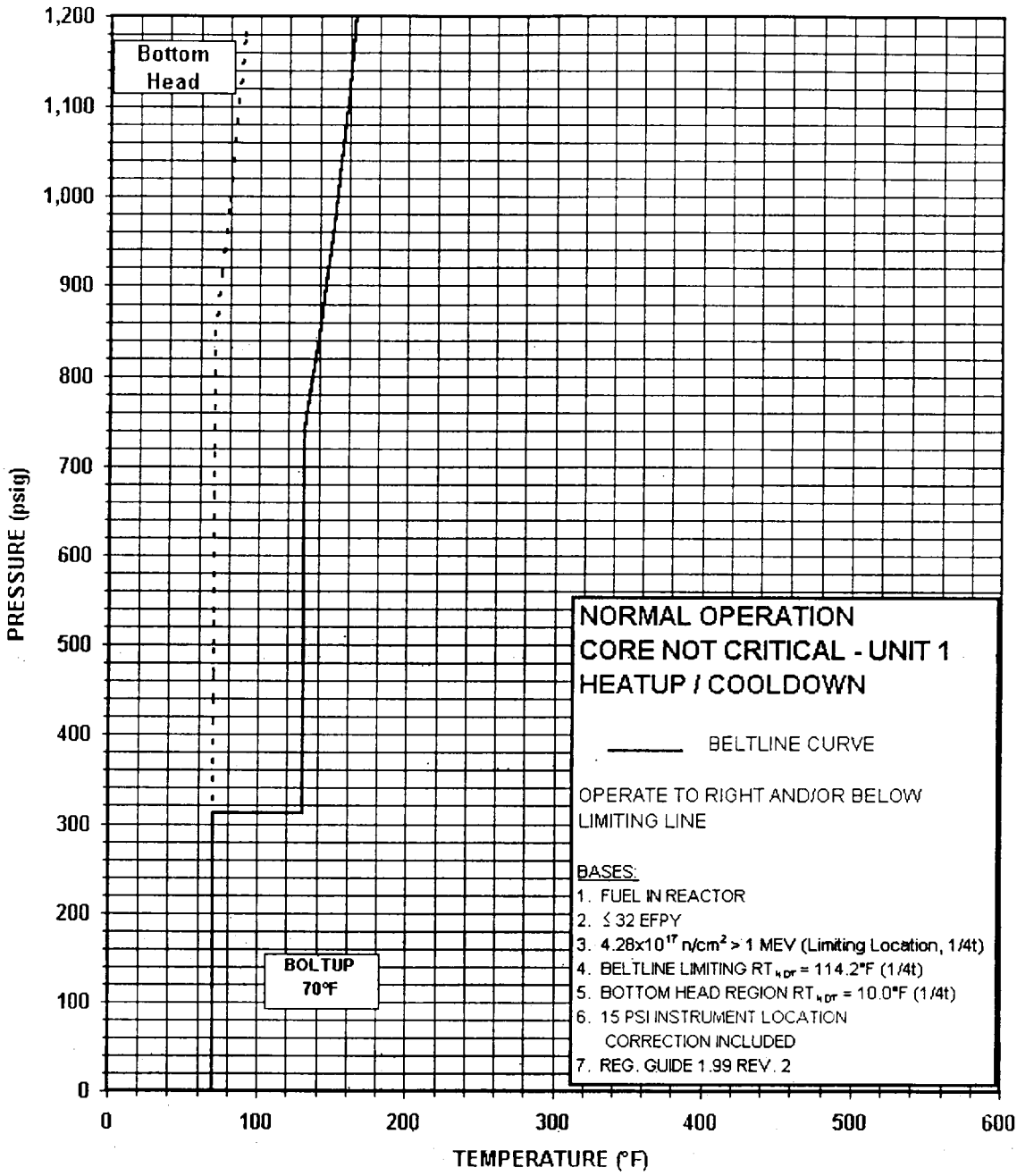


Figure x.x.x-x (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation With Core Not Critical ≤ 32 EFPY

Pressure-Temperature Curve Calculation

(Core Critical = Curve C)

Inputs:

Plant =	**Brunswick 1**	
EFPY =	**32**	
Curve A Leak Test Temperature =	**152.4**	°F (at 1,100 psig)
Hydro Test Pressure =	**1,565**	psig
Flange RT_{NDT} =	**16.0**	°F

Curve B Temperature N16 Nozzle (°F)	Curve B Pressure for N16 Nozzle (psig)	Curve B Temperature Bottom Head (°F)	Curve B Pressure for Bottom Head (psig)	Curve C Temperature N16 Nozzle (°F)	Curve C Pressure N16 Nozzle (psig)	Curve C Temperature Bottom Head (°F)	Curve C Pressure Bottom Head (psig)
70.0	0	0.0	0	76.0	0	76.0	0
70.0	313	5.0	348	76.0	313	76.0	348
75.0	313	10.0	368	76.0	313	76.0	368
80.0	313	15.0	389	80.0	313	76.0	389
85.0	313	20.0	413	85.0	313	76.0	413
90.0	313	25.0	440	90.0	313	76.0	440
95.0	313	30.0	469	95.0	313	76.0	469
130.0	313	35.0	501	176.0	313	76.0	501
130.0	742	40.0	537	176.0	742	80.0	537
135.0	790	45.0	576	176.0	790	85.0	576
140.0	844	50.0	619	180.0	844	90.0	619
145.0	902	55.0	667	185.0	902	95.0	667
150.0	967	60.0	720	190.0	967	100.0	720
155.0	1039	65.0	779	195.0	1039	105.0	779
160.0	1119	70.0	844	200.0	1119	110.0	844
165.0	1206	75.0	916	205.0	1206	115.0	916
170.0	1303	80.0	995	210.0	1303	120.0	995
175.0	1411	85.0	1082	215.0	1411	125.0	1082
180.0	1529	90.0	1179	220.0	1529	130.0	1179
		95.0	1286			135.0	1286
		100.0	1294			140.0	1294

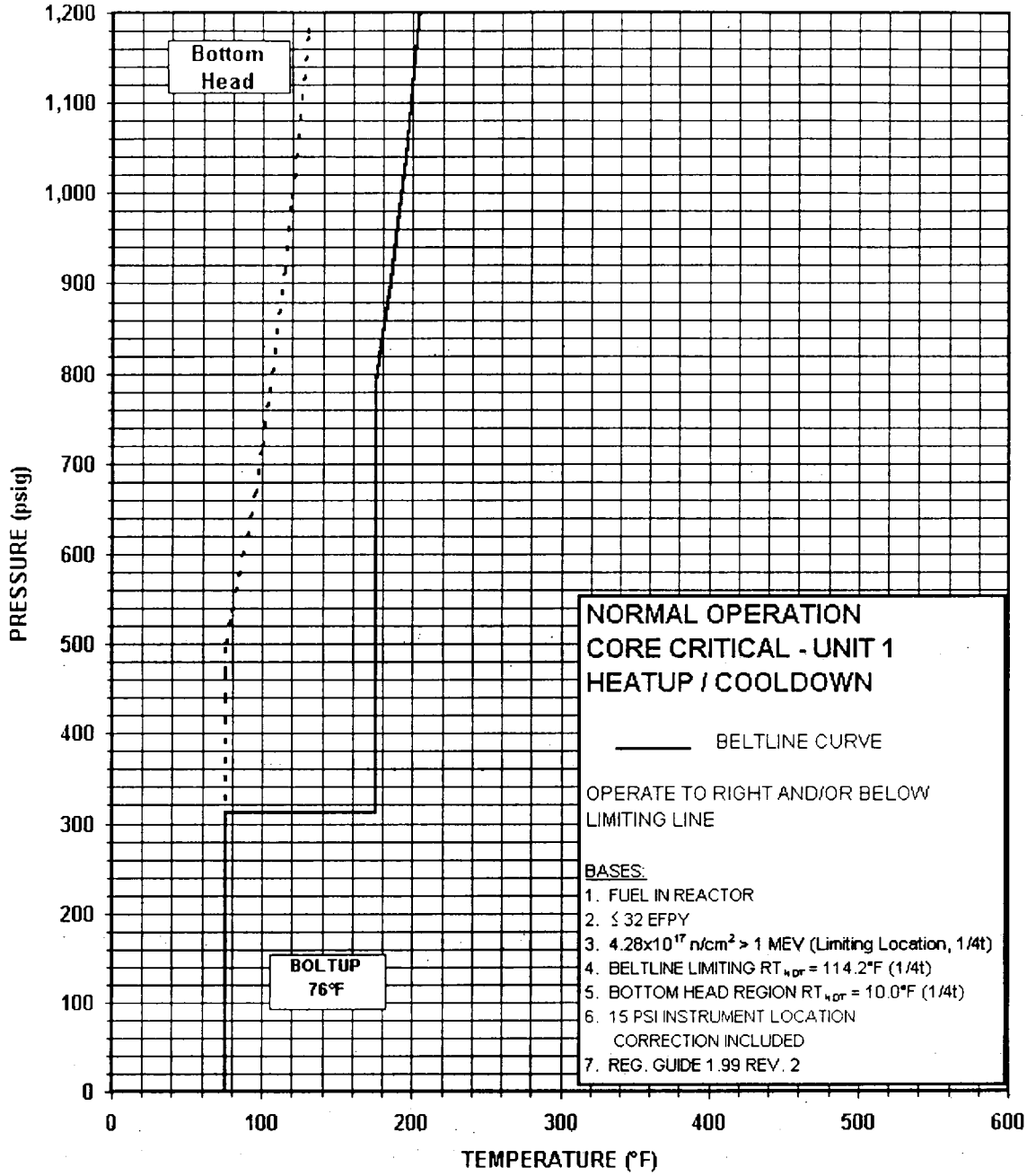


Figure x.x.x-x (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation With Core Critical ≤ 32 EFPY

Appendix C
P-T Curves for BSEP-2

File = "U2-PTEST.XLS" (Pressure Test Curves):

Sheet = "Beltline (32)" (for beltline @ 32 EFPY)	[1 page]
Sheet = "Bottom Head" (for bottom head)	[1 page]
Sheet = "N16 Nozzle (32)" (for N16 Nozzle @ 32 EFPY)	[1 page]
Plot = "Beltline vs. Nozzle" (shows nozzle is limiting)	[1 page]
Plot = "32 EFPY Curve" (P-T curve for 32 EFPY)	[1 page]

File = "U2-CNC.XLS" (Core Not Critical Curves):

Sheet = "Beltline (32)" (for beltline @ 32 EFPY)	[1 page]
Sheet = "Bottom Head" (for bottom head)	[1 page]
Sheet = "N16 Nozzle (32)" (for N16 Nozzle @ 32 EFPY)	[1 page]
Plot = "Beltline vs. Nozzle" (shows nozzle is limiting)	[1 page]
Plot = "32 EFPY CNC Curve" (P-T curve for 32 EFPY)	[1 page]

File = "U2-CC.XLS" (Core Critical Curves):

Sheet = "Curve C (32)" (for N16 Nozzle & Bottom Head @ 32 EFPY)	[1 page]
Plot = "32 EFPY CC Curve" (P-T curve for 32 EFPY)	[1 page]

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Total = [12 pages]

Pressure-Temperature Curve Calculation

(Pressure Test)

Inputs:

Plant =	**Brunswick 2**	
Component =	**Beltline**	
Vessel thickness, t =	**5.466**	inches (minimum)
M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**110.3125**	inches (maximum)
RT_{NDT} =	**85.1**	°F ====== **32 EFPY**
ΔT_w =	**0.0**	°F (no thermal for pressure test)
K_{IT} =	**0.0**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**0.0**	°F (no thermal for pressure test)
Stress Multiplier, F =	**1.00**	
Safety Factor =	**1.50**	(for pressure test)
M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	70.0	48.53	32.35	0	70	0
70	70.0	48.53	32.35	313	70	313
75	75.0	50.14	33.43	313	75	313
80	80.0	51.92	34.62	313	80	313
85	85.0	53.89	35.93	313	85	313
90	90.0	56.07	37.38	313	90	313
95	95.0	58.47	38.98	313	95	313
100	100.0	61.13	40.75	313	100	313
100	100.0	61.13	40.75	841	100	826
105	105.0	64.07	42.71	882	105	867
110	110.0	67.32	44.88	927	110	912
115	115.0	70.90	47.27	976	115	961
120	120.0	74.87	49.91	1031	120	1016
125	125.0	79.25	52.83	1091	125	1076
126.9	126.9	81.04	54.02	1115	127	1100
130	130.0	84.10	56.06	1157	130	1142
135	135.0	89.45	59.63	1231	135	1216
140	140.0	95.36	63.58	1313	140	1298
145	145.0	101.90	67.93	1403	145	1388
150	150.0	109.13	72.75	1502	150	1487
155	155.0	117.11	78.08	1612	155	1597

Pressure-Temperature Curve Calculation

(Pressure Test)

Inputs:

Plant =	**Brunswick 2**	
Component =	**Bottom Head**	
Vessel thickness, t =	**5.420**	inches (minimum)
M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**110.3125**	inches (maximum)
RT_{NDT} =	**40.0**	°F ====== **All EFPYs**
ΔT_w =	**0.0**	°F (no thermal for pressure test)
K_{IT} =	**0.0**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**0.0**	°F (no thermal for pressure test)
Stress Multiplier, F =	**1.50**	(for spherical bottom head with penetrations)
Safety Factor =	**1.50**	(for pressure test)
M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	70.0	70.98	47.32	0	70	0
70	70.0	70.98	47.32	646	70	631
75	75.0	74.95	49.97	682	75	667
80	80.0	79.34	52.90	722	80	707
85	85.0	84.20	56.13	766	85	751
90	90.0	89.56	59.71	815	90	800
95	95.0	95.49	63.66	869	95	854
100	100.0	102.04	68.03	928	100	913
105	105.0	109.28	72.85	994	105	979
110	110.0	117.28	78.19	1067	110	1052
113.1	113.1	122.66	81.77	1116	113	1101
115	115.0	126.12	84.08	1148	115	1133
120	120.0	135.90	90.60	1236	120	1221
125	125.0	146.70	97.80	1335	125	1320
130	130.0	158.63	105.76	1443	130	1428
135	135.0	171.83	114.55	1563	135	1548

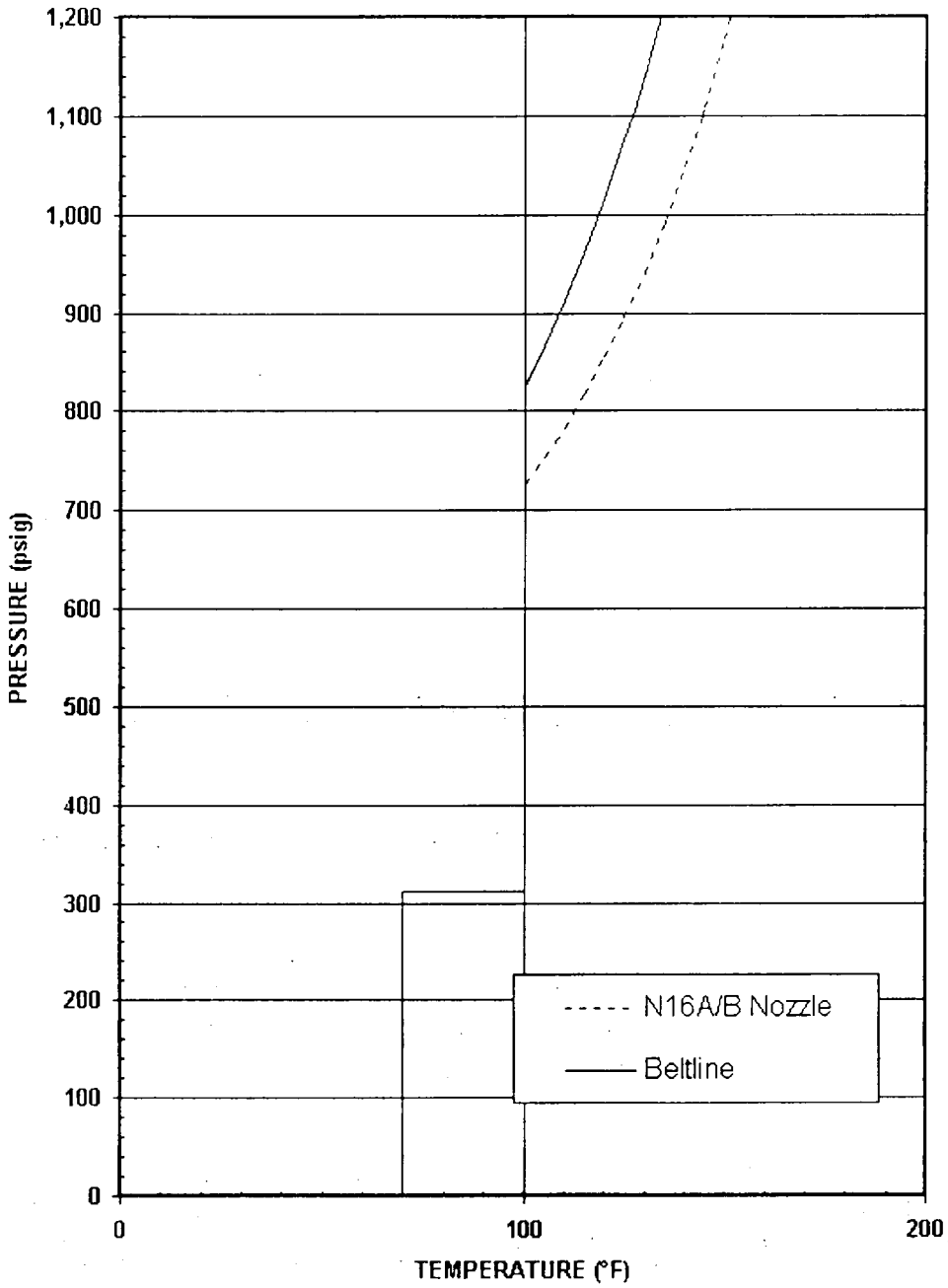
Pressure-Temperature Curve Calculation

(Pressure Test)

Inputs:

Plant =	**Brunswick 2**	
Component =	**N16 A/B**	(2" Instrument Nozzles)
Vessel thickness, t =	**N/A**	inches (minimum)
M_t =	**N/A**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**N/A**	inches (maximum)
RT_{NDT} =	**106.1**	°F ====== **32 EFPY**
ΔT_w =	**0.0**	°F (no thermal for pressure test)
K_{IT} =	**0.0**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**0.0**	°F (no thermal for pressure test)
Stress Multiplier, F =	**N/A**	
Safety Factor =	**1.50**	(for pressure test)
M_m =	**N/A**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	70.0	43.27	28.85	0	70	0
70	70.0	43.27	28.85	313	70	313
75	75.0	44.33	29.55	313	75	313
80	80.0	45.50	30.33	313	80	313
85	85.0	46.80	31.20	313	85	313
90	90.0	48.23	32.15	313	90	313
95	95.0	49.81	33.20	313	95	313
100	100.0	51.55	34.37	313	100	313
100	100.0	51.55	34.37	740	100	725
105	105.0	53.48	35.66	768	105	753
110	110.0	55.62	37.08	798	110	783
115	115.0	57.97	38.65	832	115	817
120	120.0	60.58	40.39	870	120	855
125	125.0	63.46	42.31	911	125	896
130	130.0	66.64	44.43	957	130	942
135	135.0	70.16	46.77	1007	135	992
140	140.0	74.04	49.36	1063	140	1048
144.3	144.3	77.71	51.81	1115	144	1100
145	145.0	78.34	52.23	1124	145	1109
150	**150.0**	**83.09**	**55.39**	**1193**	**150**	**1178**
155	155.0	88.33	58.89	1268	155	1253
160	160.0	94.13	62.76	1351	160	1336
165	165.0	100.54	67.03	1443	165	1428
170	170.0	107.62	71.75	1545	170	1530



