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OCT 05 2005

U. S. Nuclear Regulatory Commission
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Mail Stop OP1-17
Washington, DC 20555

**SUSQUEHANNA STEAM ELECTRIC STATION
PROPOSED AMENDMENT NO. 280 TO UNIT 1
FACILITY OPERATING LICENSE NPF-14 AND
PROPOSED AMENDMENT NO. 249 TO UNIT 2
FACILITY OPERATING LICENSE NPF-22: REVISE
TECHNICAL SPECIFICATION 3.4.10 "RCS PRESSURE
AND TEMPERATURE (P/T) LIMITS"
PLA-5933**

**Docket Nos. 50-387
and 50-388**

In accordance with the provisions of 10 CFR 50.90, PPL Susquehanna, LLC is submitting a request for amendment to the Technical Specification 3.4.10 "RCS Pressure and Temperature (P/T) Limits" for Susquehanna SES Unit 1 and Unit 2.

The enclosure to this letter contains PPL's evaluation of these proposed changes. Included are a description of the proposed change, technical analysis of the change, regulatory analysis of the change (No Significant Hazards Consideration and the Applicable Regulatory Requirements), and the environmental considerations associated with the change.

Attachment 1 to this letter contains the applicable pages of the Susquehanna SES Unit 1 and Unit 2 Technical Specifications (TS), marked to show the proposed changes. Attachment 2 contains changes to the Technical Specification Bases (TSB) required as a result of the proposed TS changes.

Attachment 3 provides the detailed technical analysis used to develop the revised P/T limits curves for Susquehanna SES Units 1 and 2.

There are no regulatory commitments associated with these proposed Amendments which have been reviewed by the Susquehanna SES Plant Operations Review Committee and the Susquehanna Review Committee. PPL requests the NRC complete its review of the proposed changes by March 31, 2006, with the changes becoming effective within 30-days of NRC approval.

A001

Any questions regarding this request should be directed to Mr. Duane L. Filchner at (610) 774-7819.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on: 10-5-05

B. T. McKinney

Enclosure: PPL Susquehanna Evaluation of the Proposed Changes

Attachments:

Attachment 1 - Proposed Technical Specification Changes (Mark-ups)
Attachment 2 - Proposed Technical Specification Bases Changes (Mark-ups)
Attachment 3 – Structural Integrity Associates, Inc. Revised P/T Curves for SSES

cc: NRC Region I
Mr. B. A. Bickett, NRC Sr. Resident Inspector
Mr. R. V. Guzman, NRC Project Manager
Mr. R. Janati, DEP/BRP

ENCLOSURE TO PLA-5933

PPL SUSQUEHANNA EVALUATION OF PROPOSED CHANGE

UNIT 1 AND UNIT 2 CHANGES TO TECHNICAL SPECIFICATION 3.4.10

PPL EVALUATION

Subject: UNIT 1 AND UNIT 2 CHANGE TO TECHNICAL SPECIFICATION 3.4.10

1.0 DESCRIPTION

In accordance with 10 CFR 50.90, this is a request to amend Facility Operating License Nos. NPF-14 and NPF-22 for PPL Susquehanna, LLC (PPL), Susquehanna Steam Electric Station (SSES) Unit 1 and Unit 2. The proposed changes are to the SSES Technical Specification (TS) 3.4.10 "RCS Pressure and Temperature (P/T) Limits," which are revisions to the P/T Limits curves. The primary effect of the revision is to establish new limits on use of the P/T curves to 35.7 Effective Full Power Years (EFPY) for SSES Unit 1 and 30.2 EFPY for SSES Unit 2.

The calculations for the revised curves include a previously implemented power level increase from 3293 MWT to 3441 MWT, a feedwater instrument upgrade that increased power level from 3441 MWT to 3489 MWT, and a future power level uprate from 3441 MWT to 3952 MWT. The future increase is due to implementation of extended power uprate (EPU), for both SSES Unit 1 and SSES Unit 2, (See Attachment 3).

The revised P/T Limits curves were developed in accordance with 10 CFR 50 Appendix G, the 1998 Edition (2000 Addenda) of ASME Code, Section XI, Appendix G and are based in part on fluence calculations performed using the NRC approved BWRVIP RAMA Code methodology, (Reference 7.1). The RAMA Code methodology meets the intent of Regulatory Guide 1.190, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence."

The existing P/T Limits curves, in TS 3.4.10, were approved in Amendment Nos. 200 and 197 of Facility Operating License Nos. NPF-14 and NPF-22 for PPL SSES, Units 1 and 2, for use until May 1, 2006. Therefore, PPL requests approval of these proposed changes no later than March 31, 2006.

2.0 PROPOSED CHANGES

The proposed changes are to TS Figures 3.4.10-1, 3.4.10-2, and 3.4.10-3, which show the P/T limits curves for inservice leakage and hydrostatic testing, non-nuclear heatup and cooldown, and criticality, respectively.

The proposed P/T limit curves are valid for 35.7 EFPY for SSES Unit 1 and 30.2 EFPY for SSES Unit 2. The plotted values of the proposed curves have been developed to be identical to the plotted values on the present curves, contained in NRC approved Amendments 200 and 197 for Unit 1 and Unit 2 respectively. Only the limit on the validity of the curves has changed. This change in validity is due to using new BWRVIP RAMA Code (Reference 1) fluence calculation methodology recently approved by the NRC. The new fluence calculations also incorporate the proposed EPU power level of 3952 MWT.

The EPU fuel core configuration used for the fluence calculation is a proposed design that assures extended power rating for a full 24 months. The fuel vendor created this design to show that it is possible to run at EPU power for a full cycle. This proposed fuel load design provided for very conservative results for the fluence calculation method. The dates for the application of EPU used for the fluence calculation are starting in 2007 for Unit 2 and 2008 for Unit 1. These are the anticipated dates for initiation of EPU.

The marked-up TS pages are provided in Attachment 1 to this submittal. Attachment 2 contains marked-up TS Bases pages as a result of the TS changes.

3.0 BACKGROUND

On July 17, 2001, PPL submitted a license amendment request to update the P/T limit curves for SSES Unit 1 and SSES Unit 2 (Reference 7.2). The validity of the curves was established through May 1, 2006 for Unit 1 and May 1, 2005 for Unit 2. These curves were approved for use on February 7, 2002 as amendments 200 and 174 for SSES Unit 1 and SSES Unit 2 (Reference 7.3).

The validity date of the Unit 2 P/T limit curves was subsequently changed to May 1, 2006 by approved Unit 2 Amendment 197, dated April 25, 2005 (Reference 7.4).

The basis for NRC approval of the above license amendment requests was the conservatism in the estimated vessel irradiation at the end of life and at the end of the curve's valid period on May 1, 2006.

Since the existing Unit 1 and Unit 2 P/T Limit curves will be no longer valid after May 1, 2006, it is necessary to recalculate the curves and establish their validity. The curves have been recalculated using the RAMA code for evaluation of the neutron flux through the core, vessel internals, and vessel geometry. Use of the RAMA code is acceptable based on NRC approval on May 13, 2005. (Reference 7.1)

3.0 TECHNICAL SAFETY ANALYSIS OF THE PROPOSED CHANGES

The P/T limits curves 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 reactor coolant pressure boundary, a condition that is unanalyzed. The operating limits for pressure and temperature are required for three categories of operation: (a) hydrostatic pressure tests and leak tests, referred to as Curve A; (b) non-nuclear heatup/cooldown and low-level physics tests, referred to as Curve B; (c) core critical operations, referred to as Curve C.

The methodology used to develop P/T curves is described in Attachment 2. There are three regions of the RPV that are evaluated: (1) the beltline region, (2) the bottom head region, and (3) the feedwater nozzle/upper vessel region. These regions bound all other regions with respect to brittle fracture. The method of generating the curves is primarily the same for each region for both Curves A and B. The exception is the method used to create the upper vessel/feedwater region Curve B.

All components in the Reactor Coolant System (RCS) are designed to withstand the effects of cyclic loads due to system temperature and pressure changes. Normal load transients, reactor trips, and startup and shutdown operations introduce these cyclic loads. During startup and shutdown, the rates of temperature and pressure changes are limited so that the maximum specified heatup and cool down rate are consistent with the design assumptions and satisfy the stress limits for cyclic operation.

The heatup and cooldown process for SSES Unit 1 and SSES Unit 2 is controlled by P/T limit curves, which are developed based on fracture mechanics analysis. These limits are developed according to Appendix G of the ASME Boiler and Pressure Vessel Code, Section XI, and incorporate a number of safety margins.

The present SSES Unit 1 and SSES Unit 2 Technical Specification Figures 3.4.10 –1, 3.4.10-2, and 3.4.10-3 represent the reactor pressure vs. minimum vessel temperature limits. The three curves (A, B, and C) are based on 10 CFR 50 Appendix G requirements of the ASME Boiler and Pressure Vessel Code, Section XI, and incorporate a number of safety margins.

As stated in the Background Section above, the applicability of the present curves is limited to May 1, 2006. This date was established due to the calculation methodology used to determine neutron fluence. The proposed change to the P/T curves establishes the applicability of the Unit 2 curves at 30.2 EFPY, and the applicability of the Unit 1 curves at 35.7 EFPY. It is estimated that on 5/1/2006 the actual exposure will be 19.01 EFPY for Unit 1 and 18.68 EFPY for Unit 2.

New fluence calculations were performed for the proposed curves utilizing the RAMA Code, and the impacts of EPU from 3489 MWT to 3952 MWT have been included. The plotted values of the proposed curves were developed to be identical to the plotted values of the currently approved curves in order to avoid changing the associated administrative procedures and to reduce the potential for human error. The effect of maintaining the curves identical is that the EFPY restriction on use has been recalculated to be 35.7 EFPY for Unit 1 and 30.2 EFPY for Unit 2.

5.0 REGULATORY SAFETY ANALYSIS

5.1 No Significant Hazards Consideration

The Commission has provided standards in 10 CFR 50.92(c) for determining whether a significant hazards consideration exists. A proposed amendment to an operating license for a facility involves no significant hazards consideration if operation of the facility in accordance with the proposed amendment would not (1) involve a significant increase in the probability or consequences of an accident previously evaluated; (2) create the possibility of a new or different kind of accident from any accident previously evaluated; or (3) involve a significant reduction in a margin of safety.

PPL proposes changes to Appendix A, Technical Specifications (TS), of Facility Operating License Nos. NPF-14 and NPF-22 for the Susquehanna Steam Electric Station (SSES) Units 1 and 2 respectively.