BELTLINE VS. N16A/B NOZZLE @ 32 EFPY
PRESSURE TEST CONDITIONS
(NOZZLE IS MORE LIMITING)

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Preparer/Date	GLS 10/19/00			
Checker/Date	JAH 10/19/00			
File No. CPL-54Q-303			**Page C-5 of C-13**	

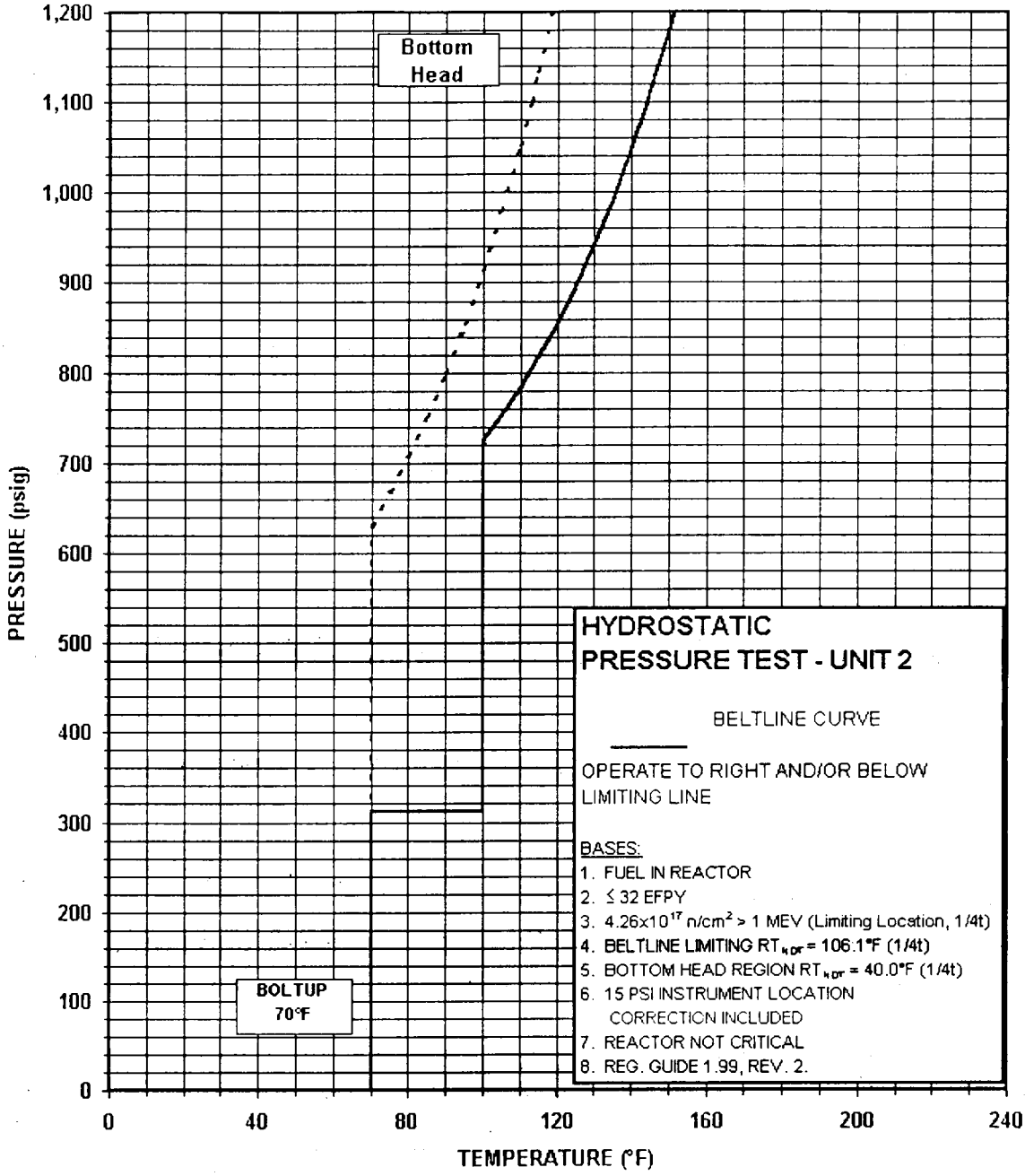


Figure x.x.x-x (page 1 of 1)
RCS Pressure and Temperature Limits
Hydrostatic and Leak Tests ≤ 32 EFPY

Pressure-Temperature Curve Calculation

(Core Not Critical)

Inputs:

Plant =	**Brunswick 2**	
Component =	**Beltline**	
Vessel thickness, t =	**5.466**	inches (minimum)
M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**110.3125**	inches (maximum)
RT_{NDT} =	**85.1**	°F ====== **32 EFPY**
ΔT_w =	**26.2**	°F (temp. difference between inside and outside surfac
K_{IT} =	**7.2**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**19.3**	°F (temperature difference between fluid and crack tip)
Stress Multiplier, F =	**1.00**	
Safety Factor =	**2.00**	(for heatup/cooldown)
M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	89.3	55.75	24.28	0	70	0
70	89.3	55.75	24.28	313	70	313
75	94.3	58.12	25.47	313	75	313
80	99.3	60.74	26.78	313	80	313
85	104.3	63.64	28.23	313	85	313
90	109.3	66.84	29.83	313	90	313
95	114.3	70.38	31.60	313	95	313
130	149.3	108.07	50.44	313	130	313
130	149.3	108.07	50.44	1041	130	1026
135	154.3	115.95	54.38	1123	135	1108
140	159.3	124.65	58.73	1213	140	1198
145	164.3	134.27	63.54	1312	145	1297
150	169.3	144.90	68.85	1422	150	1407
155	174.3	156.64	74.73	1543	155	1528

Pressure-Temperature Curve Calculation

(Core Not Critical)

Inputs:

Plant =	**Brunswick 2**	
Component =	**Bottom Head**	
Vessel thickness, t =	**5.420**	inches (minimum)
M_t =	**0.274**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**110.3125**	inches (maximum)
RT_{NDT} =	**40.0**	°F ====== **All EFPYs**
ΔT_w =	**25.8**	°F (temp. difference between inside and outside surfac
K_{IT} =	**7.1**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**19.1**	°F (temperature difference between fluid and crack tip)
Stress Multiplier, F =	**1.50**	(for spherical bottom head with penetrations)
Safety Factor =	**2.00**	(for heatup/cooldown)
M_m =	**2.40**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
0	19.1	46.85	19.89	0	70	0
5	24.1	48.29	20.60	281	70	266
10	29.1	49.87	21.40	292	70	277
15	34.1	51.63	22.27	304	70	289
20	39.1	53.56	23.24	317	70	302
25	44.1	55.71	24.31	332	70	317
30	49.1	58.07	25.50	348	70	333
35	54.1	60.69	26.80	366	70	351
40	59.1	63.58	28.25	386	70	371
45	64.1	66.77	29.85	407	70	392
50	69.1	70.31	31.61	431	70	416
55	74.1	74.21	33.56	458	70	443
60	79.1	78.52	35.72	488	70	473
65	84.1	83.29	38.10	520	70	505
70	89.1	88.56	40.74	556	70	541
75	94.1	94.38	43.65	596	75	581
80	99.1	100.81	46.87	640	80	625
85	104.1	107.92	50.42	688	85	673
90	109.1	115.78	54.35	742	90	727
95	114.1	124.47	58.69	801	95	786
100	119.1	134.06	63.49	867	100	852
105	124.1	144.67	68.80	939	105	924
110	129.1	156.40	74.66	1019	110	1004
115	134.1	169.35	81.14	1107	115	1092
120	139.1	183.67	88.30	1205	120	1190
125	144.1	199.50	96.21	1313	125	1298
130	149.1	200.00	96.46	1316	130	1301

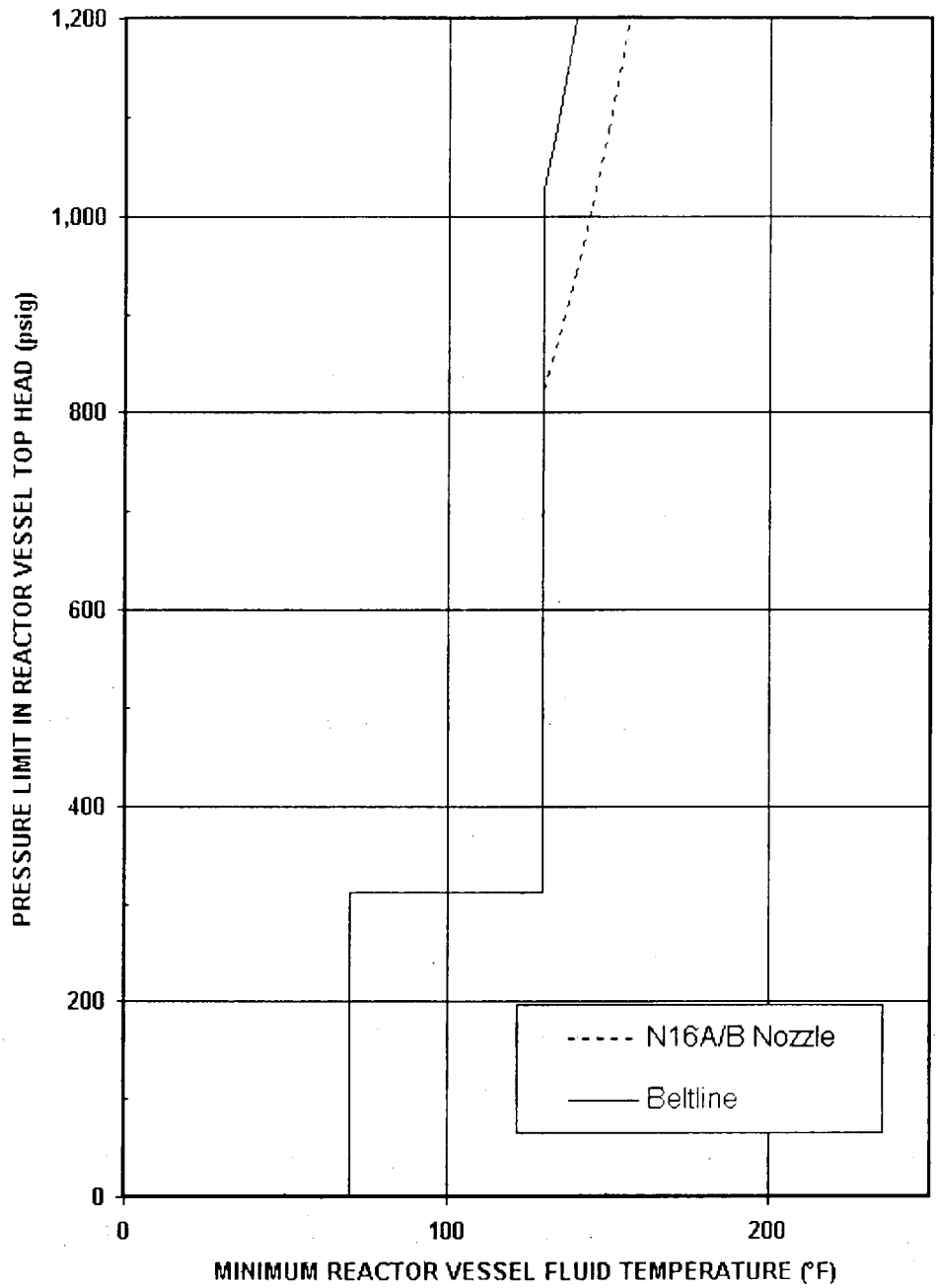
Pressure-Temperature Curve Calculation

(Core Not Critical)

Inputs:

Plant =	**Brunswick 2**	
Component =	**N16 A/B**	(2" Instrument Nozzles)
Vessel thickness, t =	**N/A**	inches (minimum)
M_t =	**N/A**	(per Figure G-2214-2 of App. G, mod. for E, α)
Vessel Radius, R =	**N/A**	inches (maximum)
RT_{NDT} =	**106.1**	°F ====== **32 EFPY**
ΔT_w =	**N/A**	°F (temp. difference between inside and outside surfac
K_{IT} =	**5.4**	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	**20.1**	°F (temperature difference between fluid and crack tip)
Stress Multiplier, F =	**N/A**	
Safety Factor =	**2.00**	(for heatup/cooldown)
M_m =	**N/A**	(per Figure G-2214-1 of App. G, assuming σ/σ_{ys} = 1.0)
Temperature Instrument Error =	**0.0**	°F
Pressure Instrument Error =	**15.0**	psig
Hydro Test Pressure =	**1563**	psig
Flange RT_{NDT} =	**10.0**	°F

Fluid Temperature T (°F)	1/4t Temperature (°F)	K_{Ic} (ksi*inch$^{1/2}$)	K_{IP} (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
70	90.1	48.27	21.43	0	70	0
70	90.1	48.27	21.43	313	70	313
75	95.1	49.85	22.22	313	75	313
80	100.1	51.60	23.10	313	80	313
85	105.1	53.54	24.07	313	85	313
90	110.1	55.67	25.14	313	90	313
95	115.1	58.04	26.32	313	95	313
130	150.1	83.22	38.91	313	130	313
130	150.1	83.22	38.91	838	130	823
135	155.1	88.48	41.54	894	135	879
140	160.1	94.29	44.45	957	140	942
145	165.1	100.72	47.66	1026	145	1011
150	170.1	107.82	51.21	1103	150	1088
155	175.1	115.67	55.13	1187	155	1172
160	180.1	124.34	59.47	1280	160	1265
165	185.1	133.92	64.26	1384	165	1369
170	190.1	144.52	69.56	1498	170	1483
175	195.1	156.22	75.41	1624	175	1609



BELTLINE VS. N16A/B NOZZLE @ 32 EFPY
CORE NOT CRITICAL CONDITIONS
(NOZZLE IS MORE LIMITING)

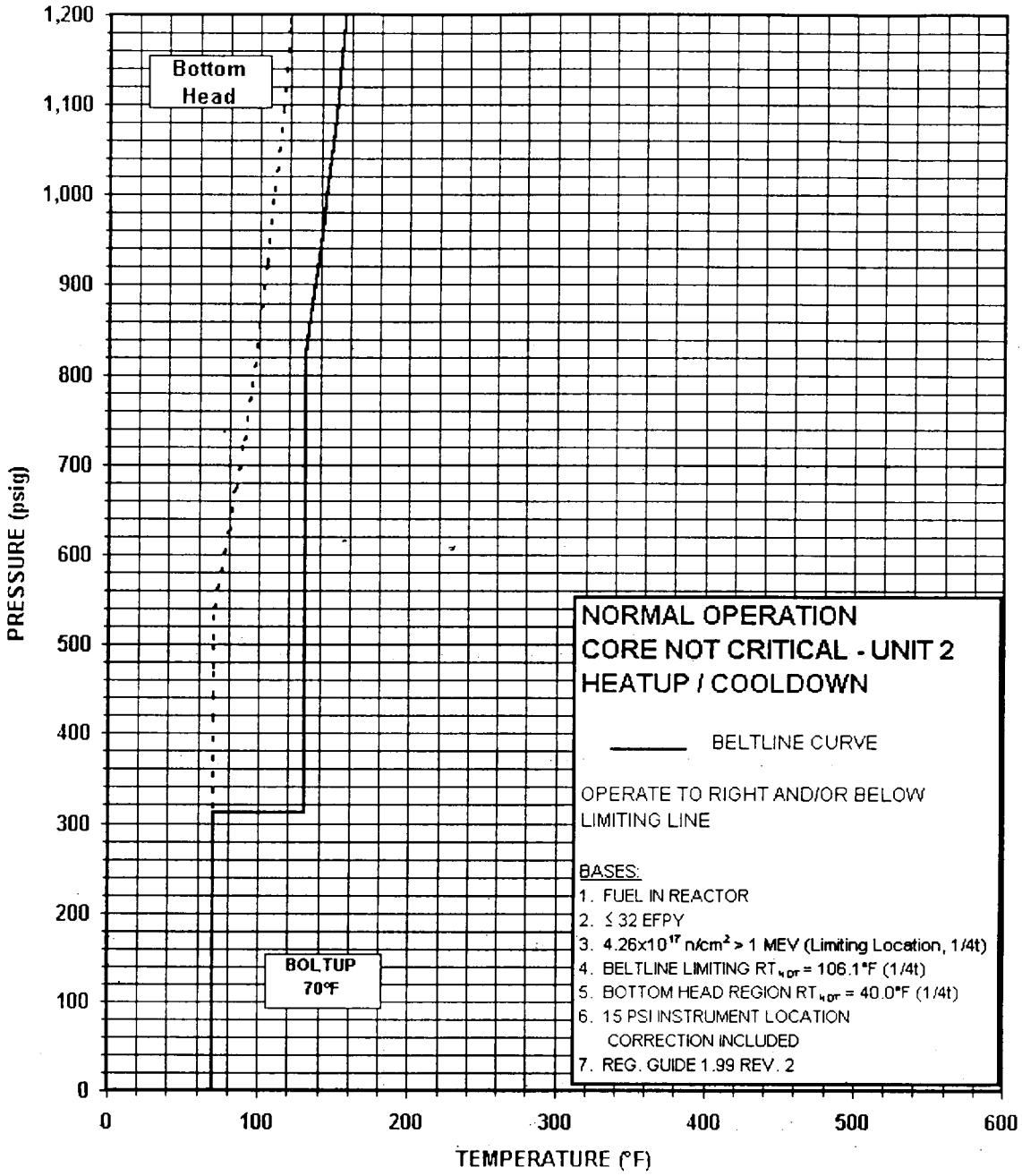


Figure x.x.x-x (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation With Core Not Critical ≤ 32 EFPY

Pressure-Temperature Curve Calculation

(Core Critical = Curve C)

Inputs:

Plant =	**Brunswick 2**	
EFPY =	**32**	
Curve A Leak Test Temperature =	**144.3**	°F (at 1,100 psig)
Hydro Test Pressure =	**1,565**	psig
Flange RT_{NDT} =	**10.0**	°F