The proposed changes revise TS Section 3.4.10, "RCS Pressure and Temperature (P/T) Limits," by removing the valid date and replacing it with the Effective Full

Power Years (EFPY) of radiation exposure limit on each of the P/T curves for SSES Units 1 and 2.

In accordance with the criteria set forth in 10 CFR 50.92, PPL has evaluated the proposed TS change and determined it does not represent a significant hazards consideration. The following is provided in support of this conclusion.

1. **Does the proposed change involve a significant increase in the probability or consequences of an accident previously evaluated?**

   No. The proposed changes request that the P/T limits curves in TS 3.4.10, "RCS Pressure and Temperature (P/T) Limits" be revised by removing the valid date and replacing it with the Effective Full Power Years of radiation exposure limit on each of the P/T curves for SSES Units 1 and 2.

   The P/T limits are prescribed during all operational conditions to avoid encountering pressure, temperature, and temperature rate of change conditions that might cause undetected flaws to propagate, resulting in nonductile failure of the reactor coolant pressure boundary, an unanalyzed condition. Therefore, the proposed changes do not have any effect on the probability of an accident previously evaluated.

   The P/T curves are used as operational limits 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 P/T curves provide assurance that station operation is consistent with previously evaluated accidents. Thus, the radiological consequences of an accident previously evaluated are not increased.

   Therefore, the proposed changes do not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. **Does the proposed change create the possibility of a new or different kind of accident from any accident previously evaluated?**

   No. The proposed changes do not change the response of any plant equipment to transient conditions. The proposed changes do not introduce any new equipment, modes of system operation, or failure mechanisms.

   Therefore, there are no new types of failures or new or different kinds of accidents or transients that could be created by these changes. The

proposed changes do not create the possibility of a new or different kind of accident from any accident previously evaluated.

3. **Does the proposed change involve a significant reduction in a margin of safety?**

   No. The consequences of a previously evaluated accident are not increased by these proposed changes, since the Loss of Coolant Accident analyzed in the FSAR assumes a complete break of the reactor coolant pressure boundary. The changes to the P/T limits curves do not change this assumption.

   Therefore, the proposed changes do not involve a significant reduction in a margin of safety.

Conclusion:

Based upon the above responses, PPL concludes that the proposed amendment presents no significant hazards consideration under the standards set forth in 10 CFR 50.92(c), "Issuance of Amendment," and, accordingly, a finding of no significant hazards consideration is justified.

5.2 Applicable Regulatory Requirements/Criteria

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 reactor coolant pressure boundary, a condition that is unanalyzed. Therefore, the P/T limits curves must be included in the Technical Specifications in accordance with 10 CFR 50.36(c)(2)(ii), "Limiting Conditions for Operation."

The proposed P/T curves, and the methodology used to develop them, comply with the requirements for monitoring fracture toughness, minimum temperature, and performing material surveillances in accordance with 10 CFR 50 Appendix G, "Fracture Toughness Requirements, and the 1998 Edition (2000 Addenda) of ASME Code, Section XI, Appendix G."

6.0 ENVIRONMENTAL CONSIDERATION

10 CFR 51.22(c)(9) identifies certain licensing and regulatory actions, which are eligible for categorical exclusion from the requirement to perform an environmental assessment. A proposed amendment to an operating license for a facility does not require an environmental assessment if operation of the facility in accordance with the proposed amendment would not (1) involve a significant hazards consideration; (2) result in a significant change in the types or significant increase in the amounts of any effluents that may be released offsite; or (3) result in a significant increase in individual or cumulative occupational radiation exposure. PPL has evaluated the proposed change and has determined that the proposed change meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Accordingly, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment needs to be prepared in connection with issuance of the amendment. This determination, using the above criteria, is:

0. As demonstrated in the No Significant Hazards Consideration Evaluation, the proposed amendment does not involve a significant hazards consideration.

0. There is no significant change in the types or significant increase in the amounts of any effluents that may be released offsite. The proposed change does not involve any physical alteration of the plant (no new or different type of equipment will be permanently installed) or change in methods governing normal plant operation.

3. There is no significant increase in individual or cumulative occupational radiation exposure. The proposed change does not involve any physical alteration of the plant (no new or different type of equipment will be permanently installed) or change in methods governing normal plant operation.

6.0 REFERENCES

7.1 Letter from U.S. NRC to Bill Eaton (BWRVIP) Chairman Entergy Operations - Safety Evaluation of Proprietary EPRI Reports: "BWR Vessel and Internals Project, RAMA Fluence Methodology Manual (BWRVIP-114); RAMA Fluence Methodology Benchmark Manual Evaluation of Regulatory Guide 1.190 Benchmark Problems (BWRVIP-115); RAMA Fluence Methodology – Susquehanna Unit 2 Surveillance Capsule Fluence Evaluation for Cycles 1-5 (BWRVIP-117); RAMA Fluence Methodology Procedures Manual (BWRVIP-121); and Hope Creek Flux Wire Dosimeter

Activation Evaluation for Cycle 1 (TWE-PSE-001-R-001) (TAC NO. MB9765)," dated May 13, 2005.

6.1 PLA-5341, letter from R. G. Byram (PPL) to U.S. NRC, "Proposed Amendment No. 240 to License NFP-14 and Proposed Amendment No. 205 to License NFP-22: Changes to Reactor Pressure Vessel Pressure-Temperature (P-T) Limits and Request for Exemption from the Requirements of 10CFR50 Section 50.50(a)," dated July 17, 2001.

6.1 Letter from U.S. NRC to R. G. Byram, "Susquehanna Steam Electric Station, Units 1 and 2 – Issuance of Amendment Re: Reactor Pressure Vessel Pressure-Temperature Limit Curves (TAC NOS. MB2516 and MB2518)," dated February 7, 2002.

6.1 Letter from U.S. NRC to B. L. Shriver, "Susquehanna Steam Electric Station, Unit 2 – Issuance of Amendment Regarding Reactor Pressure Vessel Pressure-Temperature Limits (TAC NO. MC4534)," dated April 25, 2005.

Attachment 1 to PLA-5933

Proposed Technical Specification Changes (Markups)

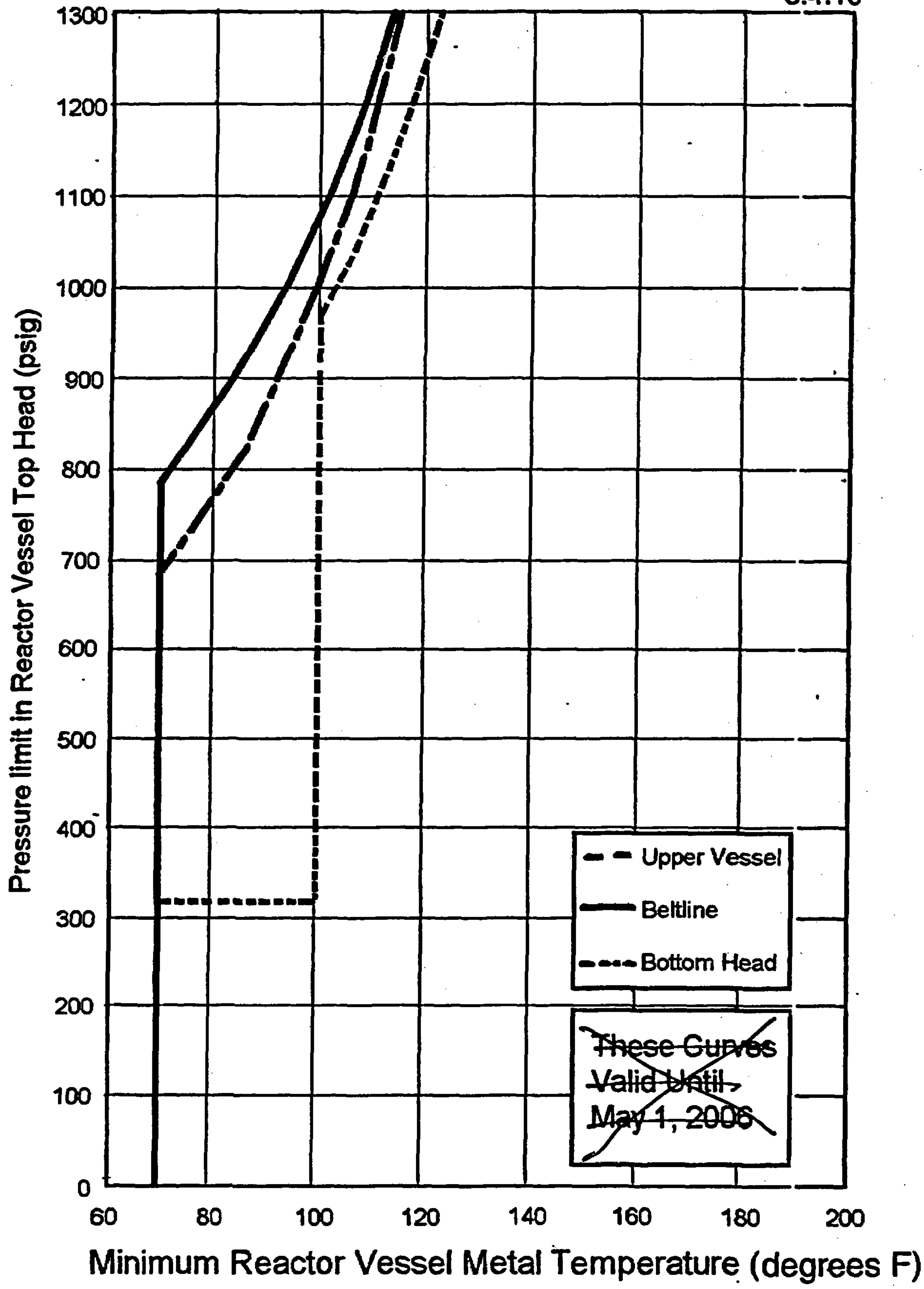

FIGURE 3.4.10-1
System Hydrotest Limit with Fuel in Vessel (Curve A)
for 35.7 EFPY

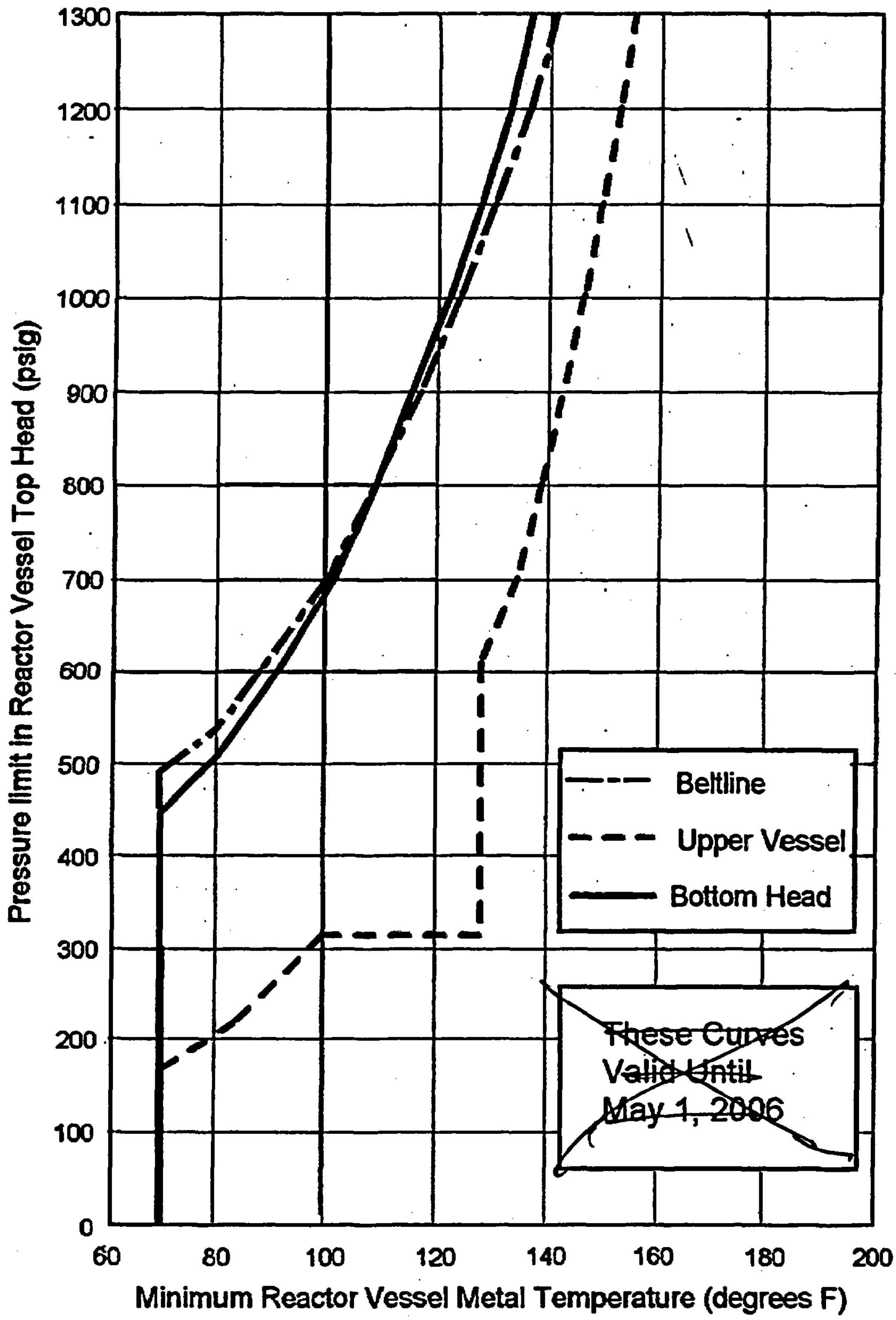

Figure 3.4.10-2
Non-Nuclear Heating Limit (Curve B)
for 35.7 EFPY

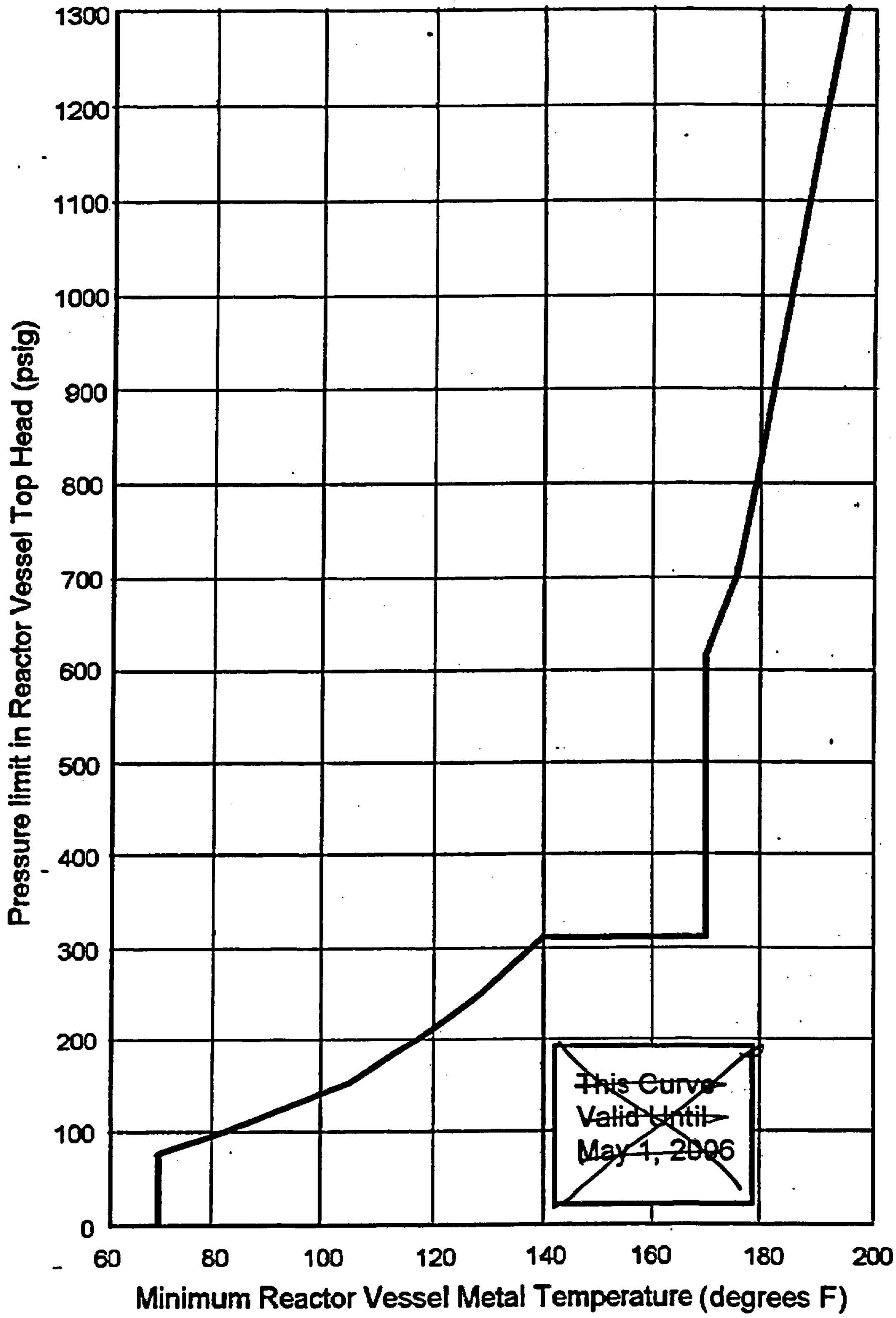

Figure 3.4.10-3
Nuclear (Core Critical) Limit (Curve C)
for 35.7 EFPY

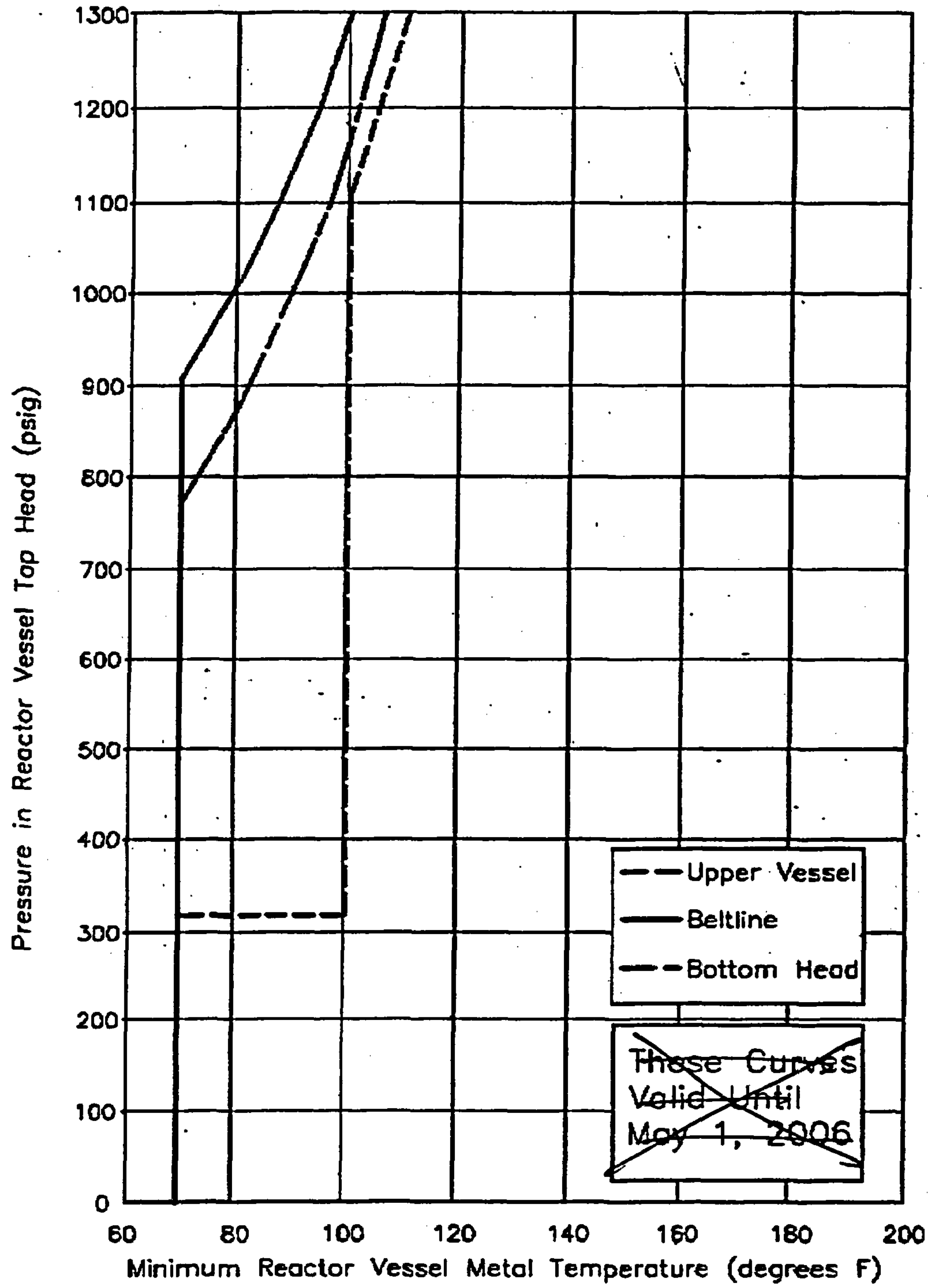

Figure 3.4.10-1
System Hydrotest Limit with Fuel in Vessel (Curve A)
for 30.2 EFPY