Curve B Temperature N16 Nozzle (°F)	Curve B Pressure for N16 Nozzle (psig)	Curve B Temperature Bottom Head (°F)	Curve B Pressure for Bottom Head (psig)	Curve C Temperature N16 Nozzle (°F)	Curve C Pressure N16 Nozzle (psig)	Curve C Temperature Bottom Head (°F)	Curve C Pressure Bottom Head (psig)
70.0	0	0.0	0	70.0	0	70.0	0
70.0	313	5.0	266	70.0	313	70.0	266
75.0	313	10.0	277	75.0	313	70.0	277
80.0	313	15.0	289	80.0	313	70.0	289
85.0	313	20.0	302	85.0	313	70.0	302
90.0	313	25.0	317	90.0	313	70.0	317
95.0	313	30.0	333	95.0	313	70.0	333
130.0	313	35.0	351	170.0	313	75.0	351
130.0	823	40.0	371	170.0	823	80.0	371
135.0	879	45.0	392	175.0	879	85.0	392
140.0	942	50.0	416	180.0	942	90.0	416
145.0	1011	55.0	443	185.0	1011	95.0	443
150.0	1088	60.0	473	190.0	1088	100.0	473
155.0	1172	65.0	505	195.0	1172	105.0	505
160.0	1265	70.0	541	200.0	1265	110.0	541
165.0	1369	75.0	581	205.0	1369	115.0	581
170.0	1483	80.0	625	210.0	1483	120.0	625
175.0	1609	85.0	673	215.0	1609	125.0	673
		90.0	727			130.0	727
		95.0	786			135.0	786
		100.0	852			140.0	852
		105.0	924			145.0	924
		110.0	1004			150.0	1004
		115.0	1092			155.0	1092
		120.0	1190			160.0	1190
		125.0	1298			165.0	1298
		130.0	1301			170.0	1301

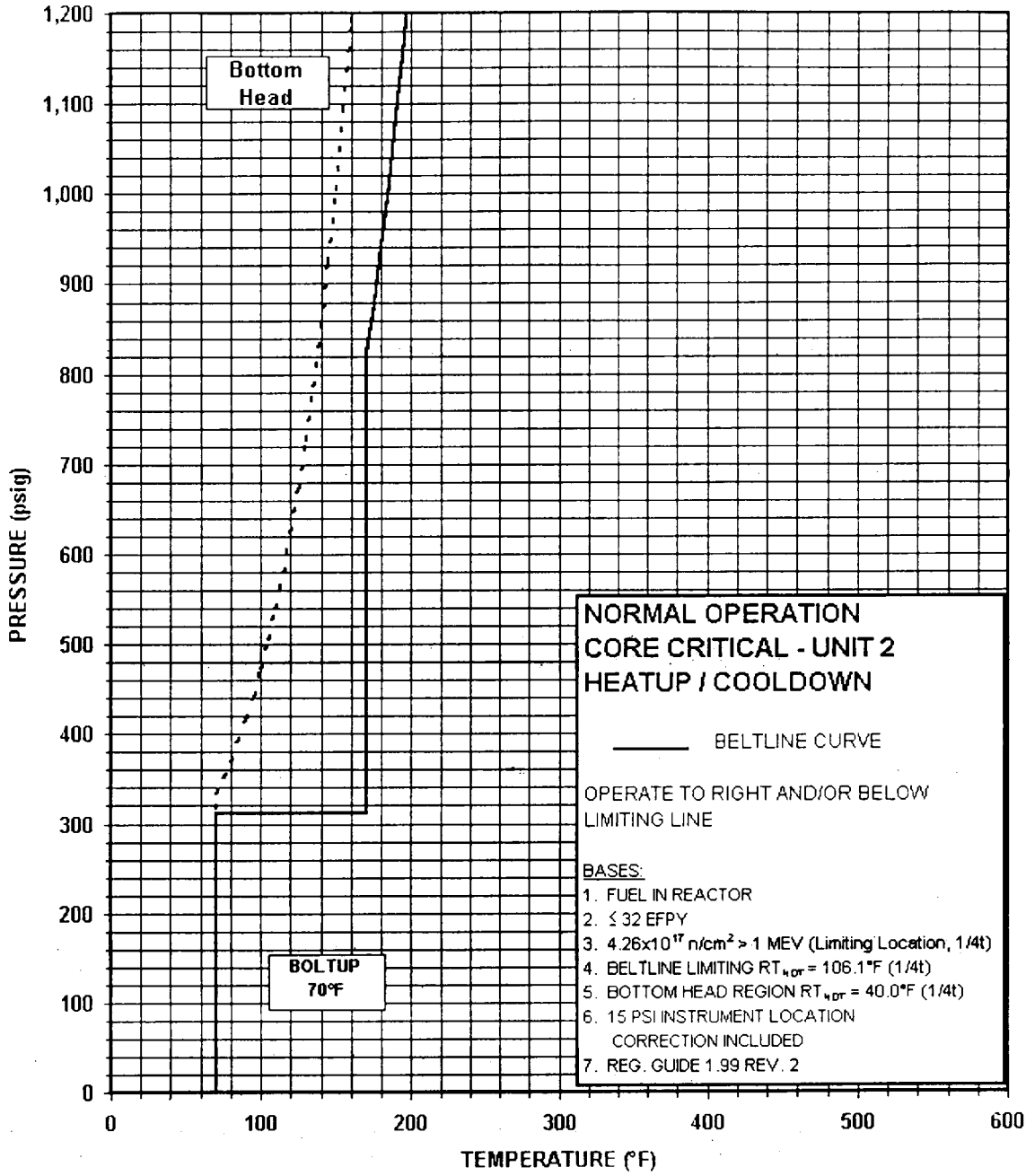


Figure x.x.x-x (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation With Core Critical ≤ 32 EFPY

ATTACHMENT 2
Sheet 1 of 1
Record of Lead Review

Design Structural Integrity Associates Calculation CPL-549-303 **Revision** 0

The signature below of the Lead Reviewer records that:
- the review indicated below has been performed by the Lead Reviewer;
- appropriate reviews were performed and errors/deficiencies (for all reviews performed) have been resolved and these records are included in the design package;
- the review was performed in accordance with EGR-NGGC-0003.

☐ **Design Verification Review** ☐ **Engineering Review** ☑ **Owner's Review**
- ☐ Design Review
- ☐ Alternate Calculation
- ☐ Qualification Testing

☐ **Special Engineering Review** _____

☐ YES ☐ N/A **Other Records are attached.**

Lead Reviewer (print/sign)	Discipline	Date
Phillip Gore / Phillip Gore	Mech	10/31/00

Item No.	Deficiency	Resolution
	No Comments.	

FORM EGR-NGGC-0003-2-5
This form is a QA Record when completed and included with a completed design package. Owner's Reviews may be processed as stand alone QA records when Owner's Review is completed.

ATTACHMENT 6

Design Verification Record
(following page)

ATTACHMENT 2
Sheet 1 of 1
Record of Lead Review

Design: **Calculation 0B11-0005** **Revision 0**

The signature below of the Lead Reviewer records that:

- the review indicated below has been performed by the Lead Reviewer;
- appropriate reviews were performed and errors/deficiencies (for all reviews performed) have been resolved and these records are included in the design package;
- the review was performed in accordance with EGR-NGGC-0003.

■ **Design Verification Review** **Engineering Review** **Owner Review**

■ Design Review

Alternate Calculation

Qualification Testing

Special Engineering Review_____

YES N/A **Other Records are attached.**

L. Yemma / L. Yemma structural 11.8.00

Lead Reviewer (print/sign) **Discipline** **Date**

Item No.	Deficiency	Resolution/Date
	None	

FORM EGR-NGGC-0003-2-0

ENCLOSURE 3

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 AND 50-324/LICENSE NOS. DPR-71 AND DPR-62
REQUEST FOR LICENSE AMENDMENTS – CHANGES TO REACTOR PRESSURE VESSEL PRESSURE-TEMPERATURE LIMITS AND REQUEST FOR EXEMPTION FROM 10 CFR 50, APPENDIX G, REQUIREMENTS

10 CFR 50.92 Evaluation

Carolina Power & Light (CP&L) Company is requesting a license amendment to revise the pressure-temperature limits curves contained in the Technical Specifications (TS) for the Brunswick Steam Electric Plant (BSEP), Unit Nos. 1 and 2. The existing pressure-temperature limits curves for normal operation are valid up to 16 effective full power years (EFPY), and the existing pressure-temperature limits curves for hydrostatic and leak testing are valid up to 14 and 16 EFPY. The revised pressure-temperature limits curves for normal operation and hydrostatic/leak tests will be valid up to 32 EFPY. CP&L has concluded that the proposed changes to the pressure-temperature limits do not involve a Significant Hazards Consideration. In support of this determination, an evaluation of each of the three (3) standards set forth in 10 CFR 50.92 is provided below.

1. The proposed license amendments do not involve a significant increase in the probability or consequences of an accident previously evaluated.

   The changes to the calculation methodology for the pressure-temperature limits are based on American Society of Mechanical Engineers (ASME) Code Case N-640, "Alternative Reference Fracture Toughness for Development of P-T Limit Curves for ASME Section XI, Division 1," and provide adequate margin in the prevention of a non-ductile type fracture of the reactor pressure vessel. The code case was developed based upon the knowledge gained through years of industry experience. The pressure-temperature limits developed using the allowances of ASME Code Case N-640 provide more operating margin. However, experience gained in the areas of fracture toughness of materials and pre-existing undetected defects shows that some of the existing assumptions used for the calculation of pressure-temperature limits are unnecessarily conservative and unrealistic. Therefore, use of the allowances of ASME Code Case N-640 in developing the pressure-temperature limits will provide adequate protection against nonductile-type fractures of the reactor pressure vessel.

   Development of the revised BSEP, Unit 1 and 2 pressure-temperature limits was performed using the approved methodologies of 10 CFR 50, Appendix G, and using the allowances of ASME Code Case N-640. The pressure-temperature limits generated using these methods ensure the pressure-temperature limits will not be exceeded during any phase of reactor operation. Therefore, the probability of occurrence and the consequences of a previously analyzed event are not significantly increased. Finally, the proposed

changes will not affect any other system or piece of equipment designed for the prevention or mitigation of previously analyzed events.

Thus, the probability of occurrence and the consequences of any previously analyzed event are not significantly increased as the result of the proposed changes to the pressure-temperature limits.

2. The proposed license amendments will not create the possibility of a new or different kind of accident from any accident previously evaluated.

   The proposed changes provide more operating margin in the pressure-temperature limits for hydrostatic pressure testing, non-nuclear heatup and cooldown, and criticality, with the benefits being primarily realizable during the pressure tests. The changes also extend the pressure-temperature limits for use up to 32 EFPY of operation. However, operation in the "new" regions of the pressure-temperature limits has been analyzed and will provide adequate protection against a nonductile-type fracture of the reactor pressure vessel. Otherwise, the proposed pressure-temperature limits do not result in any new or unanalyzed operation of any system or piece of equipment important to safety and, as a result, the possibility of a new type event is not created.

3. The proposed license amendments do not involve a significant reduction in a margin of safety.

   The revised pressure-temperature limits provide more operating margin and operational flexibility than the existing pressure-temperature limits. With the increased operational margin, a reduction in the safety margin results with respect to the existing limits. However, the industry experience since the inception of pressure-temperature limits confirms that some of the existing methodologies used to develop pressure-temperature limits are unrealistic and unnecessarily conservative. Accordingly, ASME Code Case N-640 takes advantage of this acquired knowledge by establishing more realistic methodologies for the development of pressure-temperature limits. Therefore, operational flexibility is gained and an acceptable margin of safety to reactor pressure vessel non-ductile type fracture is maintained. Evaluation of the revised pressure-temperature limits for use up to 32 EFPY was performed using 10 CFR 50 and ASME Code Case N-640; thus, the margin of safety is not significantly reduced as the result of the proposed changes.

ENCLOSURE 4

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 AND 50-324/LICENSE NOS. DPR-71 AND DPR-62
REQUEST FOR LICENSE AMENDMENTS – CHANGES TO REACTOR PRESSURE VESSEL PRESSURE-TEMPERATURE LIMITS AND REQUEST FOR EXEMPTION FROM 10 CFR 50, APPENDIX G, REQUIREMENTS

Request For Exemption From 10 CFR 50, Appendix G, Paragraph (IV)(A)(2)(b)

Introduction

In accordance with 10 CFR 50.12(a), Carolina Power & Light (CP&L) Company is requesting an exemption from the requirements of 10 CFR Part 50, Appendix G, paragraph (IV)(A)(2)(b), to use American Society of Mechanical Engineers (ASME) Code Case N-640, "Alternative Reference Fracture Toughness for Development of P-T Limit Curves for ASME Section XI, Division 1" to support the license amendment request revising the Technical Specifications pressure-temperature limits. Paragraph (IV)(A)(2)(b) of 10 CFR Part 50, Appendix G, requires that pressure-temperature limits be at least as conservative as limits obtained by following the methods of analysis and the margins of safety of Appendix G of Section XI of the ASME Code. Pressure-temperature limits obtained using ASME Code Case N-640 do not meet the requirements in paragraph (IV)(A)(2)(b).

10 CFR 50.12(a) Requirements

10 CFR 50.12 states that the Commission may grant an exemption from requirements contained in 10 CFR 50.12 providing certain criteria are met. Each criterion is discussed below.

1. The Requested Exemption is Authorized by Law

   No law exists that precludes the activities covered by this exemption request. 10 CFR 50.60(b) allows the use of alternatives to 10 CFR Part 50, Appendices G and H, when an exemption is granted by the Commission under 10 CFR 50.12.

2. The Requested Exemption Does Not Present An Undue Risk To The Public Health and Safety

   The revised pressure-temperature limits being proposed for the Brunswick Steam Electric Plant (BSEP), Unit Nos. 1 and 2, rely in part on the requested exemption. ASME Code Case N-640 permits the use of the K_{IC} fracture toughness curve of ASME Code, Section XI, Appendix A, Figure A-2200-1, in lieu of the K_{IA} fracture toughness curve from ASME Code, Section XI, Appendix G, Figure G-2200-1, as the lower bound for fracture toughness. The exemption request involves only a change of the fracture toughness curve used for development of the pressure-temperature limits from K_{IA} to K_{IC}.

The other margins involved with the ASME Code, Section XI, Appendix G, process of determining pressure-temperature limits remain unchanged.

Use of the K_{IC} curve in determining the lower bound fracture toughness in the development of pressure-temperature limits is more technically correct than the K_{IA} curve. The K_{IC} curve appropriately implements the use of static initiation fracture toughness behavior to evaluate the controlled heat-up and cooldown process of a reactor pressure vessel. The use of the initial conservatism of the K_{IA} curve when the curve was codified in 1974 was necessary due to the limited knowledge of reactor pressure vessel materials. Since 1974, additional knowledge has been gained about reactor pressure vessel materials, which demonstrates that the lower bound on fracture toughness provided by the K_{IA} curve is well beyond the margin of safety required to protect the public health and safety from potential reactor pressure vessel failure.

In addition, pressure-temperature limits based on the K_{IC} curve will enhance overall plant safety by opening the pressure-temperature operating window, especially in the region of low temperature operations. Safety benefits during the pressure test include a reduction in challenges to plant operators in maintaining a high temperature in a limited operating window, personnel safety while conducting inspections in primary containment at elevated temperatures, and increased availability of plant systems, including the Residual Heat Removal system due to the reduction of the heatup and testing time.

Based on the above information, CP&L has concluded that the requested exemption does not present an undue risk to the public health and safety.

3. <u>The Requested Exemption Will Not Endanger The Common Defense and Security</u>

The requested exemption relates to revising the operating and test pressure-temperature limits for the BSEP, Unit 1 and BSEP, Unit 2 reactor pressure vessels using industry-proposed guidance. As such, the requested exemption will not endanger the common defense and security.

4. <u>Special Circumstances</u>

The following special circumstances from 10 CFR 50.12(a)(2) are present:

(ii) Application of the regulation in this particular circumstance is not necessary to achieve the underlying purpose of the rule.

Paragraph (IV)(A)(2)(b) of 10 CFR Part 50, Appendix G, requires that pressure-temperature limits be at least as conservative as limits obtained by following the methods of analysis and the margins of safety of Appendix G of Section XI of the ASME Code. The ASME Code, Section XI, Appendix G, provides the process for determining pressure-temperature limits. Implementation of these requirements ensures that the reactor coolant pressure boundary will be operated in a regime with sufficient margin to ensure, when stressed, the reactor pressure vessel behaves in a non-brittle manner and the probability of a rapidly

propagating fracture is minimized. Implementation of these requirements also ensures that the pressure-temperature limits provide adequate margin considering uncertainties in determining the effects of irradiation on material properties.

The existing approach for determining pressure-temperature limits was conservatively developed based on the level of knowledge existing in 1974. Since 1974, the level of knowledge in this area has been greatly expanded. This increased knowledge permits relaxation of the current ASME Code, Section XI, Appendix G, requirements as provided by ASME Code Case N-640, while maintaining the underlying purpose of the ASME Code and the NRC regulations for ensuring an acceptable margin of safety.

(iii) Compliance would result in undue hardships or costs that are significantly in excess of those contemplated when the regulation was developed.

The reactor coolant system pressure-temperature operating window is defined by the pressure-temperature operating and test limit curves developed in accordance with the ASME Code, Section XI, Appendix G. Continued operation of BSEP, Units 1 and 2, without the use of ASME Code Case N-640, would unnecessarily require plant operators to maintain a high reactor pressure vessel temperature in a limited pressure-temperature operating window during pressure tests. The restriction could also subject personnel conducting inspections in primary containment to potential steam vapor hazards. Implementation of the proposed pressure-temperature limits, as allowed by ASME Code Case N-640, does not significantly reduce the margin of safety and could potentially reduce the risks associated with performing inspections at higher temperatures by allowing inspections in primary containment to be conducted at lower coolant temperatures. Based on the above, maintaining pressure-temperature limits based on the K_{IA} fracture toughness curve from ASME Code, Section XI, Appendix G, Figure G-2200-1, as the lower bound for fracture toughness, constitutes an unnecessary burden that can be alleviated by allowing the use of ASME Code Case N-640.

Conclusion

The exemption requirements of 10 CFR 50.12 are satisfied because special circumstances are present, as described in 10 CFR 50.12(a)(2)(ii) and (iii), to warrant granting the exemption. Paragraph (IV)(A)(2)(b) of 10 CFR Part 50, Appendix G, requires that pressure-temperature limits be at least as conservative as limits obtained by following the methods of analysis and the margins of safety of Appendix G of Section XI of the ASME Code. Implementation of these requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. ASME Code Case N-640 allows a reduction in the lower bound fracture toughness used in the ASME Code, Section XI, Appendix G, process for determination of the pressure-temperature limits. Since 1974, the level of knowledge in this area has been greatly expanded. This increased knowledge permits relaxation of the current ASME Code, Section XI, Appendix G, requirements as provided by ASME Code Case N-640, while

maintaining the underlying purpose of the ASME Code and the NRC regulations for ensuring an acceptable margin of safety.

ENCLOSURE 5

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 AND 50-324/LICENSE NOS. DPR-71 AND DPR-62
REQUEST FOR LICENSE AMENDMENTS – CHANGES TO REACTOR PRESSURE VESSEL PRESSURE-TEMPERATURE LIMITS AND REQUEST FOR EXEMPTION FROM 10 CFR 50, APPENDIX G, REQUIREMENTS

Environmental Considerations

Carolina Power & Light (CP&L) Company is requesting license amendments to revise the pressure-temperature limits contained in the Technical Specifications (TS) for the Brunswick Steam Electric Plant (BSEP), Unit Nos. 1 and 2. The existing pressure-temperature limits curves for normal operation are valid up to 16 effective full power years (EFPY), and the existing pressure-temperature limits curves for hydrostatic and leak testing are valid up to 14 and 16 EFPY. The revised pressure-temperature limits curves for normal operation and hydrostatic/leak tests will be valid up to 32 EFPY.

The revised pressure-temperature limits have been developed, in part, using American Society of Mechanical Engineers (ASME) Code Case N-640, "Alternative Reference Fracture Toughness for Development of P-T Limit Curves for ASME Section XI, Division 1," in establishing the reactor pressure vessel pressure limits at low temperatures. As a result, CP&L also is requesting an exemption from the requirements of 10 CFR Part 50, Appendix G, paragraph (IV)(A)(2)(b) to allow application of ASME Code Case N-640. CP&L's conclusions with respect to the environmental considerations associated with both the proposed exemption and the proposed revision to the BSEP, Unit 1 and 2 Technical Specifications, are discussed separately below.

Proposed Exemption

1. Identification of the Proposed Action

   Appendix G of 10 CFR Part 50 requires that pressure-temperature limits be established for reactor pressure vessels during normal operating and hydrostatic or leak rate testing conditions. Specifically, 10 CFR Part 50, Appendix G, states, "The appropriate requirements on both the pressure-temperature limits and the minimum permissible temperature must be met for all conditions." Appendix G of 10 CFR Part 50 specifies that the requirements for these limits are the ASME Boiler and Pressure Vessel Code, Section XI, Appendix G limits.

   In support of the proposed amendment to the Technical Specification pressure-temperature limits, CP&L is requesting that the NRC exempt BSEP, Units 1 and 2, from the requirements of 10 CFR Part 50, Appendix G, paragraph (IV)(A)(2)(b) to allow application of ASME Code Case N-640 in establishing the reactor vessel pressure limits at low temperatures.

Code Case N-640 permits the use of an alternate reference fracture toughness (K_{IC} fracture toughness curve instead of the K_{IA} fracture toughness curve) for reactor vessel materials in determining the pressure-temperature limits. Since the K_{IC} fracture toughness curve shown in ASME, Section XI, Appendix A, Figure A-2200-1 (the K_{IC} fracture toughness curve), provides greater allowable fracture toughness than the corresponding K_{IA} fracture toughness curve of ASME, Section XI, Appendix G, Figure G-2210-1 (the K_{IA} fracture toughness curve), using ASME Code Case N-640 for establishing the pressure-temperature limits would be less conservative than the methodology currently endorsed by 10 CFR Part 50, Appendix G. Therefore, an exemption is required in order to apply the code case. It should be noted that, although ASME Code Case N-640 was incorporated into the ASME Code recently, an exemption is still required because the proposed pressure-temperature limits, excluding ASME Code Case N-640, are based on the 1989 edition of the ASME Code.

2. The Need for the Proposed Action

The purpose of 10 CFR Part 50, Section 50.60(a), and 10 CFR Part 50, Appendix G, is to protect the integrity of the reactor coolant pressure boundary. These regulations specify, in part, that fracture toughness requirements for ferritic materials of the reactor coolant pressure boundary. In accordance with 10 CFR Part 50, Appendix G, pressure-temperature limits for the reactor coolant system are required to be at least as conservative as those obtained by applying the methodology of the ASME Code, Section XI, Appendix G.

ASME Code Case N-640 is needed to revise the method used to determine the reactor coolant system pressure-temperature limits, since continued use of the present limits unnecessarily restricts the pressure-temperature operating window. Since the reactor coolant system pressure-temperature operating window is defined by the pressure-temperature operating and test limits developed in accordance with the ASME Section XI, Appendix G procedure, continued operation of BSEP, Units 1 and 2, with these pressure-temperature limits without the relief provided by ASME Code Case N-640 could unnecessarily require the reactor pressure vessel to maintain a temperature exceeding 212 degrees Fahrenheit in a limited operating window during the pressure test. Consequently, steam vapor hazards could be one of the safety concerns for personnel conducting inspections in primary containment. Implementation of the revised pressure-temperature limits, as allowed by ASME Code Case N-640, does not significantly reduce the margin of safety, but supports conducting inspections in primary containment at lower coolant temperatures, thus avoiding potential steam vapor hazards.

CP&L has determined that, in accordance with 10 CFR 50.12(a)(2)(ii), the underlying purpose of the regulation will continue to be served by the implementation of this Code Case.

3. Environmental Impacts of the Proposed Exemption

The proposed exemption described above will provide an adequate margin of safety against brittle failure of the BSEP, Unit 1 and 2 reactor pressure vessels.

The proposed exemption allowing implementation of ASME Code Case N-640 will not increase the probability or consequences of accidents, will not result in changes to the types of any effluents that may be released offsite, and will not significantly increase occupational or public radiation exposure. Therefore, there are no significant radiological environmental impacts associated with the proposed action.

With regard to potential nonradiological environmental impacts, the proposed exemption does not involve any historic sites. It does not affect nonradiological plant effluents and has no other environmental impacts. Therefore, there are no significant nonradiological impacts associated with the proposed action.

4. Alternative Use of Resources

This proposed exemption does not involve the use of any resources not previously considered in the Final Environmental Statement for BSEP, Units 1 and 2, dated January 1974.

Proposed License Amendments

Currently, the pressure-temperature limits for normal operation and hydrostatic pressure testing of the BSEP, Unit 1 and 2 reactor pressure vessels are valid for operation up to 16 EFPY. The proposed license amendments revise the BSEP, Unit 1 and 2 pressure-temperature limits for operation up to 32 EFPY. The proposed changes are based on ASME Code Case N-640 for determining allowable pressure-temperature limits. CP&L has concluded that the proposed changes to the BSEP, Unit 1 and 2 Technical Specifications pressure-temperature limits are eligible for categorical exclusion from performing an environmental assessment. In support of this determination, an evaluation of each of the three (3) criteria set forth in 10 CFR 51.22(c)(9) is provided below.

1. The proposed license amendments do not involve a significant hazards consideration, as shown in Enclosure 3.

2. The proposed license amendments do not result in a significant change in the types or a significant increase in the amounts of any effluent that may be released offsite. The proposed license amendments do not introduce any new equipment nor require any existing equipment or systems to perform a different type of function than presently designed to perform. The proposed license amendments do not alter the function of existing equipment and will ensure that the consequences of any previously evaluated accident do not increase. Therefore, CP&L has concluded that there will not be a significant increase in the types or amounts of any effluent that may be released offsite and, as such, the changes do not involve irreversible environmental consequences beyond those already associated with normal operation.

3. The proposed license amendments do not result in an increase in individual or cumulative occupational radiation exposure.

ENCLOSURE 6

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 AND 50-324/LICENSE NOS. DPR-71 AND DPR-62
REQUEST FOR LICENSE AMENDMENTS – CHANGES TO REACTOR PRESSURE VESSEL PRESSURE-TEMPERATURE LIMITS AND REQUEST FOR EXEMPTION FROM 10 CFR 50, APPENDIX G, REQUIREMENTS

Page Change Instructions

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3.4-26	3.4-26
3.4-27	---

UNIT 2	
Removed page	Inserted page
3.4-21	3.4-21
3.4-23	3.4-23
3.4-24	3.4-24
3.4-25	3.4-25
3.4-26	3.4-26
3.4-27	---

ENCLOSURE 7

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 AND 50-324/LICENSE NOS. DPR-71 AND DPR-62
REQUEST FOR LICENSE AMENDMENTS – CHANGES TO REACTOR PRESSURE VESSEL PRESSURE-TEMPERATURE LIMITS AND REQUEST FOR EXEMPTION FROM 10 CFR 50, APPENDIX G, REQUIREMENTS

Typed Technical Specification Pages - Unit No. 1

3.3	INSTRUMENTATION (continued)	
3.3.6.2	Secondary Containment Isolation Instrumentation . .	3.3-59
3.3.7.1	Control Room Emergency Ventilation (CREV) System Instrumentation	3.3-63
3.3.7.2	Condenser Vacuum Pump Isolation Instrumentation . .	3.3-65
3.3.8.1	Loss of Power (LOP) Instrumentation	3.3-68
3.3.8.2	Reactor Protection System (RPS) Electric Power Monitoring	3.3-71
3.4	REACTOR COOLANT SYSTEM (RCS)	3.4-1
3.4.1	Recirculation Loops Operating	3.4-1
3.4.2	Jet Pumps	3.4-3
3.4.3	Safety/Relief Valves (SRVs)	3.4-5
3.4.4	RCS Operational LEAKAGE	3.4-7
3.4.5	RCS Leakage Detection Instrumentation	3.4-9
3.4.6	RCS Specific Activity	3.4-12
3.4.7	Residual Heat Removal (RHR) Shutdown Cooling System—Hot Shutdown	3.4-14
3.4.8	Residual Heat Removal (RHR) Shutdown Cooling System—Cold Shutdown	3.4-17
3.4.9	RCS Pressure and Temperature (P/T) Limits	3.4-19
3.4.10	Reactor Steam Dome Pressure	3.4-26
3.5	EMERGENCY CORE COOLING SYSTEMS (ECCS) AND REACTOR CORE ISOLATION COOLING (RCIC) SYSTEM	3.5-1
3.5.1	ECCS—Operating	3.5-1
3.5.2	ECCS—Shutdown	3.5-8
3.5.3	RCIC System	3.5-12
3.6	CONTAINMENT SYSTEMS	3.6-1
3.6.1.1	Primary Containment	3.6-1
3.6.1.2	Primary Containment Air Lock	3.6-3
3.6.1.3	Primary Containment Isolation Valves (PCIVs) . . .	3.6-7
3.6.1.4	Drywell Air Temperature	3.6-14
3.6.1.5	Reactor Building-to-Suppression Chamber Vacuum Breakers	3.6-15
3.6.1.6	Suppression Chamber-to-Drywell Vacuum Breakers . .	3.6-18
3.6.2.1	Suppression Pool Average Temperature	3.6-20
3.6.2.2	Suppression Pool Water Level	3.6-23
3.6.2.3	Residual Heat Removal (RHR) Suppression Pool Cooling	3.6-24
3.6.3.1	Primary Containment Oxygen Concentration	3.6-26
3.6.3.2	Containment Atmosphere Dilution (CAD) System . . .	3.6-27
3.6.4.1	Secondary Containment	3.6-29
3.6.4.2	Secondary Containment Isolation Dampers (SCIDs) . .	3.6-31
3.6.4.3	Standby Gas Treatment (SGT) System	3.6-34

(continued)

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.4.9.2	----------NOTE---------- Only required to be performed during RCS inservice leak and hydrostatic testing. ---------- Verify: a. RCS pressure and RCS temperature are within the applicable limits specified in Figure 3.4.9-3; and b. RCS heatup and cooldown rates are ≤ 30°F in any 1 hour period.	30 minutes
SR 3.4.9.3	Verify RCS pressure and RCS temperature are within the criticality limits specified in Figure 3.4.9-2.	Once within 15 minutes prior to control rod withdrawal for the purpose of achieving criticality
SR 3.4.9.4	----------NOTE---------- Only required to be met in MODES 1, 2, 3, and 4 during recirculation pump start. ---------- Verify the difference between the bottom head coolant temperature and the reactor pressure vessel (RPV) coolant temperature is ≤ 145°F.	Once within 30 minutes prior to each startup of a recirculation pump

(continued)

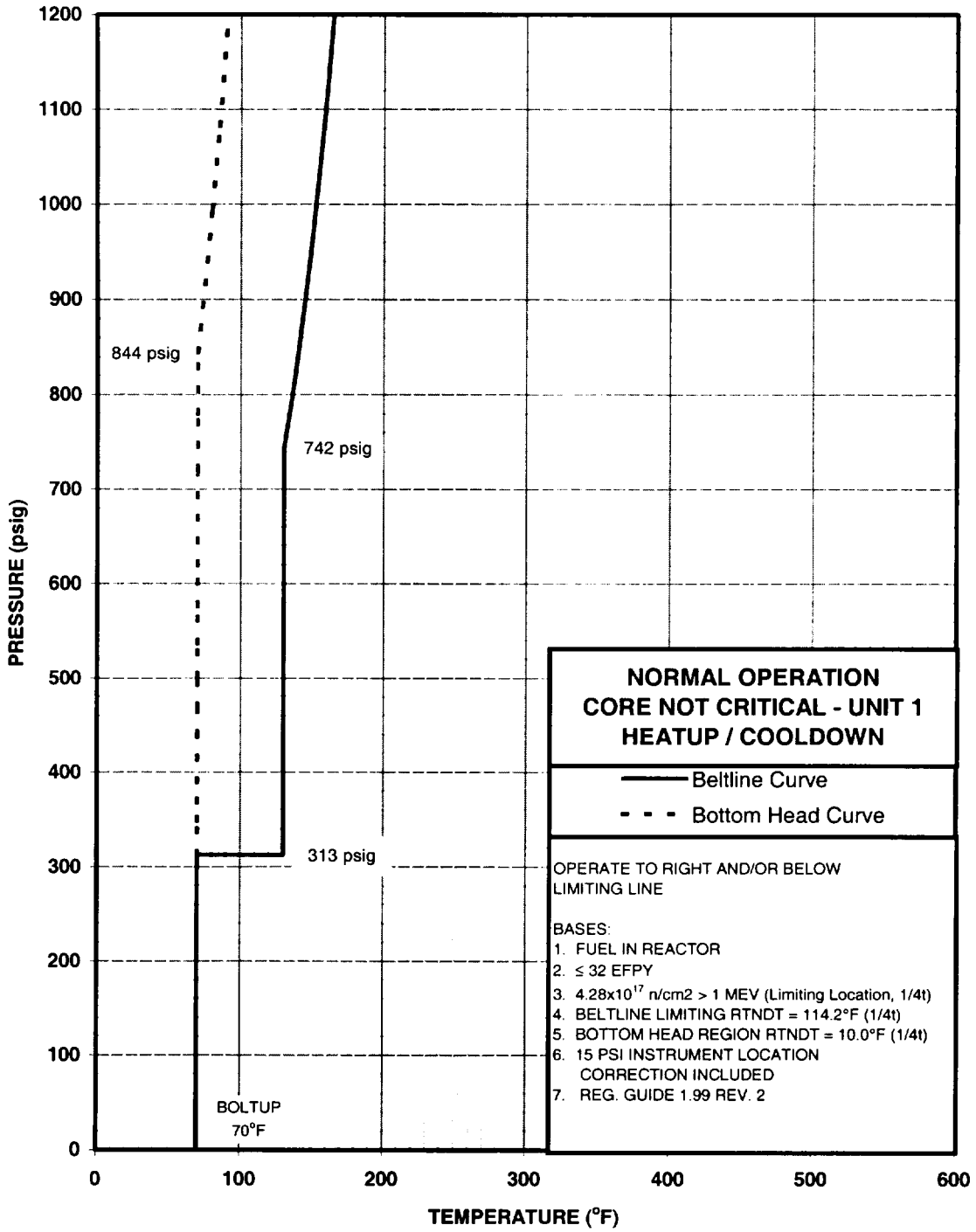

Figure 3.4.9-1 (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation with Core Not Critical

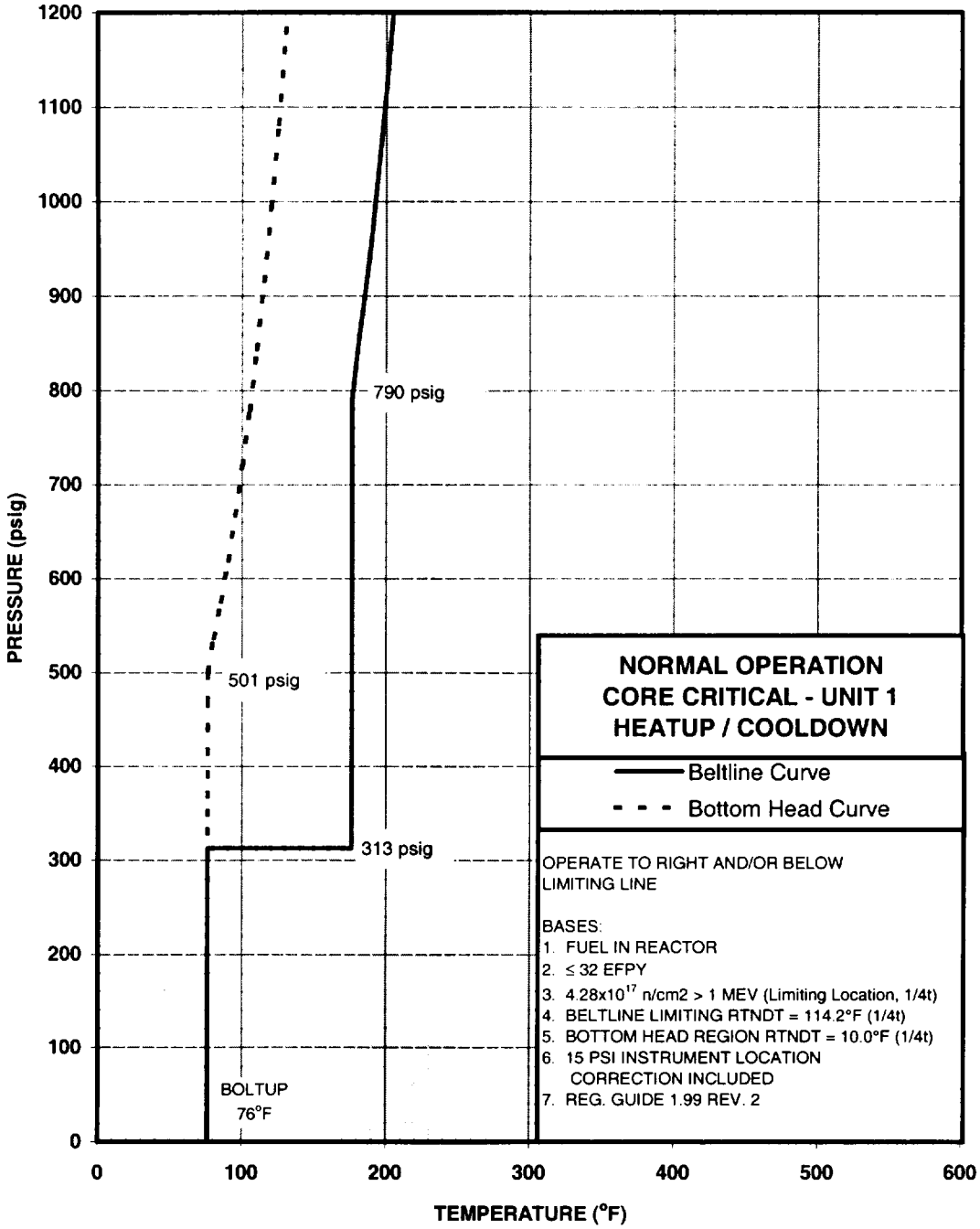

Figure 3.4.9-2 (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation with Core Critical