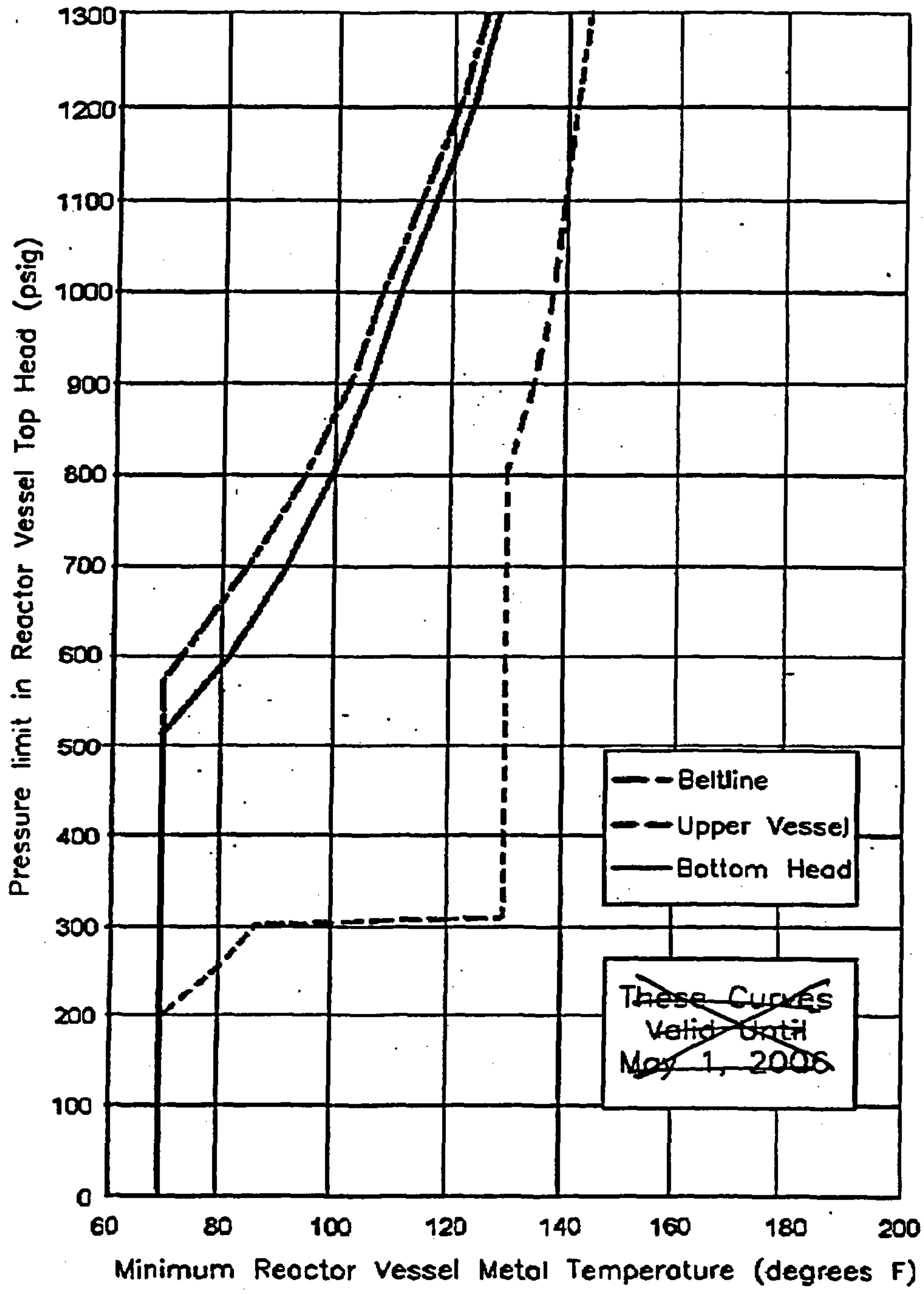

Figure 3.4.10-2
Non-Nuclear Heating Limit (Curve B)
for 30.2 EFPY

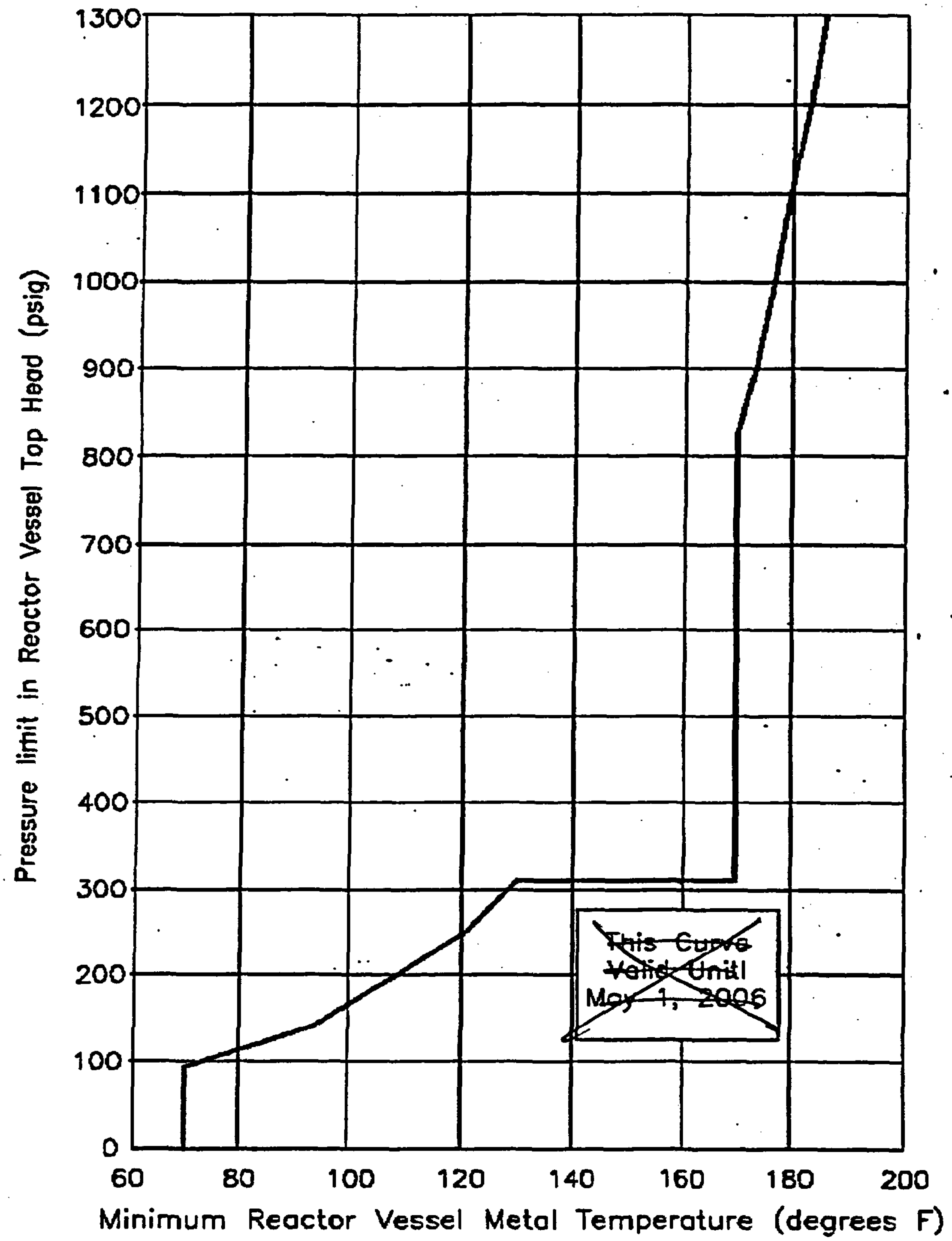

FIGURE 3.4.10-3
Nuclear (Core Critical) Limit (Curve C)
for 30.2 EFPY

Attachment 2 to PLA-5933

Proposed Technical Specification Bases Changes (Markups)

B 3.4 — REACTOR COOLANT SYSTEM (RCS)

B 3.4.10 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 limits for the maximum rate of change of reactor coolant temperature. The heatup curve provides limits for both heatup and 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 is the component most subject to brittle failure. Therefore, the LCO limits apply mainly to the vessel.

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 XI, Appendix G (Ref. 2).

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 ASTM E 185 (Ref. 3) and Appendix H of 10 CFR 50 (Ref. 4). The operating P/T limit curves will be adjusted, as necessary, based on the evaluation findings and the recommendations of ~~Reference 5.~~ RG. 1.99, "Radiation Embrittlement of Reactor Vessel Materials." (Ref 5). The calculations to determine neutron fluence will be developed using the BWRVIP RAMA Code methodology, which is NRC approved and meets the intent of RG. 1.190, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence." (Ref 11). See FSAR Section 4.1.4.5, for determining fluence. (Ref. 12)

(continued)

BASES

BACKGROUND (continued)

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 used to develop the P/T limit curve composite represents a different set of restrictions than the cooldown curve used to develop the P/T limit curve composite 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 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. 6), 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. Reference 7 establishes the methodology for determining the P/T limits. Since the P/T limits are not derived from any DBA, there are no acceptance 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 the NRC Policy Statement (Ref. 8).

The effective full power years (EFPY) shown on the curves are approximations of the ratio of the energy that has been and is anticipated to be generated in a year to the energy that could have been generated if the unit ran at original thermal power rating of 3293 MWT for the entire year. These values are based on fluence limits that are not to be exceeded.

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.4.10.7, SR 3.4.10.8, and SR 3.4.10.9 (continued)

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 ≤ 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 ≤ 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.

REFERENCES

1. 10 CFR 50, Appendix G.
2. ASME, Boiler and Pressure Vessel Code, Section XI, Appendix G.
3. ASTM E 185-73
4. 10 CFR 50, Appendix H.
5. Regulatory Guide 1.99, Revision 2, May 1988.
6. ASME, Boiler and Pressure Vessel Code, Section XI, Appendix E.
7. NEDO-21778-A, December 1978.
8. Final Policy Statement on Technical Specifications Improvements, July 22, 1993 (58 FR 39132).
9. PPL Calculation EC-062-0573, "Study to Support the Bases Section of Technical Specification 3.4.10."
10. FSAR, Section 15.4.4.
11. Regulatory Guide 1.190, March 2001
12. FSAR, Section 4.1.4.5

B 3.4 -- REACTOR COOLANT SYSTEM (RCS)

B 3.4.10 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 limits for the maximum rate of change of reactor coolant temperature. The heatup curve provides limits for both heatup and 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 is the component most subject to brittle failure. Therefore, the LCO limits apply mainly to the vessel.