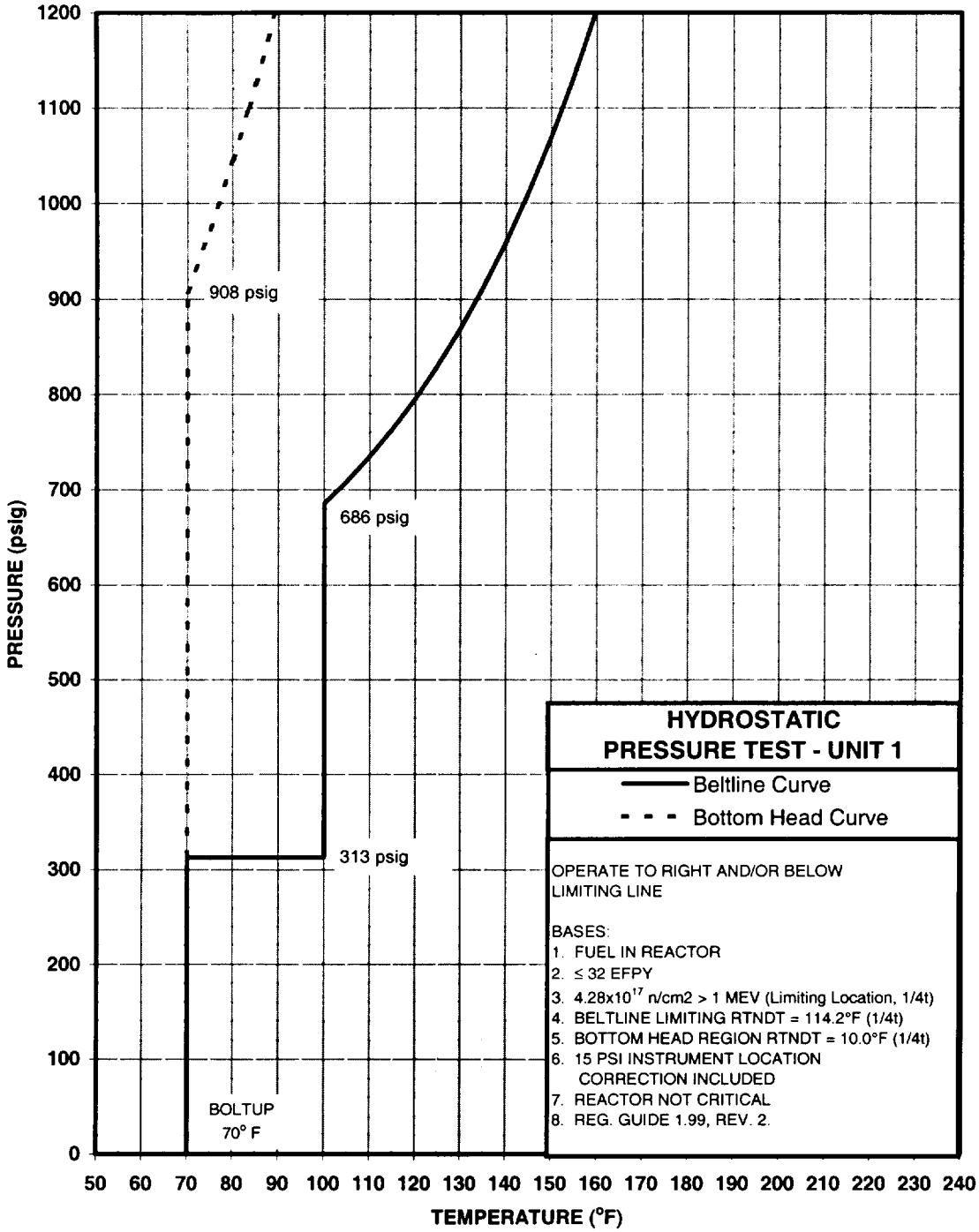

Figure 3.4.9-3 (page 1 of 1)
RCS Pressure and Temperature Limits
Hydrostatic and Leak Tests

3.4 REACTOR COOLANT SYSTEM (RCS)

3.4.10 Reactor Steam Dome Pressure

LCO 3.4.10 The reactor steam dome pressure shall be ≤ 1045 psig.

APPLICABILITY: MODES 1 and 2.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Reactor steam dome pressure not within limit.	A.1 Restore reactor steam dome pressure to within limit.	15 minutes
B. Required Action and associated Completion Time not met.	B.1 Be in MODE 3.	12 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 3.4.10.1 Verify reactor steam dome pressure is ≤ 1045 psig.	12 hours

ENCLOSURE 8

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 AND 50-324/LICENSE NOS. DPR-71 AND DPR-62
REQUEST FOR LICENSE AMENDMENTS – CHANGES TO REACTOR PRESSURE VESSEL PRESSURE-TEMPERATURE LIMITS AND REQUEST FOR EXEMPTION FROM 10 CFR 50, APPENDIX G, REQUIREMENTS

Typed Technical Specification Pages - Unit No. 2

3.3	INSTRUMENTATION (continued)	
3.3.6.2	Secondary Containment Isolation Instrumentation . .	3.3-59
3.3.7.1	Control Room Emergency Ventilation (CREV) System Instrumentation	3.3-63
3.3.7.2	Condenser Vacuum Pump Isolation Instrumentation . .	3.3-65
3.3.8.1	Loss of Power (LOP) Instrumentation	3.3-68
3.3.8.2	Reactor Protection System (RPS) Electric Power Monitoring	3.3-71
3.4	REACTOR COOLANT SYSTEM (RCS)	3.4-1
3.4.1	Recirculation Loops Operating	3.4-1
3.4.2	Jet Pumps	3.4-3
3.4.3	Safety/Relief Valves (SRVs)	3.4-5
3.4.4	RCS Operational LEAKAGE	3.4-7
3.4.5	RCS Leakage Detection Instrumentation	3.4-9
3.4.6	RCS Specific Activity	3.4-12
3.4.7	Residual Heat Removal (RHR) Shutdown Cooling System—Hot Shutdown	3.4-14
3.4.8	Residual Heat Removal (RHR) Shutdown Cooling System—Cold Shutdown	3.4-17
3.4.9	RCS Pressure and Temperature (P/T) Limits	3.4-19
3.4.10	Reactor Steam Dome Pressure	3.4-26
3.5	EMERGENCY CORE COOLING SYSTEMS (ECCS) AND REACTOR CORE ISOLATION COOLING (RCIC) SYSTEM	3.5-1
3.5.1	ECCS—Operating	3.5-1
3.5.2	ECCS—Shutdown	3.5-8
3.5.3	RCIC System	3.5-12
3.6	CONTAINMENT SYSTEMS	3.6-1
3.6.1.1	Primary Containment	3.6-1
3.6.1.2	Primary Containment Air Lock	3.6-3
3.6.1.3	Primary Containment Isolation Valves (PCIVs) . . .	3.6-7
3.6.1.4	Drywell Air Temperature	3.6-14
3.6.1.5	Reactor Building-to-Suppression Chamber Vacuum Breakers	3.6-15
3.6.1.6	Suppression Chamber-to-Drywell Vacuum Breakers . .	3.6-18
3.6.2.1	Suppression Pool Average Temperature	3.6-20
3.6.2.2	Suppression Pool Water Level	3.6-23
3.6.2.3	Residual Heat Removal (RHR) Suppression Pool Cooling	3.6-24
3.6.3.1	Primary Containment Oxygen Concentration	3.6-26
3.6.3.2	Containment Atmosphere Dilution (CAD) System . . .	3.6-27
3.6.4.1	Secondary Containment	3.6-29
3.6.4.2	Secondary Containment Isolation Dampers (SCIDs) . .	3.6-31
3.6.4.3	Standby Gas Treatment (SGT) System	3.6-34

(continued)

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.4.9.2	----------NOTE---------- Only required to be performed during RCS inservice leak and hydrostatic testing. ---------- Verify: a. RCS pressure and RCS temperature are within the applicable limits specified in Figure 3.4.9-3; and b. RCS heatup and cooldown rates are ≤ 30°F in any 1 hour period.	30 minutes
SR 3.4.9.3	Verify RCS pressure and RCS temperature are within the criticality limits specified in Figure 3.4.9-2.	Once within 15 minutes prior to control rod withdrawal for the purpose of achieving criticality
SR 3.4.9.4	----------NOTE---------- Only required to be met in MODES 1, 2, 3, and 4 during recirculation pump start. ---------- Verify the difference between the bottom head coolant temperature and the reactor pressure vessel (RPV) coolant temperature is ≤ 145°F.	Once within 30 minutes prior to each startup of a recirculation pump

(continued)

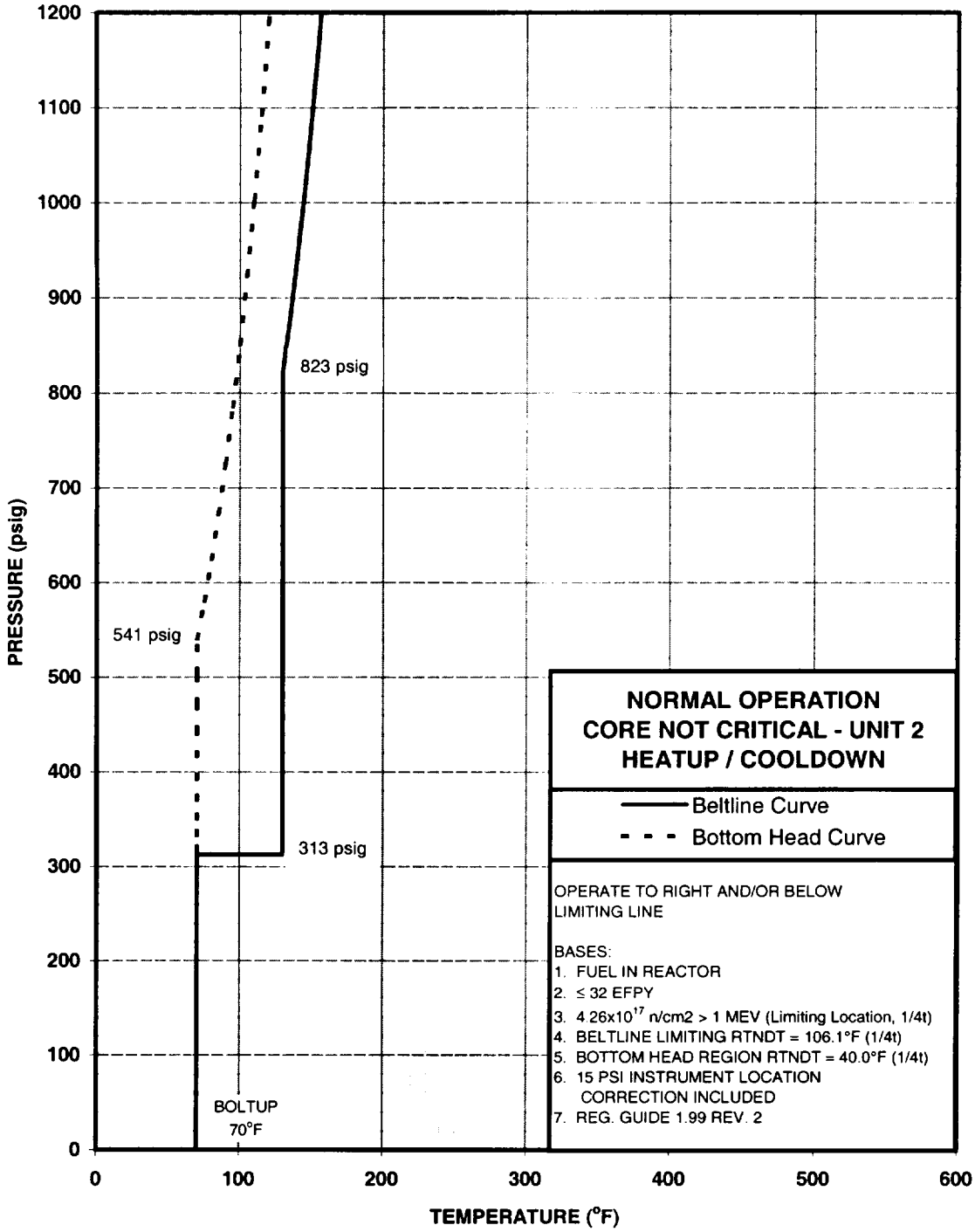

Figure 3.4.9-1 (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation with Core Not Critical

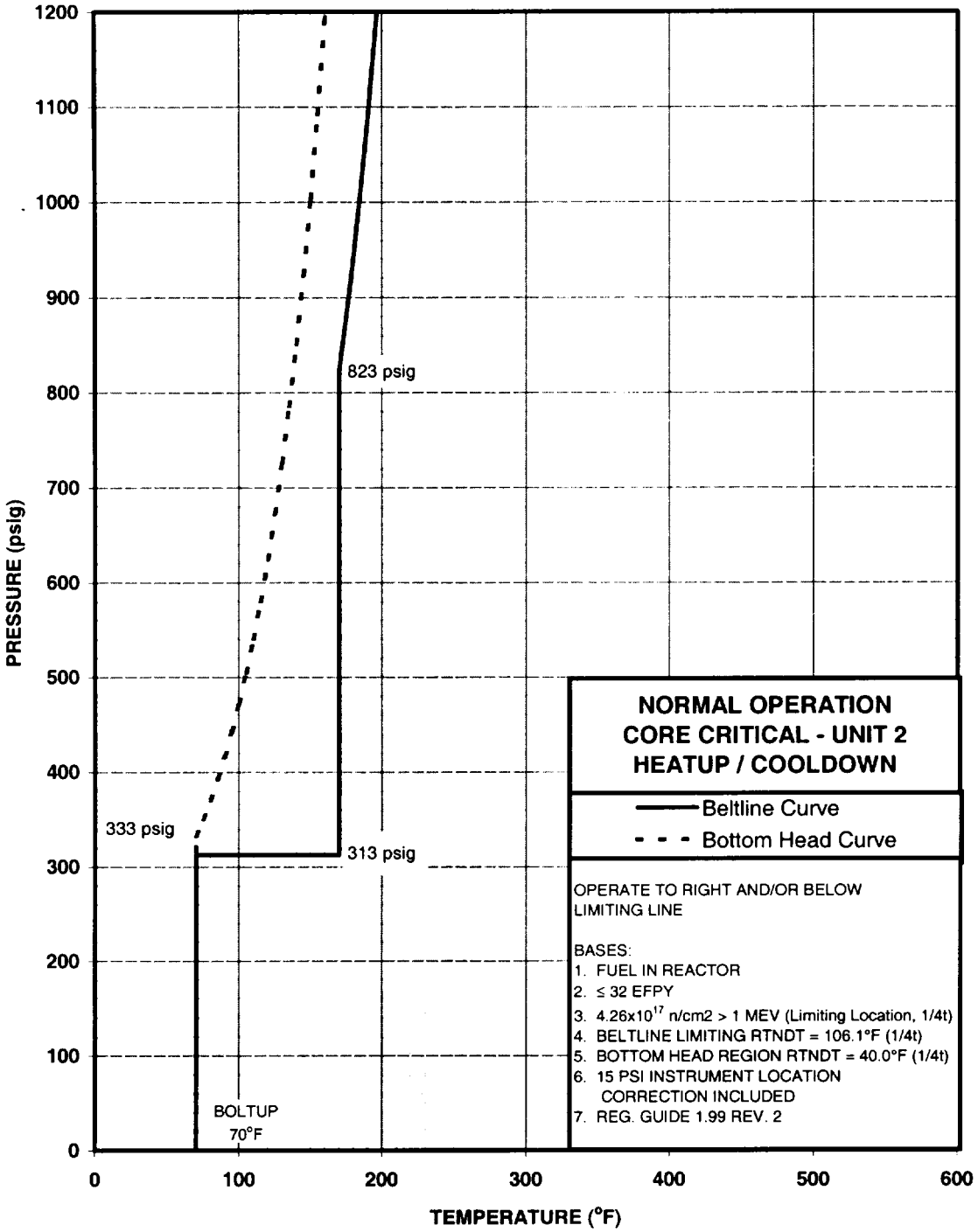

Figure 3.4.9-2 (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation with Core Critical

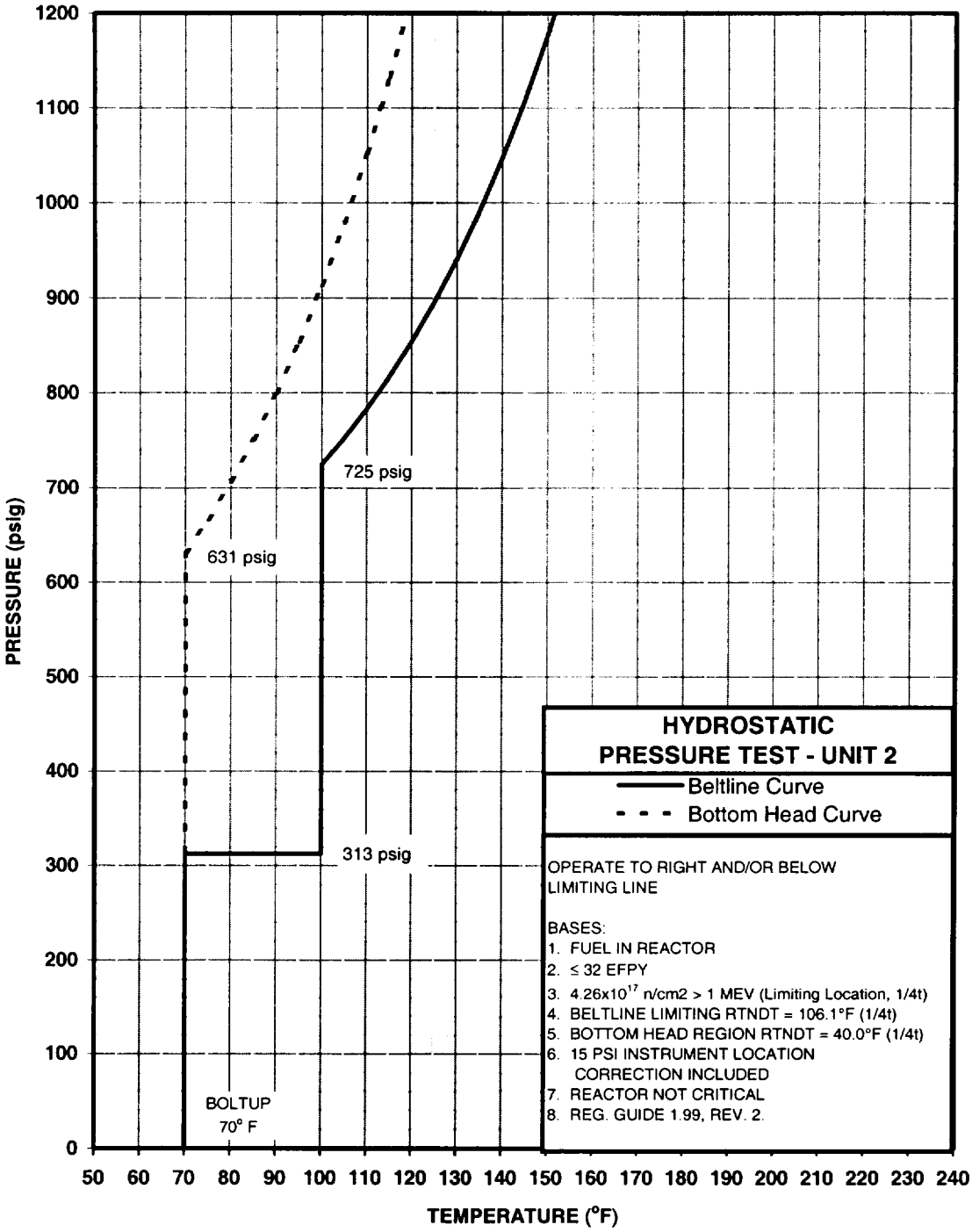

Figure 3.4.9-3 (page 1 of 1)
RCS Pressure and Temperature Limits
Hydrostatic and Leak Tests

3.4 REACTOR COOLANT SYSTEM (RCS)

3.4.10 Reactor Steam Dome Pressure

LCO 3.4.10 The reactor steam dome pressure shall be ≤ 1045 psig.