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 XI, Appendix G (Ref. 2).

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 ASTM E 185 (Ref. 3) and Appendix H of 10 CFR 50 (Ref. 4). The operating P/T limit curves will be adjusted, as necessary, based on the evaluation findings and the recommendations of ~~Reference 5.~~ RG 1.99 "Radiation Embrittlement of Reactor Vessel Materials (Ref 5.). The calculations to determine neutron fluence will be developed using the BWRVIP RAMA Code methodology, which is NRC approved and meets the intent of RG 1.190, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence." (Ref 11)

(continued)

See FSAR Section 4.1.4.5 for determining fluence. (Ref 12)

BASES

BACKGROUND (continued)

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 used to develop the P/T limit curve composite represents a different set of restrictions than the cooldown curve used to develop the P/T limit curve composite 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 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. 6), provides a recommended methodology for evaluating an operating event that causes an excursion outside the limits.

APPLICABLE SAETY 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. Reference 7 establishes the methodology for determining the P/T limits. Since the P/T limits are not derived from any DBA, there are no acceptance 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 the NRC Policy Statement (Ref. 8).

The effective full power years (EFPY) shown on the curves are approximations of the ratio of the energy that has been and is anticipated to be generated in a year to the energy that could have been generated if the unit ran at original thermal power rating of 3293 MWT for the entire year. These values are based on fluence limits that are not to be exceeded.

(continued)

BASES (continued)

REFERENCES

1. 10 CFR 50, Appendix G.
2. ASME, Boiler and Pressure Vessel Code, Section XI, Appendix G.
3. ASTM E 185-73
4. 10 CFR 50, Appendix H.
5. Regulatory Guide 1.99, Revision 2, May 1988.
6. ASME, Boiler and Pressure Vessel Code, Section XI, Appendix E.
7. NEDO-21778-A, December 1978.
8. Final Policy Statement on Technical Specifications Improvements, July 22, 1993 (58 FR 39132).
9. PPL Calculation EC-062-0573, "Study to Support the Bases Section of Technical Specification 3.4.10."
10. FSAR, Section 15.4.4.
11. Regulatory Guide 1.190, March 2001.
12. FSAR, Section 4.1.4.5

Attachment 3 to PLA-5933

Structural Integrity Associates, Inc. Revised

P/T Curves for SSES

Structural Integrity Associates, Inc.

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GLS-05-016
SIR-00-167, Rev. 1

Mr. Bruce Swoyer
PPL Susquehanna, LLC
Two North Ninth Street
Allentown, PA 18101-1179

Subject: Revised Pressure-Temperature Curves for SSES

Reference: PPL Purchase Order No. 305567-C dated 3/28/2005.

Dear Bruce:

The attachment to this letter documents the revised set of pressure-temperature (P-T) curves developed for Susquehanna Steam Electric Station Units 1 and 2 (SSES-1 and SSES-2), in accordance with Structural Integrity's Quality Assurance Program. 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 35.7 EFPY for SSES-1 and 30.2 EFPY for SSES-2. The curves were developed in accordance with U.S. 10CFR 50 Appendix G, and the 1998 Edition (2000 Addenda) of ASME Code, Section XI, Appendix G.

The inputs, methodology, and results for this effort are summarized in the attachment. The detailed calculations for this work (PPL-21Q-301, Rev. 1 and PPL-21Q-302, Rev. 1) are also attached.

Please don't hesitate to call me if you have any questions.

Prepared By: *Gary L. Stevens*
Gary L. Stevens, P. E.
Senior Associate

Reviewed By: *H L Gustin*
H. L. Gustin, P. E.
Associate

Approved By: *Gary L. Stevens*
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Senior Associate

Attachment
cc: PPL-21Q-106, -301, -302, -401, SSES-19Q-106

ATTACHMENT

REVISED P-T CURVES FOR SUSQUEHANNA UNITS 1 & 2

1.0 Introduction

This attachment documents the revised set of pressure-temperature (P-T) curves developed for the Susquehanna Steam Electric Station Units 1 and 2 (SSES-1 and SSES-2), in accordance with Structural Integrity's Quality Assurance Program. This work includes a full set of updated P-T curves (i.e., pressure test, core not critical, and core critical conditions) for SSES-1 for 35.7 effective full power years (EFPY) and for 30.2 EFPY for SSES-2[1]. The curves were developed using the methodology specified in 10CFR50 Appendix G [4], WRC-175 [5], and the 1998 Edition (2000 Addenda) of ASME Code, Section XI, Appendix G [3].

2.0 ART_{NDT} Values

Adjusted reference temperature (ART_{NDT}) values were developed for the SSES-1 and SSES-2 reactor pressure vessel (RPV) materials in the Reference [6] calculation. The values for a power increase from 3,293 MWT to 3,441 MWT were used in the current analysis.

3.0 P-T Curve Methodology

The P-T curve methodology is based on the requirements of References [3] through [5]. The supporting calculations for the curves are contained in References [1] and [2]. There are three regions of the RPV that are evaluated: (1) the beltline region, (2) the bottom head region, and (3) the feedwater nozzle/upper vessel region. These regions bound all other regions with respect to brittle fracture. The method of generating the curves is primarily the same for each region for both Curves A and B. The exception is the method used to create the upper vessel/feedwater region Curve B. That method will be described separately.

The approach used for the Curve A beltline, bottom head, and upper vessel/feedwater nozzle regions, and the Curve B beltline and bottom head regions, includes the following steps:

a. Assume a fluid temperature, T. The temperature at the assumed flaw tip, $T_{1/4t}$ (i.e., 1/4t into the vessel wall) is determined by adding a temperature drop term, $\Delta T_{1/4t}$, to T. For the SSES evaluation, the temperature drop term was conservatively set to zero.

[1] The ART_{NDT} values used in the P-T curve development include a power increase from 3,293 MWT to 3,441 MWT, a feedwater instrument upgrade that increased power from 3,441 MWT to 3,489 MWT, and a future projected equilibrium power uprate increase to 3,952 MWT, as defined in Table 3-2 of References [7] and [8].

b. Calculate the reference fracture toughness, K_{Ic}, based on $T_{1/4t}$ using the relationship from Appendix G [3], as follows:

$$K_{Ic} = 20.734\, e^{[0.02(T_{1/4t} - ART_{NDT})]} + 33.2$$

where:
- $T_{1/4t}$ = metal temperature at assumed flaw tip (°F)
- ART_{NDT} = adjusted reference temperature for location under consideration and desired EFPY (°F)
- K_{Ic} = reference fracture toughness (ksi√inch)

c. Calculate the thermal stress intensity factor, K_{It} from ASME Code, Section XI, Appendix G [3].

d. Calculate the allowable pressure stress intensity factor, K_{Ip}, using the following relationship:

$$K_{Ip} = (K_{Ic} - K_{It})/SF$$

where:
- K_{Ip} = allowable pressure stress intensity factor (ksi√inch)
- SF = safety factor
  - = 1.5 for pressure test conditions (Curve A)
  - = 2.0 for heatup/cooldown conditions (Curves B and C)

e. Compute the allowable pressure, P, from the allowable pressure stress intensity factor, K_{Ip}. For the bottom head region, a stress concentration factor of 3 is included to account for the bottom head penetrations, consistent with WRC-175 methodology [5] and other BWR P-T curve evaluations.

f. Apply any adjustments for temperature and/or pressure, such as for instrument uncertainty and the static head for the weight of the water in the RPV, to T and P, respectively.

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

The approach used for the Curve B upper vessel/feedwater nozzle region includes the following steps:

a. Assume a pressure, P.

b. Calculate the thermal stress intensity factor, K_{It}, by combining the secondary membrane stress intensity factor, K_{Im} and the secondary bending stress intensity factor, K_{Ib}, per ¶G-2222 of Appendix G [3] and including the correction factor, R, from Reference [5]:

$$K_{It} = R\,(K_{Im} + K_{Ib})$$

where:	R	=	correction factor, calculated to consider the nonlinear effects in the plastic region based on the assumptions and recommendations of WRC Bulletin 175 [5].
	K_{Im}	=	secondary membrane stress intensity factor
		=	$M_m{*}\sigma_{sm}$
	K_{Ib}	=	secondary bending stress intensity factor
		=	$(2/3)M_m{*}\sigma_{sb}$

The stress reports for the SSES feedwater nozzles did not provide sufficient detail for secondary stresses in the nozzle forging area. Therefore, the secondary stresses used in calculating the secondary membrane and bending stress intensity factors are those obtained from "generic" General Electric (GE) boiling water reactor P-T curve calculations (used to develop previous SSES P-T curves).

c. Calculate the allowable pressure stress intensity factor, K_{Ip}, based on the assumed P using the following relationship:

$$K_{Ip} = F(a/r_n)\,(\sigma_{pm} + R\sigma_{pb})\sqrt{(\pi a)}$$

where:	$F(a/r_n)$	=	nozzle stress factor, from Figure A5-1 of [5]
	σ_{pm}	=	primary membrane stress
	R	=	correction factor, defined above
	σ_{pb}	=	primary bending stress
	a	=	1/4t crack depth for nozzle corner (inches)

d. Calculate the reference fracture toughness, K_{Ic}, using the following relationship:

$$K_{Ic} = K_{It} + K_{Ip}{*}SF$$

where: SF = safety factor = 2.0

e. Compute the fluid temperature, T (assumed equal to the 1/4t flaw temperature, $T_{1/4t}$), from the critical stress intensity factor K_{IC}. The K_{IC} equation from Appendix G [3] is manipulated to solve for $T_{1/4t}$ as follows:

$$T = 50 * \ln[\,(K_{IC}-33.2) / 20.734] + ART_{NDT}$$

f. Apply any adjustments for temperature and/or pressure to T and P, such as for instrument uncertainty and the static head for the weight of the water in the RPV, respectively.

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

The following additional requirements were used to define the P-T curves. These limits are established in Reference [4]:

For Pressure Test Conditions (Curve A):

- If the pressure is greater than 20% of the pre-service hydro test pressure (1,563 psig), the temperature must be greater than ART_{NDT} of the limiting flange material + 90°F.
- If the pressure is less than or equal to 20% of the pre-service hydro test pressure, the minimum temperature is must be greater than or equal to the ART_{NDT} of the limiting flange material + 60°F. This limit has been a standard recommendation for the BWR industry for non-ductile failure protection.