APPLICABILITY: MODES 1 and 2.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Reactor steam dome pressure not within limit.	A.1 Restore reactor steam dome pressure to within limit.	15 minutes
B. Required Action and associated Completion Time not met.	B.1 Be in MODE 3.	12 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 3.4.10.1 Verify reactor steam dome pressure is ≤ 1045 psig.	12 hours

ENCLOSURE 9

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 AND 50-324/LICENSE NOS. DPR-71 AND DPR-62
REQUEST FOR LICENSE AMENDMENTS – CHANGES TO REACTOR PRESSURE VESSEL PRESSURE-TEMPERATURE LIMITS AND REQUEST FOR EXEMPTION FROM 10 CFR 50, APPENDIX G, REQUIREMENTS

Marked-Up Technical Specification Pages - Unit No. 1

3.3	INSTRUMENTATION (continued)	
3.3.6.2	Secondary Containment Isolation Instrumentation . .	3.3-59
3.3.7.1	Control Room Emergency Ventilation (CREV) System Instrumentation	3.3-63
3.3.7.2	Condenser Vacuum Pump Isolation Instrumentation . .	3.3-65
3.3.8.1	Loss of Power (LOP) Instrumentation	3.3-68
3.3.8.2	Reactor Protection System (RPS) Electric Power Monitoring	3.3-71
3.4	REACTOR COOLANT SYSTEM (RCS)	3.4-1
3.4.1	Recirculation Loops Operating	3.4-1
3.4.2	Jet Pumps	3.4-3
3.4.3	Safety/Relief Valves (SRVs)	3.4-5
3.4.4	RCS Operational LEAKAGE	3.4-7
3.4.5	RCS Leakage Detection Instrumentation	3.4-9
3.4.6	RCS Specific Activity	3.4-12
3.4.7	Residual Heat Removal (RHR) Shutdown Cooling System—Hot Shutdown	3.4-14
3.4.8	Residual Heat Removal (RHR) Shutdown Cooling System—Cold Shutdown	3.4-17
3.4.9	RCS Pressure and Temperature (P/T) Limits	3.4-19
3.4.10	Reactor Steam Dome Pressure	3.4-~~27~~ 26
3.5	EMERGENCY CORE COOLING SYSTEMS (ECCS) AND REACTOR CORE ISOLATION COOLING (RCIC) SYSTEM	3.5-1
3.5.1	ECCS—Operating	3.5-1
3.5.2	ECCS—Shutdown	3.5-8
3.5.3	RCIC System	3.5-12
3.6	CONTAINMENT SYSTEMS	3.6-1
3.6.1.1	Primary Containment	3.6-1
3.6.1.2	Primary Containment Air Lock	3.6-3
3.6.1.3	Primary Containment Isolation Valves (PCIVs) . . .	3.6-7
3.6.1.4	Drywell Air Temperature	3.6-14
3.6.1.5	Reactor Building-to-Suppression Chamber Vacuum Breakers	3.6-15
3.6.1.6	Suppression Chamber-to-Drywell Vacuum Breakers . .	3.6-18
3.6.2.1	Suppression Pool Average Temperature	3.6-20
3.6.2.2	Suppression Pool Water Level	3.6-23
3.6.2.3	Residual Heat Removal (RHR) Suppression Pool Cooling	3.6-24
3.6.3.1	Primary Containment Oxygen Concentration	3.6-26
3.6.3.2	Containment Atmosphere Dilution (CAD) System . . .	3.6-27
3.6.4.1	Secondary Containment	3.6-29
3.6.4.2	Secondary Containment Isolation Dampers (SCIDs) . .	3.6-31
3.6.4.3	Standby Gas Treatment (SGT) System	3.6-34

(continued)

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.4.9.2	----------NOTE---------- Only required to be performed during RCS inservice leak and hydrostatic testing. ---------- Verify: a. RCS pressure and RCS temperature are within the applicable limits specified in Figure 3.4.9-3 ~~or 3.4.9-4~~; and b. RCS heatup and cooldown rates are ≤ 30°F in any 1 hour period.	30 minutes
SR 3.4.9.3	Verify RCS pressure and RCS temperature are within the criticality limits specified in Figure 3.4.9-2.	Once within 15 minutes prior to control rod withdrawal for the purpose of achieving criticality
SR 3.4.9.4	----------NOTE---------- Only required to be met in MODES 1, 2, 3, and 4 during recirculation pump start. ---------- Verify the difference between the bottom head coolant temperature and the reactor pressure vessel (RPV) coolant temperature is ≤ 145°F.	Once within 30 minutes prior to each startup of a recirculation pump

(continued)

Replace with revised Figure 3.4.9-1

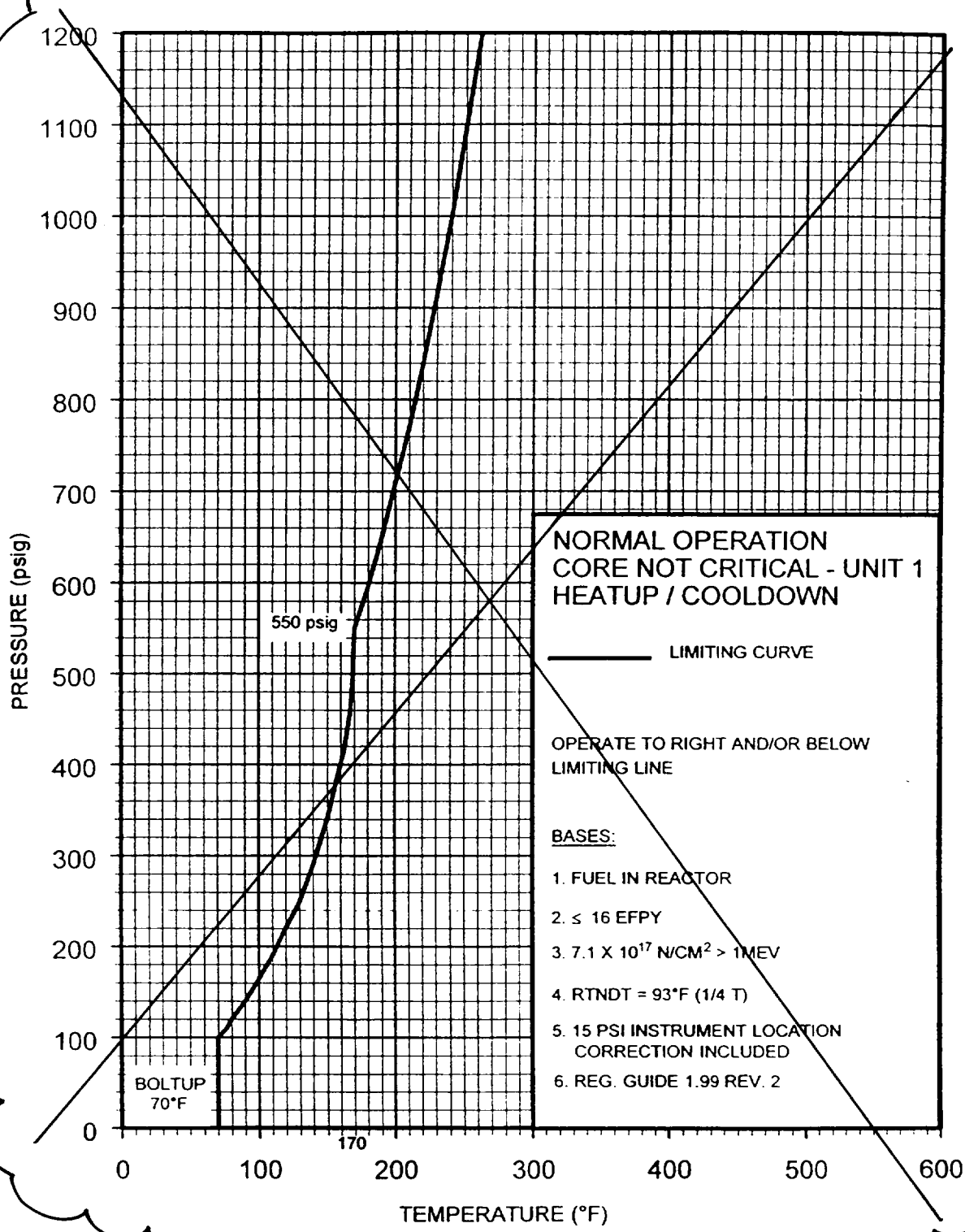

Figure 3.4.9-1 (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation with Core Not Critical

Replace with revised Figure 3.4.9-2

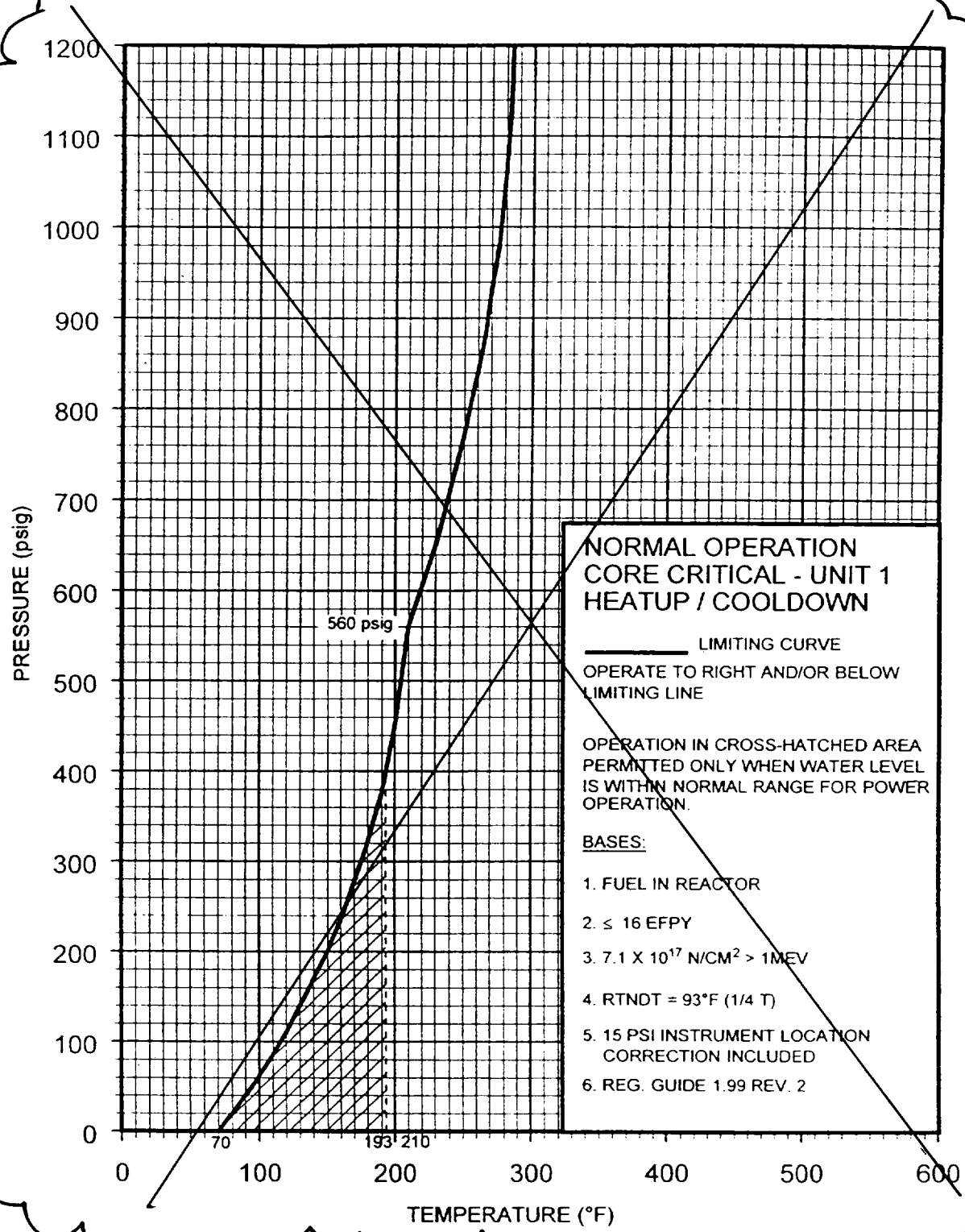

Figure 3.4.9-2 (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation with Core Critical

Replace with revised Figure 3.4.9-3

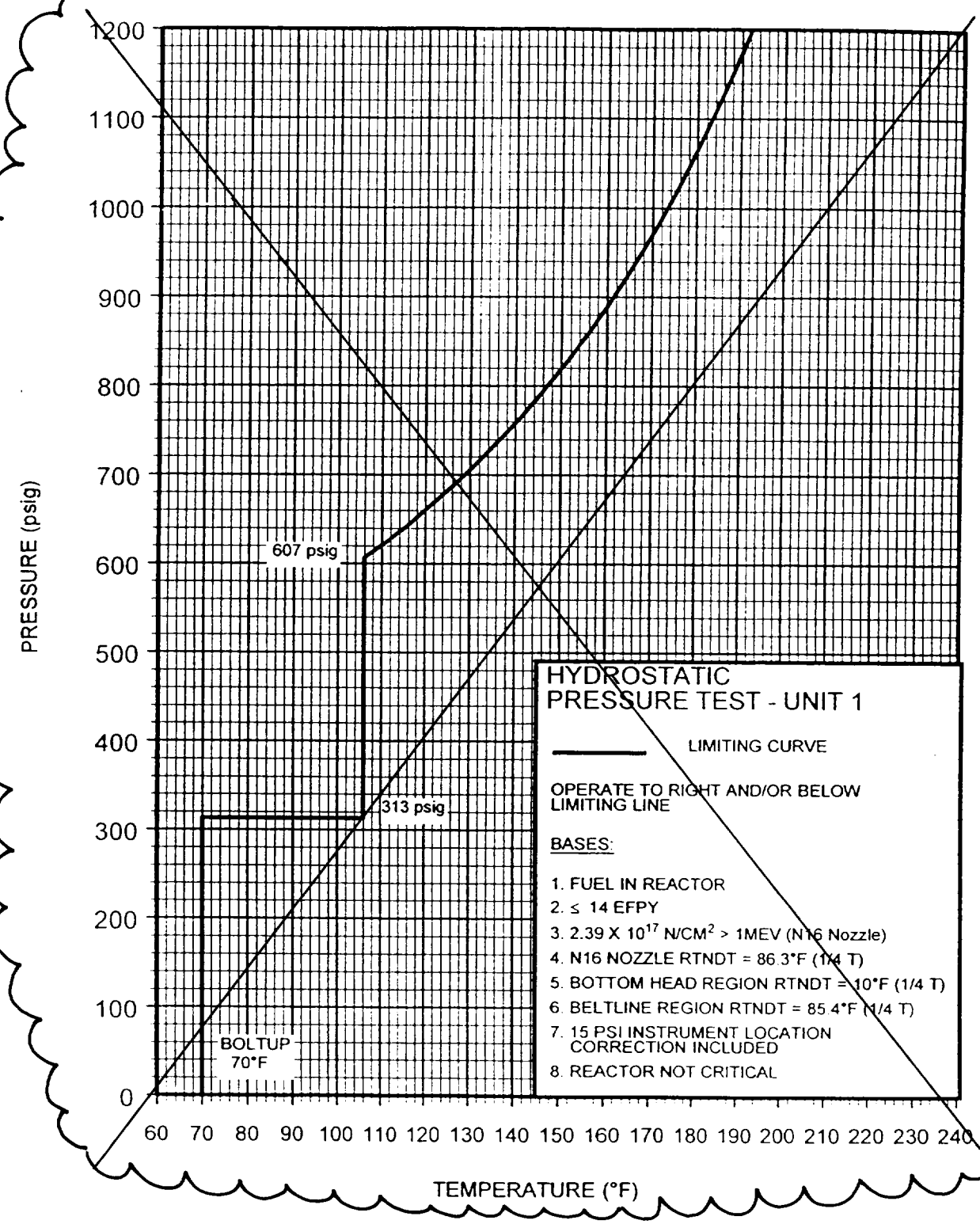

Figure 3.4.9-3 (page 1 of 1)
RCS Pressure and Temperature Limits
Hydrostatic and Leak Tests ~~≤ 14 EFPY~~

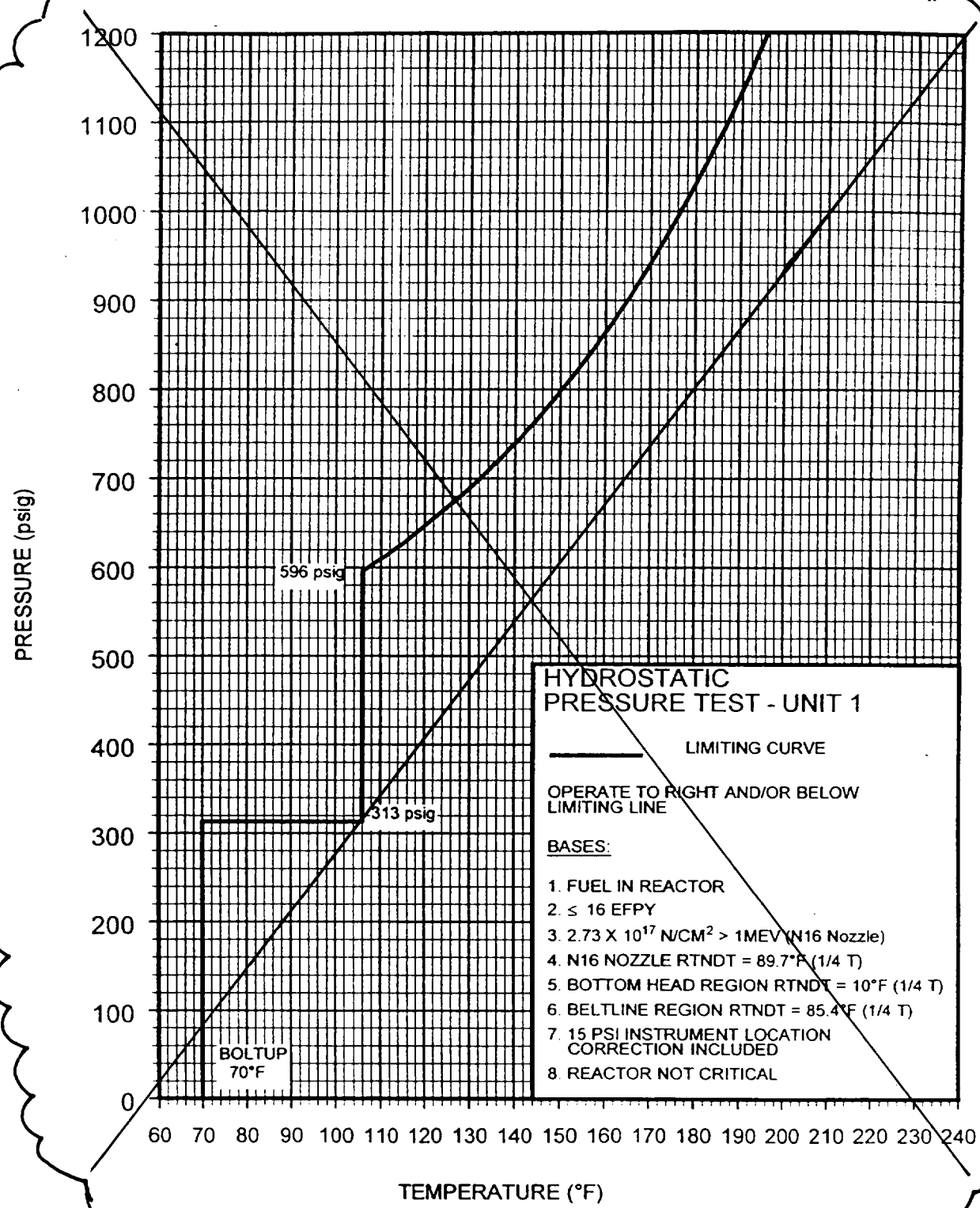

Figure 3.4.9-4 (page 1 of 1)
RCS Pressure and Temperature Limits
Hydrostatic and Leak Tests ≤ 16 EFPY

3.4 REACTOR COOLANT SYSTEM (RCS)

3.4.10 Reactor Steam Dome Pressure

LCO 3.4.10 The reactor steam dome pressure shall be ≤ 1045 psig.

APPLICABILITY: MODES 1 and 2.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Reactor steam dome pressure not within limit.	A.1 Restore reactor steam dome pressure to within limit.	15 minutes
B. Required Action and associated Completion Time not met.	B.1 Be in MODE 3.	12 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 3.4.10.1 Verify reactor steam dome pressure is ≤ 1045 psig.	12 hours

ENCLOSURE 10

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 AND 50-324/LICENSE NOS. DPR-71 AND DPR-62
REQUEST FOR LICENSE AMENDMENTS – CHANGES TO REACTOR PRESSURE VESSEL PRESSURE-TEMPERATURE LIMITS AND REQUEST FOR EXEMPTION FROM 10 CFR 50, APPENDIX G, REQUIREMENTS

Marked-Up Technical Specification Pages - Unit No. 2

3.3	INSTRUMENTATION (continued)	
3.3.6.2	Secondary Containment Isolation Instrumentation . .	3.3-59
3.3.7.1	Control Room Emergency Ventilation (CREV) System Instrumentation	3.3-63
3.3.7.2	Condenser Vacuum Pump Isolation Instrumentation . .	3.3-65
3.3.8.1	Loss of Power (LOP) Instrumentation	3.3-68
3.3.8.2	Reactor Protection System (RPS) Electric Power Monitoring	3.3-71
3.4	REACTOR COOLANT SYSTEM (RCS)	3.4-1
3.4.1	Recirculation Loops Operating	3.4-1
3.4.2	Jet Pumps	3.4-3
3.4.3	Safety/Relief Valves (SRVs)	3.4-5
3.4.4	RCS Operational LEAKAGE	3.4-7
3.4.5	RCS Leakage Detection Instrumentation	3.4-9
3.4.6	RCS Specific Activity	3.4-12
3.4.7	Residual Heat Removal (RHR) Shutdown Cooling System—Hot Shutdown	3.4-14
3.4.8	Residual Heat Removal (RHR) Shutdown Cooling System—Cold Shutdown	3.4-17
3.4.9	RCS Pressure and Temperature (P/T) Limits	3.4-19
3.4.10	Reactor Steam Dome Pressure	3.4-~~20~~ 26
3.5	EMERGENCY CORE COOLING SYSTEMS (ECCS) AND REACTOR CORE ISOLATION COOLING (RCIC) SYSTEM	3.5-1
3.5.1	ECCS—Operating	3.5-1
3.5.2	ECCS—Shutdown	3.5-8
3.5.3	RCIC System	3.5-12
3.6	CONTAINMENT SYSTEMS	3.6-1
3.6.1.1	Primary Containment	3.6-1
3.6.1.2	Primary Containment Air Lock	3.6-3
3.6.1.3	Primary Containment Isolation Valves (PCIVs) . . .	3.6-7
3.6.1.4	Drywell Air Temperature	3.6-14
3.6.1.5	Reactor Building-to-Suppression Chamber Vacuum Breakers	3.6-15
3.6.1.6	Suppression Chamber-to-Drywell Vacuum Breakers . .	3.6-18
3.6.2.1	Suppression Pool Average Temperature	3.6-20
3.6.2.2	Suppression Pool Water Level	3.6-23
3.6.2.3	Residual Heat Removal (RHR) Suppression Pool Cooling	3.6-24
3.6.3.1	Primary Containment Oxygen Concentration	3.6-26
3.6.3.2	Containment Atmosphere Dilution (CAD) System . . .	3.6-27
3.6.4.1	Secondary Containment	3.6-29
3.6.4.2	Secondary Containment Isolation Dampers (SCIDs) . .	3.6-31
3.6.4.3	Standby Gas Treatment (SGT) System	3.6-34

(continued)

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.4.9.2	----------NOTE---------- Only required to be performed during RCS inservice leak and hydrostatic testing. ---------- Verify: a. RCS pressure and RCS temperature are within the applicable limits specified in Figure 3.4.9-3 ~~or 3.4.9-4~~; and b. RCS heatup and cooldown rates are ≤ 30°F in any 1 hour period.	30 minutes
SR 3.4.9.3	Verify RCS pressure and RCS temperature are within the criticality limits specified in Figure 3.4.9-2.	Once within 15 minutes prior to control rod withdrawal for the purpose of achieving criticality
SR 3.4.9.4	----------NOTE---------- Only required to be met in MODES 1, 2, 3, and 4 during recirculation pump start. ---------- Verify the difference between the bottom head coolant temperature and the reactor pressure vessel (RPV) coolant temperature is ≤ 145°F.	Once within 30 minutes prior to each startup of a recirculation pump

(continued)

Replace with revised Figure 3.4.9-1

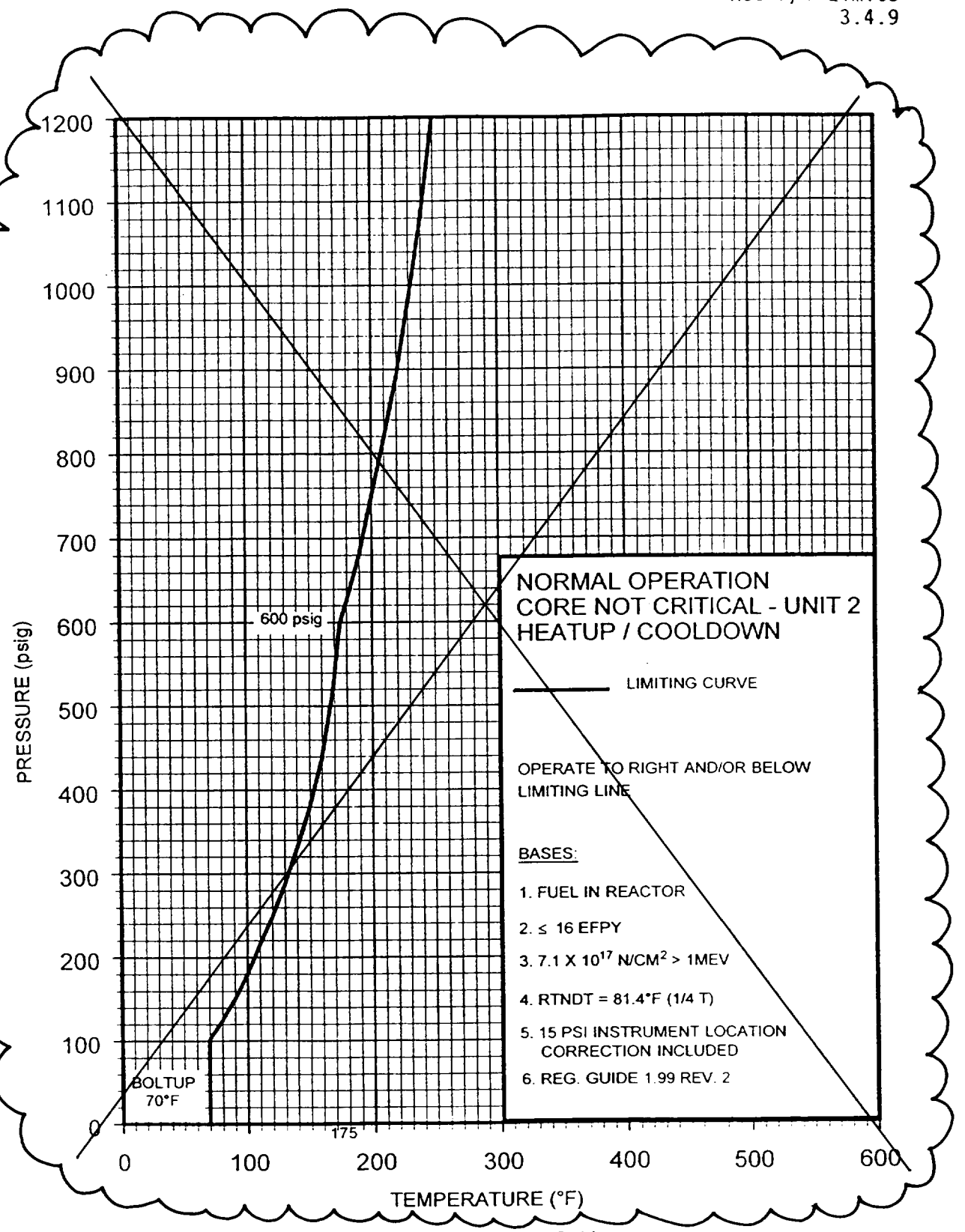

Figure 3.4.9-1 (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation with Core Not Critical

Replace with revised Figure 3.4.9-2

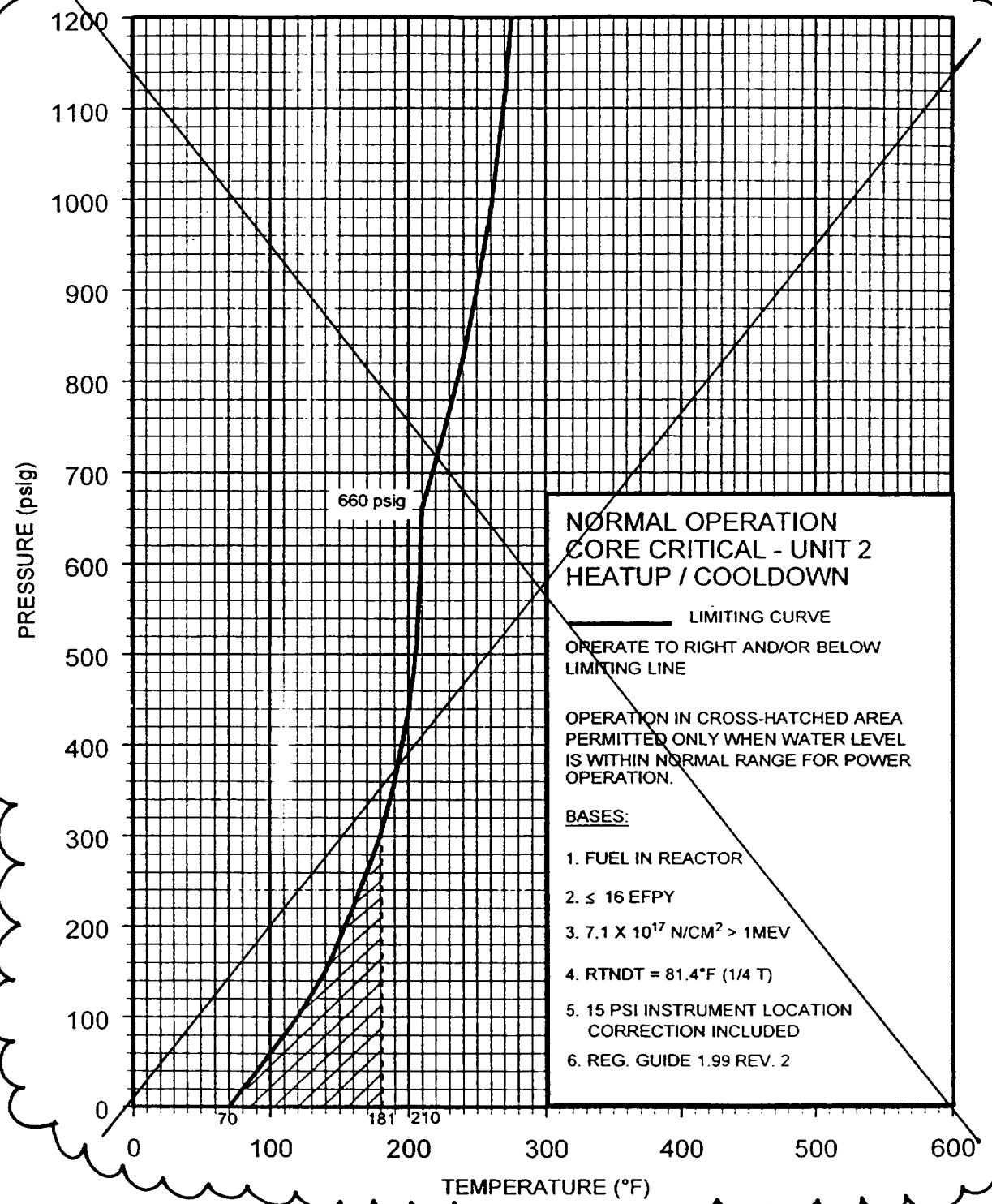

Figure 3.4.9-2 (page 1 of 1)
RCS Pressure and Temperature Limits
Normal Operation with Core Critical

Replace with revised Figure 3.4.9-3

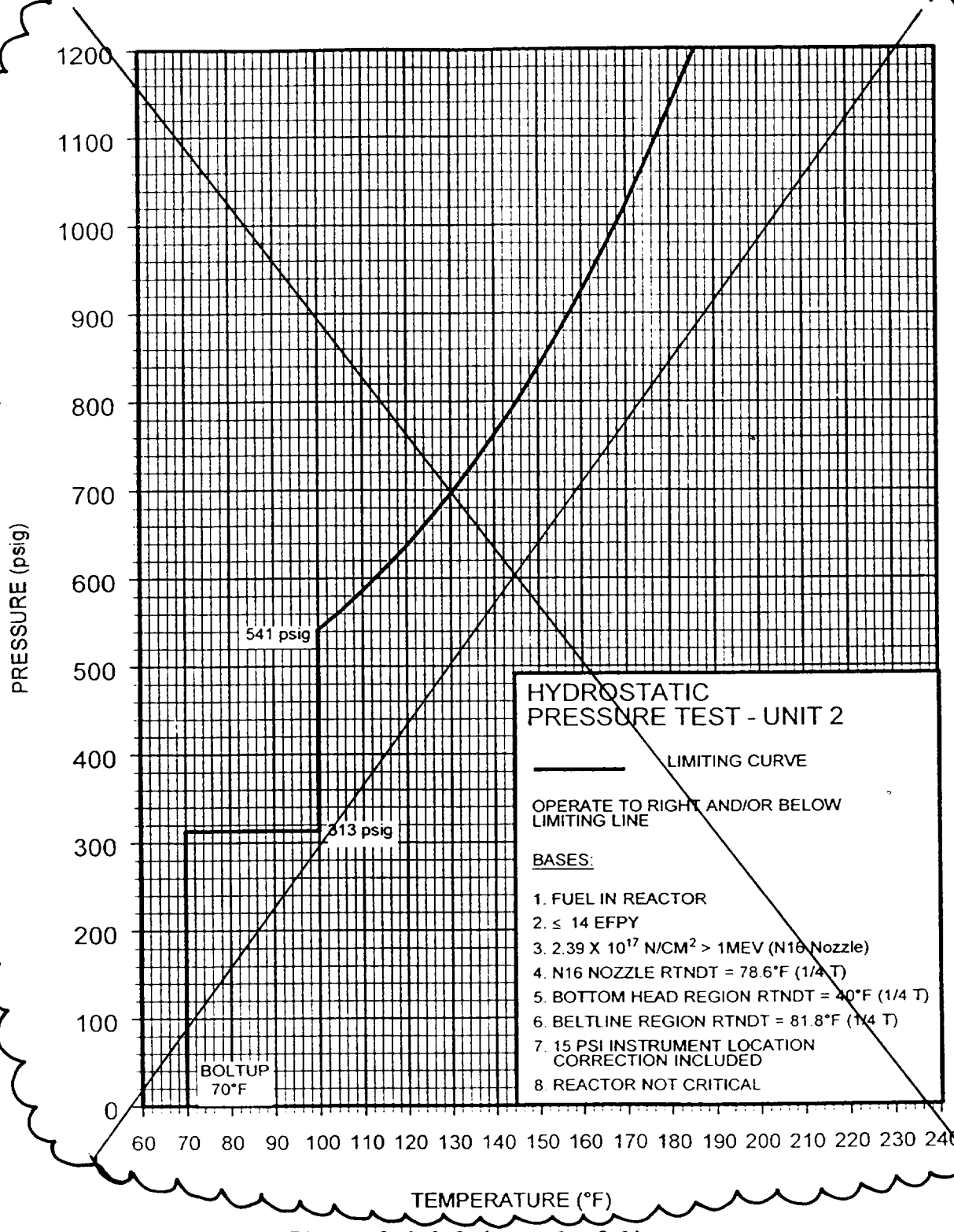

Figure 3.4.9-3 (page 1 of 1)
RCS Pressure and Temperature Limits
Hydrostatic and Leak Tests ~~≤ 14 EFPY~~