For Core Not Critical Conditions (Curve B):

- If the pressure 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 the pressure is less than or equal to 20% of the pre-service hydro test pressure, the minimum temperature must be greater than or equal to the ART_{NDT} of the limiting flange material + 60°F. This limit has been a standard recommendation for the BWR industry for non-ductile failure protection.

For Core Critical Conditions (Curve C):

- 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 (ART_{NDT} + 60°F) if the pressure is below 20% of the pre-service hydro test pressure.
- Also per Table 1 of Reference [4], 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 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 Curve B + 40°F, whichever is greater.

The resulting pressure and temperature series constitutes the P-T curve. The P-T curve relates the minimum required fluid temperature to the reactor pressure.

4.0 P-T Curves

Tabulated values for the P-T curves are shown in Tables 1 through 14. The resulting P-T curves are shown in Figures 1 through 6.

5.0 References

1. Structural Integrity Associates Calculation No. PPL-21Q-301, Revision 1, "Development of Pressure Test (Curve A) P-T Curves," 06/08/05.

2. Structural Integrity Associates Calculation No. PPL-21Q-302, Revision 1, "Development of Heatup/Cooldown (Curves B & C) P-T Curves," 06/08/05.

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," 1998 Edition including the 2000 Addenda.

4. U. S. Code of Federal Regulations, Title 10, Part 50, Appendix G, "Fracture Toughness Requirements," 1-1-04 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. Structural Integrity Associates Calculation No. SSES-19Q-301, Revision 0, "ΔRTNDT and ART Evaluation, 06/02/05.

7. PPL Nuclear Engineering Calculation No. EC-062-1107, Revision 0, "Final Report SSES Unit 1 RPV Fluence," TransWare Enterprises, Inc. Report No. PPL-FLU-002-R-002, Revision 0, "Susquehanna Unit 1 Reactor Pressure Vessel Fluence Evaluation," May 2005, SI File No. SSES-19Q-205.

8. PPL Nuclear Engineering Calculation No. EC-062-1105, Revision 0, "Final Report SSES Unit 2 RPV Fluence," TransWare Enterprises, Inc. Report No. PPL-FLU-002-R-001, Revision 0, "Susquehanna Unit 2 Reactor Pressure Vessel Fluence Evaluation," May 2005, SI File No. SSES-19Q-204.

Table 1
Tabulated Values for SSES-1 Beltline Pressure Test Curve (Curve A) for 35.7 EFPY

Inputs:

Plant =	SSES-1			
Component =	Beltline			
Vessel thickness, t =	6.1875	inches, so $\sqrt{t}$ =	2.487	$\sqrt{inch}$
Vessel Radius, R =	126.6875	inches		
ART_{NDT} =	61.4	°F ======>	35.7 EFPY	
K_{It} =	0.0	ksi*inch$^{1/2}$		
$\Delta T_{1/4t}$ =	0.0	°F (no thermal for pressure test)		
Safety Factor =	1.5	(for pressure test)		
M_m =	2.303			
Temperature Adjustment =	0.0	°F		
Pressure Adjustment =	30	psig (hydrostatic pressure for a full vessel)		
Hydro Test Pressure =	1,563	psig		
Flange RT_{NDT} =	10.0	°F		

Fluid Temperature T (°F)	1/4t Temperature (°F)	KIc (ksi*inch$^{1/2}$)	KIp (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
-	-	-	-	-	70	0
70	70	57.83	38.55	817	70	787
75	75	60.42	40.28	854	75	824
80	80	63.28	42.18	894	80	864
85	85	66.44	44.29	939	85	909
90	90	69.94	46.62	989	90	959
95	95	73.80	49.20	1043	95	1,013
100	100	78.07	52.05	1104	100	1,074
105	105	82.79	55.19	1170	105	1,140
110	110	88.00	58.67	1244	110	1,214
115	115	93.77	62.51	1325	115	1,295
120	120	100.14	66.76	1416	120	1,386

Table 2
Tabulated Values for SSES-2 Beltline Pressure Test Curve (Curve A) for 30.2 EFPY

Inputs:				
Plant =	SSES-2			
Component =	Beltline			
Vessel thickness, t =	6.1875	inches, so √t =	2.487	√inch
Vessel Radius, R =	126.6875	inches		
ART_{NDT} =	46.7	°F ======>	30.2 EFPY	
K_{It} =	0.0	ksi*inch$^{1/2}$		
$\Delta T_{1/4t}$ =	0.0	°F (no thermal for pressure test)		
Safety Factor =	1.5	(for pressure test)		
M_m =	2.303			
Temperature Adjustment =	0.0	°F		
Pressure Adjustment =	30	psig (hydrostatic pressure for a full vessel)		
Hydro Test Pressure =	1,563	psig		
Flange RT_{NDT} =	10.0	°F		

Fluid Temperature T (°F)	1/4t Temperature (°F)	Kic (ksi*inch$^{1/2}$)	Kip (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
-	-	-	-	-	70	0
70	70	66.24	44.16	936	70	906
75	75	69.72	46.48	986	75	956
80	80	73.56	49.04	1040	80	1,010
85	85	77.80	51.87	1100	85	1,070
90	90	82.49	55.00	1166	90	1,136
95	95	87.68	58.45	1239	95	1,209
100	100	93.41	62.27	1320	100	1,290
105	105	99.74	66.49	1410	105	1,380

Table 3
Tabulated Values for SSES-1 Feedwater Nozzle/Upper Vessel Region Pressure Test Curve (Curve A)

Inputs:				
Plant =	SSES-1			
Component =	Upper Vessel	(based on FW nozzle)		
ART_{NDT} =	40.0	°F =====>	All EFPY	
Vessel thickness, t =	6.5	inches, so √t	2.55	√inch
Vessel Radius, R =	126.7	inches		
F(a/rn) =	1.6	nozzle stress factor		
Crack Depth, a =	1.63	inches		
Safety Factor =	1.5			
Temperature Adjustment =	0.0	°F		
Pressure Adjustment =	0.0	psig		
Unit Pressure =	1,563	psig		
Flange RT_{NDT} =	10.0	°F		

Fluid Temperature T (°F)	1/4t Temperature (°F)	KIc (ksi*inch$^{1/2}$)	KIp (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
-	-	-	-	-	70	0
-	-	-	-	-	70	312.5
-	-	-	-	-	100	312.5
0	0	42.52	28.34	402	100	402
10	10	44.58	29.72	421	100	421
20	20	47.10	31.40	445	100	445
30	30	50.18	33.45	474	100	474
40	40	53.93	35.96	509	100	509
50	50	58.52	39.02	553	100	553
60	60	64.13	42.75	606	100	606
70	70	70.98	47.32	670	100	670
80	80	79.34	52.90	750	100	750
90	90	89.56	59.71	846	100	846
100	100	102.04	68.03	964	100	964
110	110	117.28	78.19	1108	110	1108
120	120	135.90	90.60	1284	120	1284
130	130	158.63	105.76	1498	130	1498

Table 4
Tabulated Values for SSES-2 Feedwater Nozzle/Upper Vessel Region Pressure Test Curve (Curve A)

Inputs:

Plant =	SSES-2			
Component =	Upper Vessel	(based on FW nozzle)		
ART_{NDT} =	30.0	°F ======>	All EFPY	
Vessel thickness, t =	6.5	inches, so √t	2.55	√inch
Vessel Radius, R =	126.7	inches		
F(a/m) =	1.6	nozzle stress factor		
Crack Depth, a =	1.63	inches		
Safety Factor =	1.5			
Temperature Adjustment =	0.0	°F		
Pressure Adjustment =	0.0	psig		
Unit Pressure =	1,563	psig		
Flange RT_{NDT} =	10.0	°F		

Fluid Temperature T (°F)	1/4t Temperature (°F)	KIc (ksi*inch$^{1/2}$)	KIp (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
-	-	-	-	-	70	0
-	-	-	-	-	70	312.5
-	-	-	-	-	100	312.5
0	0	44.58	29.72	421	100	421
10	10	47.10	31.40	445	100	445
20	20	50.18	33.45	474	100	474
30	30	53.93	35.96	509	100	509
40	40	58.52	39.02	553	100	553
50	50	64.13	42.75	606	100	606
60	60	70.98	47.32	670	100	670
70	70	79.34	52.90	750	100	750
80	80	89.56	59.71	846	100	846
90	90	102.04	68.03	964	100	964
100	100	117.28	78.19	1108	100	1108
110	110	135.90	90.60	1284	110	1284
120	120	158.63	105.76	1498	120	1498

Table 5

Tabulated Values for SSES-1 Bottom Head Pressure Test Curve (Curve A)

Inputs:

Plant =	SSES-1	
Component =	Bottom Head	
Vessel thickness, t =	6.1875	inches, so $\sqrt{t}$: 2.487 $\sqrt{inch}$
Vessel Radius, R =	126.6875	inches
ART_{NDT} =	34.0	°F =====> All EFPY
K_t =	0.0	ksi*inch$^{1/2}$
$\Delta T_{1/4t}$ =	0.0	°F (no thermal for pressure test)
Safety Factor =	1.5	(for pressure test)
Stress Concentration Factor =	3.0	Bottom head penetrations
M_m =	2.303	
Temperature Adjustment =	0.0	°F
Height of Water for a Full Vessel =	882.0	inches
Pressure Adjustment =	31.85	psig (hydrostatic pressure at bottom head for a full vessel at 70°F)
Hydro Test Pressure =	1,563	psig
Flange RT_{NDT} =	10.0	°F

Fluid Temperature T (°F)	1/4t Temperature (°F)	Klc (ksi*inch$^{1/2}$)	Klp (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
-	-	-	-	-	70	0
70	70	75.80	50.53	714	70	682
75	75	80.28	53.52	757	75	725
80	80	85.23	56.82	803	80	771
85	85	90.70	60.47	855	85	823
90	90	96.75	64.50	912	90	880
95	95	103.43	68.95	975	95	943
100	100	110.82	73.88	1044	100	1,012
105	105	118.98	79.32	1121	105	1,089
110	110	128.00	85.33	1206	110	1,174
115	115	137.97	91.98	1300	115	1,268
120	120	148.99	99.33	1404	120	1,372

Table 6
Tabulated Values for SSES-2 Bottom Head Pressure Test Curve (Curve A)

Inputs:

Plant =	SSES-2			
Component =	Bottom Head			
Vessel thickness, t =	6.1875	inches, so √t :	2.487	√inch
Vessel Radius, R =	126.6875	inches		
ART_{NDT} =	24.0	°F =====>	All EFPY	
K_t =	0.0	ksi*inch$^{1/2}$		
$\Delta T_{1/4t}$ =	0.0	°F (no thermal for pressure test)		
Safety Factor =	1.5	(for pressure test)		
Stress Concentration Factor =	3.0	Bottom head penetrations		
M_m =	2.303			
Temperature Adjustment =	0.0	°F		
Height of Water for a Full Vessel =	882.0	inches		
Pressure Adjustment =	31.85	psig (hydrostatic pressure at bottom head for a full vessel at 70°F)		
Hydro Test Pressure =	1,563	psig		
Flange RT_{NDT} =	10.0	°F		

Fluid Temperature T (°F)	1/4t Temperature (°F)	Klc (ksi*inch$^{1/2}$)	Klp (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
-	-	-	-	-	70	0
70	70	85.23	56.82	803	70	771
75	75	90.70	60.47	855	75	823
80	80	96.75	64.50	912	80	880
85	85	103.43	68.95	975	85	943
90	90	110.82	73.88	1044	90	1,012
95	95	118.98	79.32	1121	95	1,089
100	100	128.00	85.33	1206	100	1,174
105	105	137.97	91.98	1300	105	1,268
110	110	148.99	99.33	1404	110	1,372

Table 7
Tabulated Values for SSES-1 Beltline Core Not Critical Curve (Curve B) for 35.7 EFPY

Inputs:

Plant =	SSES-1			
Component =	Beltline			
Vessel thickness, t =	6.1875	inches, so √t	2.487	√inch
Vessel Radius, R =	126.6875	inches		
ART_{NDT} =	61.4	°F ======>	35.7 EFPY	
Cooldown Rate =	100.0	°F/hr		
K_{It} =	9.08	ksi*inch$^{1/2}$		
Safety Factor =	2.0			
M_m =	2.303			
Temperature Adjustment =	0.0	°F		
Pressure Adjustment =	30.0	psig (hydrostatic pressure for a full vessel)		
Flange RT_{NDT} =	10.0	°F		

Fluid Temperature T (°F)	1/4t Temperature (°F)	KIc (ksi*inch$^{1/2}$)	KIp (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
-	-	-	-	-	70	0
70	70.0	57.83	24.37	517	70	487
75	75.0	60.42	25.67	544	75	514
80	80.0	63.28	27.10	575	80	545
85	85.0	66.44	28.68	608	85	578
90	90.0	69.94	30.43	645	90	615
95	95.0	73.80	32.36	686	95	656
100	100.0	78.07	34.50	731	100	701
105	105.0	82.79	36.86	782	105	752
110	110.0	88.00	39.46	837	110	807
115	115.0	93.77	42.35	898	115	868
120	120.0	100.14	45.53	965	120	935
125	125.0	107.18	49.05	1040	125	1010
130	130.0	114.96	52.94	1123	130	1093
135	135.0	123.56	57.24	1214	135	1184
140	140.0	133.06	61.99	1314	140	1284
145	145.0	143.56	67.24	1426	145	1396

Table 8
Tabulated Values for SSES-2 Beltline Core Not Critical Curve (Curve B) for 30.2 EFPY

Inputs:					
	Plant =	SSES-2			
	Component =	Beltline			
	Vessel thickness, t =	6.1875	inches, so √t	2.487	√inch
	Vessel Radius, R =	126.6875	inches		
	ART_{NDT} =	46.7	°F =====>	30.2 EFPY	
	Cooldown Rate =	100.0	°F/hr		
	K_{lt} =	9.08	ksi*inch$^{1/2}$		
	Safety Factor =	2.0			
	M_m =	2.303			
	Temperature Adjustment =	0.0	°F		
	Pressure Adjustment =	30.0	psig (hydrostatic pressure for a full vessel)		
	Flange RT_{NDT} =	10.0	°F		

Fluid Temperature T (°F)	1/4t Temperature (°F)	KIc (ksi*inch$^{1/2}$)	KIp (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
-	-	-	-	-	70	0
70	70.0	66.24	28.58	606	70	576
75	75.0	69.72	30.32	643	75	613
80	80.0	73.56	32.24	684	80	654
85	85.0	77.80	34.36	729	85	699
90	90.0	82.49	36.71	778	90	748
95	95.0	87.68	39.30	833	95	803
100	100.0	93.41	42.17	894	100	864
105	105.0	99.74	45.33	961	105	931
110	110.0	106.74	48.83	1035	110	1005
115	115.0	114.47	52.70	1117	115	1087
120	120.0	123.02	56.97	1208	120	1178
125	125.0	132.46	61.69	1308	125	1278
130	130.0	142.90	66.91	1419	130	1389

Table 9
Tabulated Values for SSES-1 Upper Vessel/Feedwater Nozzle Region Core Not Critical Curve (Curve B)

<u>Inputs:</u>

Plant =	SSES-1				
Component =	Upper Vessel				
ART_{NDT} =	40.0	°F —	All EFPY		
σ_{pm} =	20.49	ksi @	1050 psig		
σ_{pb} =	0.22	ksi @	1050 psig	Base Temp	
σ_{sm} =	16.19	ksi @	546 °F	90	°F
σ_{sb} =	19.04	ksi @	546 °F	90	°F
σ_{ys} =	45.0	ksi			
M_m =	2.54				
Safety Factor =	2.0				
$F(a/r_n)$ =	1.6				
Temperature Adjustment =	0.0	°F			
Pressure Adjustment =	0.0	psig			
Hydro Test Pressure =	1563	psig			
Flange RT_{NDT} =	10.0	°F			

Pressure P (psig)	Saturation Temperature (°F)	σ_{pm} (ksi)	σ_{pb} (ksi)	σ_{sm} (ksi)	σ_{sb} (ksi)	σ_{total} (ksi)	R	KIt (ksi*inch$^{1/2}$)	KIp (ksi*inch$^{1/2}$)	Total KIc (ksi*inch$^{1/2}$)	Calculated Temperature T (°F)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
-	-	-	-	-	-	-	-	-	-	-	-	70.0	0
50	297.3	0.98	0.01	7.36	8.65	17.00	1.00	33.3	3.8	41.0	0.0	70.0	50
100	337.7	1.95	0.02	8.79	10.34	21.11	1.00	39.8	7.7	55.1	0.0	70.0	100
150	365.8	2.93	0.03	9.79	11.52	24.27	1.00	44.3	11.5	67.3	64.9	70.0	150
165.9	373.4	3.24	0.03	10.06	11.83	25.16	1.00	45.5	12.7	71.0	70.0	70.0	166
200	387.9	3.90	0.04	10.58	12.44	26.96	1.00	47.9	15.3	78.5	79.1	79.1	200
250	406.2	4.88	0.05	11.23	13.20	29.36	1.00	50.8	19.2	89.1	89.6	89.6	250
300	422.1	5.85	0.06	11.79	13.86	31.57	1.00	53.3	23.0	99.4	98.0	98.0	300
312.5	425.7	6.10	0.07	11.92	14.02	32.10	1.00	53.9	24.0	101.9	99.9	99.9	312.5
312.5	425.7	6.10	0.07	11.92	14.02	32.10	1.00	53.9	24.0	101.9	99.9	130.0	312.5
350	436.0	6.83	0.07	12.28	14.45	33.63	1.00	55.6	26.8	109.3	105.0	130.0	350
400	448.5	7.81	0.08	12.73	14.97	35.59	1.00	57.6	30.7	118.9	111.0	130.0	400
450	459.9	8.78	0.09	13.13	15.45	37.45	1.00	59.4	34.5	128.4	116.2	130.0	450
500	470.4	9.76	0.10	13.51	15.88	39.25	1.00	61.1	38.3	137.8	120.9	130.0	500
550	480.1	10.73	0.12	13.85	16.29	40.99	1.00	62.7	42.2	147.0	125.1	130.0	550
600	489.1	11.71	0.13	14.17	16.67	42.67	1.00	64.1	46.0	156.1	129.0	130.0	600
614	491.6	11.98	0.13	14.26	16.77	43.13	1.00	64.5	47.1	158.7	130.0	130.0	614
650	497.6	12.68	0.14	14.47	17.02	44.31	1.00	65.5	49.9	165.2	132.5	132.5	650
700	505.6	13.66	0.15	14.76	17.35	45.92	0.97	64.9	53.7	172.3	135.2	135.2	700
750	513.2	14.64	0.16	15.03	17.67	47.49	0.93	63.0	57.5	178.0	137.2	137.2	750
800	520.4	15.61	0.17	15.28	17.97	49.03	0.88	61.1	61.3	183.6	139.1	139.1	800
850	527.3	16.59	0.18	15.53	18.26	50.55	0.84	59.1	65.1	189.3	140.9	140.9	850
900	533.9	17.56	0.19	15.76	18.53	52.04	0.80	57.2	68.9	195.0	142.7	142.7	900
950	540.1	18.54	0.20	15.98	18.80	53.52	0.76	55.3	72.7	200.6	144.4	144.4	950
1000	546.2	19.51	0.21	16.20	19.05	54.97	0.73	53.4	76.5	206.3	146.1	146.1	1000
1050	552.0	20.49	0.22	16.40	19.29	56.40	0.69	51.4	80.3	212.0	147.7	147.7	1050
1100	557.6	21.47	0.23	16.60	19.52	57.82	0.66	49.5	84.1	217.6	149.3	149.3	1100
1150	563.0	22.44	0.24	16.79	19.75	59.23	0.63	47.6	87.8	223.3	150.8	150.8	1150
1200	568.2	23.42	0.25	16.98	19.97	60.62	0.59	45.6	91.6	228.9	152.2	152.2	1200
1250	573.3	24.39	0.26	17.16	20.18	61.99	0.56	43.7	95.4	234.6	153.7	153.7	1250
1300	578.2	25.37	0.27	17.33	20.38	63.36	0.53	41.8	99.2	240.2	155.0	155.0	1300

Table 10
Tabulated Values for SSES-2 Upper Vessel/Feedwater Nozzle Region Core Not Critical Curve (Curve B)

Inputs:						
Plant =	SSES-2					
Component =	Upper Vessel					
ART_{NDT} =	30.0	°F	All EFPY			
σ_{pm} =	20.49	ksi @	1050 psig			
σ_{pb} =	0.22	ksi @	1050 psig		Base Temp	
σ_{sm} =	16.19	ksi @	546 °F			90 °F
σ_{sb} =	19.04	ksi @	546 °F			90 °F
σ_{ys} =	45.0	ksi				
M_m =	2.54					
Safety Factor =	2.0					
$F(a/r_n)$ =	1.6					
Temperature Adjustment =	0.0	°F				
Pressure Adjustment =	0.0	psig				
Hydro Test Pressure =	1563	psig				
Flange RT_{NDT} =	10.0	°F				