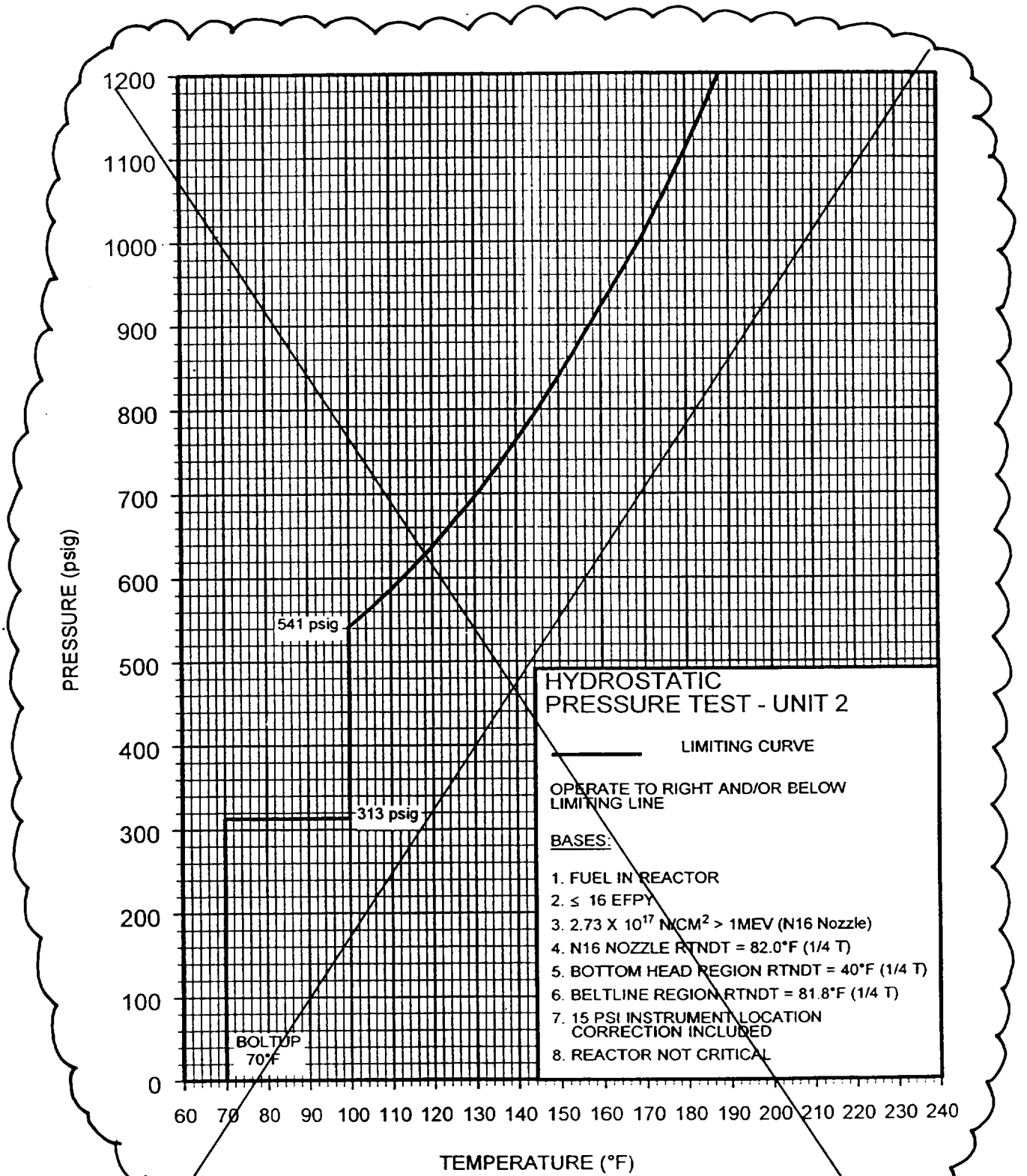

Figure 3.4.9-4 (page 1 of 1)
RCS Pressure and Temperature Limits
Hydrostatic and Leak Tests ≤ 16 EFPY

3.4 REACTOR COOLANT SYSTEM (RCS)

3.4.10 Reactor Steam Dome Pressure

LCO 3.4.10 The reactor steam dome pressure shall be ≤ 1045 psig.

APPLICABILITY: MODES 1 and 2.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Reactor steam dome pressure not within limit.	A.1 Restore reactor steam dome pressure to within limit.	15 minutes
B. Required Action and associated Completion Time not met.	B.1 Be in MODE 3.	12 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 3.4.10.1 Verify reactor steam dome pressure is ≤ 1045 psig.	12 hours

ENCLOSURE 11

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 AND 50-324/LICENSE NOS. DPR-71 AND DPR-62
REQUEST FOR LICENSE AMENDMENTS – CHANGES TO REACTOR PRESSURE VESSEL PRESSURE-TEMPERATURE LIMITS AND REQUEST FOR EXEMPTION FROM 10 CFR 50, APPENDIX G, REQUIREMENTS

Revised Technical Specification Bases Pages - Unit 1

INSERT "A"

The P/T limit curves in this Specification were developed in accordance with the 1989 Edition of the ASME Code, Section XI, Appendix G (Ref. 3). These P/T limit curves were developed using the initiation fracture toughness, KIC, for the allowable material fracture toughness. The use of KIC for development of P/T limit curves has been approved by the ASME through Code Case N-640 (Ref. 4).

INSERT "B"

3. 1989 Edition of the ASME Code, Section XI, Appendix G.
4. ASME Code Case N-640, "Alternative Reference Fracture Toughness for Development of P-T Limit Curves Section XI, Division 1."

INSERT "C"

9. Calculation 0B11-0005, "Development of RPV Pressure-Temperature Curves For BNP Units 1 and 2 For Up To 32 EFPY of Plant Operation," dated November 8, 2000.

B 3.4 REACTOR COOLANT SYSTEM (RCS)

B 3.4.9 RCS Pressure and Temperature (P/T) Limits

BASES

BACKGROUND

All components of the RCS are designed to withstand effects of cyclic loads due to system pressure and temperature changes. These loads are introduced by startup (heatup) and shutdown (cooldown) operations, power transients, and reactor trips. This LCO limits the pressure and temperature changes during RCS heatup and cooldown, within the design assumptions and the stress limits for cyclic operation.

This Specification contains P/T limit curves for heatup, cooldown, and inservice leakage and hydrostatic testing, and data for the maximum rate of change of reactor coolant temperature. The criticality curve provides limits for both heatup and cooldown during criticality.

Each P/T limit curve defines an acceptable region for normal operation. The usual use of the curves is operational guidance during heatup or cooldown maneuvering, when pressure and temperature indications are monitored and compared to the applicable curve to determine that operation is within the allowable region.

The LCO establishes operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). The vessel (including its appurtenances) is the component most subject to brittle failure. Therefore, the LCO limits apply mainly to the vessel (including its appurtenances).

10 CFR 50, Appendix G (Ref. 1), requires the establishment of P/T limits for material fracture toughness requirements of the RCPB materials. Reference 1 requires an adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. It mandates the use of the ASME Code, Section III, Appendix G (Ref. 2).

INSERT "A"

The actual shift in the RT_{NDT} of the vessel material will be established periodically by removing and evaluating the irradiated reactor vessel material specimens, in accordance with the UFSAR (Ref. 4) and Appendix H of 10 CFR 50

5

(continued)

BASES

BACKGROUND (continued)

(Ref. 6). The operating P/T limit curves will be adjusted, as necessary, based on the evaluation findings and the recommendations of Reference 7.

The P/T limit curves are composite curves established by superimposing limits derived from stress analyses of those portions of the reactor vessel and head that are the most restrictive. At any specific pressure, temperature, and temperature rate of change, one location within the reactor vessel will dictate the most restrictive limit. Across the span of the P/T limit curves, different locations are more restrictive, and, thus, the curves are composites of the most restrictive regions.

The heatup curve represents a different set of restrictions than the cooldown curve because the directions of the thermal gradients through the vessel wall are reversed. The thermal gradient reversal alters the location of the tensile stress between the outer and inner walls.

The criticality limits include the Reference 1 requirement that they be at least 40°F above the noncritical heatup curve or the cooldown curve and not lower than the minimum permissible temperature for the inservice leakage and hydrostatic testing.

The consequence of violating the LCO limits is that the RCS has been operated under conditions that can result in brittle failure of the RCPB, possibly leading to a nonisolable leak or loss of coolant accident. In the event these limits are exceeded, an evaluation must be performed to determine the effect on the structural integrity of the RCPB components. ASME Code, Section XI, Appendix E (Ref. 8), provides a recommended methodology for evaluating an operating event that causes an excursion outside the limits.

APPLICABLE SAFETY ANALYSES

The P/T limits are not derived from Design Basis Accident (DBA) analyses. They are prescribed during normal operation to avoid encountering pressure, temperature, and temperature rate of change conditions that might cause undetected flaws to propagate and cause nonductile failure of the RCPB, a condition that is unanalyzed. References 9 and 8 provide the curves and limits in this Specification. Since the P/T limits are not derived from any DBA, there are no acceptance

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)

limits related to the P/T limits. Rather, the P/T limits are acceptance limits themselves since they preclude operation in an unanalyzed condition.

RCS P/T limits satisfy Criterion 2 of 10 CFR 50.36(c)(2)(ii) (Ref. 9). 10

LCO

The elements of this LCO are:

a. RCS pressure and temperature are within the applicable limits specified in Figures 3.4.9-1 and 3.4.9-2, and heatup or cooldown rates are ≤ 100°F in any 1 hour period, during RCS heatup and cooldown;

b. RCS pressure and temperature are within the applicable limits in Figures 3.4.9-3 or 3.4.9-4, and heatup or cooldown rates are ≤ 30°F in any 1 hour period, during RCS inservice leak and hydrostatic testing;

c. The temperature difference between the reactor vessel bottom head coolant and the reactor pressure vessel (RPV) coolant is ≤ 145°F during recirculation pump startup;

d. The temperature difference between the reactor coolant in the respective recirculation loop and in the reactor vessel is ≤ 50°F during recirculation pump startup;

e. RCS pressure and temperature are within the criticality limits specified in Figure 3.4.9-2, prior to achieving criticality; and

f. The reactor vessel flange and the head flange temperatures are ≥ 70°F when tensioning the reactor vessel head bolting studs.

These limits define allowable operating regions and permit a large number of operating cycles while also providing a wide margin to nonductile failure.

The rate of change of temperature limits control the thermal gradient through the vessel wall and are used as inputs for calculating the heatup, cooldown, and inservice leakage and

(continued)

BASES

LCO (continued)

hydrostatic testing P/T limit curves. Thus, the LCO for the rate of change of temperature restricts stresses caused by thermal gradients and also ensures the validity of the P/T limit curves.

Violation of the limits places the reactor vessel outside of the bounds of the stress analyses and can increase stresses in other RCS components. The consequences depend on several factors, as follows:

a. The severity of the departure from the allowable operating pressure temperature regime or the severity of the rate of change of temperature;

b. The length of time the limits were violated (longer violations allow the temperature gradient in the thick vessel walls to become more pronounced); and

c. The existences, sizes, and orientations of flaws in the vessel material.

APPLICABILITY

The potential for violating a P/T limit exists at all times. For example, P/T limit violations could result from ambient temperature conditions that result in the reactor vessel metal temperature being less than the minimum allowed temperature for boltup. Therefore, this LCO is applicable even when fuel is not loaded in the core.

ACTIONS

A.1 and A.2

Operation outside the P/T limits while in MODES 1, 2, and 3 must be corrected so that the RCPB is returned to a condition that has been verified as safe by stress analyses.

The 30 minute Completion Time reflects the urgency of restoring the parameters to within the analyzed range. Most violations will not be severe, and the activity can be accomplished in this time in a controlled manner.

Besides restoring operation within acceptable limits, an engineering evaluation is required to determine if RCS operation can continue. This engineering evaluation will determine the effect of the P/T limit violation on the fracture toughness properties of the RCS. The evaluation

(continued)

BASES

ACTIONS

A.1 and A.2 (continued)

must verify the RCPB integrity remains acceptable and must be completed if continued operation is desired. Several methods may be used, including comparison with pre-analyzed transients in the stress analyses, new analyses, or inspection of the components.

ASME Code, Section XI, Appendix E (Ref. 8), may be used to support the evaluation. However, its use is restricted to evaluation of the vessel beltline.

The 72 hour Completion Time is reasonable to accomplish the evaluation of a mild violation. More severe violations may require special, event specific stress analyses or inspections. A favorable evaluation must be completed if continued operation is desired.

Condition A is modified by a Note requiring Required Action A.2 be completed whenever the Condition is entered. The Note emphasizes the need to perform the evaluation of the effects of the excursion outside the allowable limits. Restoration alone per Required Action A.1 is insufficient because higher than analyzed stresses may have occurred and may have affected the RCPB integrity.

B.1 and B.2

If a Required Action and associated Completion Time of Condition A are not met, the plant must be placed in a lower MODE because either the RCS remained in an unacceptable P/T region for an extended period of increased stress, or a sufficiently severe event caused entry into an unacceptable region. Either possibility indicates a need for more careful examination of the event, best accomplished with the RCS at reduced pressure and temperature. With the reduced pressure and temperature conditions, the possibility of propagation of undetected flaws is decreased.

Pressure and temperature are reduced by placing the plant in at least MODE 3 within 12 hours and in MODE 4 within 36 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

(continued)

BASES

ACTIONS (continued)

C.1 and C.2

Operation outside the P/T limits in other than MODES 1, 2, and 3 (including defueled conditions) must be corrected so that the RCPB is returned to a condition that has been verified as safe by stress analyses. The Required Action must be initiated without delay and continued until the limits are restored. With the applicable limits of Figure 3.4.9-3 or 3.4.9-4 exceeded during inservice hydrostatic and leak testing operations, the maximum temperature change shall be limited to 10°F in any 1 hour period during restoration of the P/T limit parameters to within limits.

Besides restoring the P/T limit parameters to within limits, an engineering evaluation is required to determine if RCS operation is allowed. This engineering evaluation will determine the effect of the P/T limit violation on the fracture toughness properties of the RCS. This evaluation must verify that the RCPB integrity is acceptable and must be completed before approaching criticality or heating up to > 212°F. Several methods may be used, including comparison with pre-analyzed transients, new analyses, or inspection of the components. ASME Code, Section XI, Appendix E (Ref. 8), may be used to support the evaluation; however, its use is restricted to evaluation of the beltline.

Condition C is modified by a Note requiring Required Action C.2 to be completed whenever the Condition is entered. The Note emphasizes the need to perform the evaluation of the effects of the excursion outside the allowable limits. Restoration alone per Required Action C.1 is insufficient because higher than analyzed stresses may have occurred and may have affected the RCPB integrity.

SURVEILLANCE REQUIREMENTS

SR 3.4.9.1 and SR 3.4.9.2

Verification that operation is within limits is required every 30 minutes when RCS pressure and temperature conditions are undergoing planned changes. This Frequency is considered reasonable in view of the control room indication available to monitor RCS status. Also, since temperature rate of change limits are specified in hourly increments, 30 minutes permits a reasonable time for assessment and correction of minor deviations.

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.4.9.1 and SR 3.4.9.2 (continued)

Surveillance for heatup, cooldown, or inservice leakage and hydrostatic testing may be discontinued when the criteria given in the relevant plant procedure for ending the activity are satisfied.

SR 3.4.9.1 is modified by a Note that requires the Surveillance to be performed only during system heatup and cooldown operations. SR 3.4.9.2 is modified by a Note that requires the Surveillance to be performed only during inservice leakage and hydrostatic testing.

SR 3.4.9.3

A separate limit is used when the reactor is approaching criticality. Consequently, the RCS pressure and temperature must be verified within the appropriate limits before withdrawing control rods that will make the reactor critical.

Performing the Surveillance within 15 minutes before control rod withdrawal for the purpose of achieving criticality provides adequate assurance that the limits will not be exceeded between the time of the Surveillance and the time of the control rod withdrawal.

SR 3.4.9.4 and SR 3.4.9.5

Differential temperatures within the applicable limits ensure that thermal stresses resulting from the startup of an idle recirculation pump will not exceed design allowances.

Performing the Surveillance within 30 minutes before starting the idle recirculation pump provides adequate assurance that the limits will not be exceeded between the time of the Surveillance and the time of the idle pump start.

An acceptable means of demonstrating compliance with the differential temperature requirement of SR 3.4.9.4 is to compare the temperature of the reactor coolant in the dome to the bottom head drain temperature.

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.4.9.4 and SR 3.4.9.5 (continued)

As specified in procedures, an acceptable means of demonstrating compliance with the temperature differential requirement in SR 3.4.9.5 is to compare the temperatures of the operating recirculation loop and the idle loop.

SR 3.4.9.4 and SR 3.4.9.5 are modified by a Note that requires the Surveillance to be met only in MODES 1, 2, 3, and 4. In MODE 5, the overall stress on limiting components is lower. Therefore, ΔT limits are not required. The Note also states the SR is only required to be met during recirculation pump startup, since this is when the stresses occur.

SR 3.4.9.6, SR 3.4.9.7, and SR 3.4.9.8

Limits on the reactor vessel flange and head flange temperatures are generally bounded by the other P/T limits during system heatup and cooldown. However, operations approaching MODE 4 from MODE 5 and in MODE 4 with RCS temperature less than or equal to certain specified values require assurance that these temperatures meet the LCO limits.

The flange temperatures must be verified to be above the limits 30 minutes before and while tensioning the vessel head bolting studs to ensure that once the head is tensioned the limits are satisfied. When in MODE 4 with RCS temperature $\leq$ 80°F, 30 minute checks of the flange temperatures are required because of the reduced margin to the limits. When in MODE 4 with RCS temperature $\leq$ 100°F, monitoring of the flange temperature is required every 12 hours to ensure the temperature is within the specified limits.

The 30 minute Frequency reflects the urgency of maintaining the temperatures within limits, and also limits the time that the temperature limits could be exceeded. The 12 hour Frequency is reasonable based on the rate of temperature change possible at these temperatures.

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.4.9.6, SR 3.4.9.7, and SR 3.4.9.8 (continued)

SR 3.4.9.6 is modified by a Note that requires the Surveillance to be performed only when tensioning the reactor vessel head bolting studs. SR 3.4.9.7 is modified by a Note that requires the Surveillance to be initiated 30 minutes after RCS temperature is ≤ 80°F in MODE 4. SR 3.4.9.8 is modified by a Note that requires the Surveillance to be initiated 12 hours after RCS temperature is ≤ 100°F in MODE 4. The Notes contained in these SRs are necessary to specify when the reactor vessel flange and head flange temperatures are required to be verified to be within the specified limits.

REFERENCES

1. 10 CFR 50, Appendix G.

2. ASME, Boiler and Pressure Vessel Code, Section III, Appendix G.

INSERT "B"

5. ~~3.~~ UFSAR, Section 5.3.1.6 and Appendix 5.3B.

6. ~~4.~~ 10 CFR 50, Appendix H.

7. ~~5.~~ Regulatory Guide 1.99, Revision 2, May 1988.

8. ~~6.~~ ASME, Boiler and Pressure Vessel Code, Section XI, Appendix E.

~~7. N.B. Lee (NRC) letter to L.W. Eury (CP&L), Amendment No. 140 to Facility Operating License No. DPR-71 and Amendment No. 172 to Facility Operating License No. DPR-62 - Brunswick Steam Electric Plant, Units 1 and 2, Regarding Staff Review of Pressure/Temperature Limits, dated February 15, 1990.~~

INSERT "C"

~~8. Calculation CPL-42Q-302, Brunswick Units 1 and 2 Hydro Test P-T Curve Development, Revision 1, dated August 22, 1996.~~

10. ~~9.~~ 10 CFR 50.36(c)(2)(ii).