Pressure P (psig)	Saturation Temperature (°F)	σ_{pm} (ksi)	σ_{pb} (ksi)	σ_{sm} (ksi)	σ_{sb} (ksi)	σ_{total} (ksi)	R	Kit (ksi*inch$^{1/2}$)	Kip (ksi*inch$^{1/2}$)	Total KIc (ksi*inch$^{1/2}$)	Calculated Temperature T (°F)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
-	-	-	-	-	-	-	-	-	-	-	-	70.0	0
50	297.3	0.98	0.01	7.36	8.65	17.00	1.00	33.3	3.8	41.0	0.0	70.0	50
100	337.7	1.95	0.02	8.79	10.34	21.11	1.00	39.8	7.7	55.1	0.0	70.0	100
150	365.8	2.93	0.03	9.79	11.52	24.27	1.00	44.3	11.5	67.3	54.9	70.0	150
200	387.9	3.90	0.04	10.58	12.44	26.96	1.00	47.9	15.3	78.5	69.1	70.0	200
203.7	389.4	3.98	0.04	10.63	12.50	27.15	1.00	48.1	15.6	79.3	70.0	70.0	204
250	406.2	4.88	0.05	11.23	13.20	29.36	1.00	50.8	19.2	89.1	79.6	79.6	250
300	422.1	5.85	0.06	11.79	13.86	31.57	1.00	53.3	23.0	99.4	88.0	88.0	300
312.5	425.7	6.10	0.07	11.92	14.02	32.10	1.00	53.9	24.0	101.9	89.9	130.0	312.5
312.5	425.7	6.10	0.07	11.92	14.02	32.10	1.00	53.9	24.0	101.9	89.9	130.0	312.5
350	436.0	6.83	0.07	12.28	14.45	33.63	1.00	55.6	26.8	109.3	95.0	130.0	350
400	448.5	7.81	0.08	12.73	14.97	35.59	1.00	57.6	30.7	118.9	101.0	130.0	400
450	459.9	8.78	0.09	13.13	15.45	37.45	1.00	59.4	34.5	128.4	106.2	130.0	450
500	470.4	9.76	0.10	13.51	15.88	39.25	1.00	61.1	38.3	137.8	110.9	130.0	500
550	480.1	10.73	0.12	13.85	16.29	40.99	1.00	62.7	42.2	147.0	115.1	130.0	550
600	489.1	11.71	0.13	14.17	16.67	42.67	1.00	64.1	46.0	156.1	119.0	130.0	600
650	497.6	12.68	0.14	14.47	17.02	44.31	1.00	65.5	49.9	165.2	122.5	130.0	650
700	505.6	13.66	0.15	14.76	17.35	45.92	0.97	64.9	53.7	172.3	125.2	130.0	700
750	513.2	14.64	0.16	15.03	17.67	47.49	0.93	63.0	57.5	178.0	127.2	130.0	750
757	514.3	14.77	0.16	15.06	17.71	47.71	0.92	62.7	58.0	178.7	127.4	130.0	757
800	520.4	15.61	0.17	15.28	17.97	49.03	0.88	61.1	61.3	183.6	129.1	130.0	800
825	523.9	16.10	0.17	15.41	18.12	49.79	0.86	60.1	63.2	186.5	130.0	130.0	825
850	527.3	16.59	0.18	15.53	18.26	50.55	0.84	59.1	65.1	189.3	130.9	130.9	850
900	533.9	17.56	0.19	15.76	18.53	52.04	0.80	57.2	68.9	195.0	132.7	132.7	900
950	540.1	18.54	0.20	15.98	18.80	53.52	0.76	55.3	72.7	200.6	134.4	134.4	950
1000	546.2	19.51	0.21	16.20	19.05	54.97	0.73	53.4	76.5	206.3	136.1	136.1	1000
1050	552.0	20.49	0.22	16.40	19.29	56.40	0.69	51.4	80.3	212.0	137.7	137.7	1050
1100	557.6	21.47	0.23	16.60	19.52	57.82	0.66	49.5	84.1	217.6	139.3	139.3	1100
1150	563.0	22.44	0.24	16.79	19.75	59.23	0.63	47.6	87.8	223.3	140.8	140.8	1150
1200	568.2	23.42	0.25	16.98	19.97	60.62	0.59	45.6	91.6	228.9	142.2	142.2	1200
1250	573.3	24.39	0.26	17.16	20.18	61.99	0.56	43.7	95.4	234.6	143.7	143.7	1250
1300	578.2	25.37	0.27	17.33	20.38	63.36	0.53	41.8	99.2	240.2	145.0	145.0	1300

Table 11
Tabulated Values for SSES-1 Bottom Head Core Not Critical Curve (Curve B)

Inputs:

Plant =	SSES-1			
Component =	Bottom Head	(Penetrations Portion)		
Vessel thickness, t =	6.1875	inches, so √t	2.487	√inch
Vessel Radius, R =	126.6875	inches		
Cooldown Rate =	100.0	°F/hr		
Safety Factor =	2.0			
Stress Concentration Factor =	3.0			
ART_{NDT} =	34.0	°F ======>	All EFPY	
M_m =	2.303			
K_{lt} =	9.08	ksi*inch$^{1/2}$		
Temperature Adjustment =	0.00	°F		
Height of full vessel =	882.0	inches		
Pressure Adjustment =	31.85	psig		
Unit Pressure =	1563	psig		
Flange RT_{NDT} =	10.0	°F		

Fluid Temperature T (°F)	1/4t Temperature (°F)	Kic (ksi*inch$^{1/2}$)	Kip (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
-	-	-	-	-	70	0
70	70.0	75.80	33.36	472	70	440
75	75.0	80.28	35.60	503	75	471
80	80.0	85.23	38.08	538	80	506
85	85.0	90.70	40.81	577	85	545
90	90.0	96.75	43.84	620	90	588
95	95.0	103.43	47.18	667	95	635
100	100.0	110.82	50.87	719	100	687
105	105.0	118.98	54.95	777	105	745
110	110.0	128.00	59.46	841	110	809
115	115.0	137.97	64.45	911	115	879
120	120.0	148.99	69.96	989	120	957
125	125.0	161.17	76.05	1075	125	1043
130	130.0	174.63	82.78	1170	130	1138
135	135.0	189.50	90.21	1275	135	1243
140	140.0	205.94	98.43	1391	140	1360

Table 12
Tabulated Values for SSES-2 Bottom Head Core Not Critical Curve (Curve B)

Inputs:

Plant =	SSES-2			
Component =	Bottom Head	(Penetrations Portion)		
Vessel thickness, t =	6.1875	inches, so √t	2.487	√inch
Vessel Radius, R =	126.6875	inches		
Cooldown Rate =	100.0	°F/hr		
Safety Factor =	2.0			
Stress Concentration Factor =	3.0			
ART_{NDT} =	24.0	°F ======>	All EFPY	
M_m =	2.303			
K_{It} =	9.08	ksi*inch$^{1/2}$		
Temperature Adjustment =	0.00	°F		
Height of full vessel =	882.0	inches		
Pressure Adjustment =	31.85	psig		
Unit Pressure =	1563	psig		
Flange RT_{NDT} =	10.0	°F		

Fluid Temperature T (°F)	1/4t Temperature (°F)	Klc (ksi*inch$^{1/2}$)	Klp (ksi*inch$^{1/2}$)	Calculated Pressure P (psig)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
-	-	-	-	-	70	0
70	70.0	85.23	38.08	538	70	506
75	75.0	90.70	40.81	577	75	545
80	80.0	96.75	43.84	620	80	588
85	85.0	103.43	47.18	667	85	635
90	90.0	110.82	50.87	719	90	687
95	95.0	118.98	54.95	777	95	745
100	100.0	128.00	59.46	841	100	809
105	105.0	137.97	64.45	911	105	879
110	110.0	148.99	69.96	989	110	957
115	115.0	161.17	76.05	1075	115	1043
120	120.0	174.63	82.78	1170	120	1138
125	125.0	189.50	90.21	1275	125	1243
130	130.0	205.94	98.43	1391	130	1360

Table 13
Tabulated Values for SSES-1 Core Critical Curve (Curve C) for 35.7 EFPY

Inputs:					
Plant =	SSES-1				
Component =	Upper Vessel				
ART_{NDT} =	40.0	°F			
σ_{pm} =	20.49	ksi @	1050 psig		
σ_{pb} =	0.22	ksi @	1050 psig	Base Temp	
σ_{sm} =	16.19	ksi @	546 °F		90 °F
σ_{sb} =	19.04	ksi @	546 °F		90 °F
σ_{ys} =	45.0	ksi			
M_m =	2.54				
Safety Factor =	2.0				
$F(a/r_n)$ =	1.6				
Temperature Adjustment =	0.0	°F			
Pressure Adjustment =	0.0	psig			
Hydro Test Pressure =	1563	psig			
Flange RT_{NDT} =	10.0	°F			

Pressure P (psig)	Saturation Temperature (°F)	σ_{pm} (ksi)	σ_{pb} (ksi)	σ_{sm} (ksi)	σ_{sb} (ksi)	σ_{total} (ksi)	R	Kit ksi*inch$^{1/2}$	Kip ksi*inch$^{1/2}$	Total Kic ksi*inch$^{1/2}$	Calculated Temperature T (°F)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
-	-	-	-	-	-	-	-	-	-	-	-	70.0	0
50	297.3	0.98	0.01	7.36	8.65	17.00	1.00	33.3	3.8	41.0	-	70.0	50
81.4	324.7	1.59	0.02	8.33	9.80	19.73	1.00	37.7	6.2	50.2	30.0	70.0	81
100	337.7	1.95	0.02	8.79	10.34	21.11	1.00	39.6	7.7	55.1	42.8	82.8	100
150	365.8	2.93	0.03	9.79	11.52	24.27	1.00	44.3	11.5	67.3	64.9	104.9	150
200	387.9	3.90	0.04	10.58	12.44	26.96	1.00	47.9	15.3	78.5	79.1	119.1	200
250	406.2	4.88	0.05	11.23	13.20	29.36	1.00	50.8	19.2	89.1	89.6	129.6	250
300	422.1	5.85	0.06	11.79	13.86	31.57	1.00	53.3	23.0	99.4	98.0	138.0	300
312.5	425.7	6.10	0.07	11.92	14.02	32.10	1.00	53.9	24.0	101.9	99.9	139.9	312.5
312.5	425.7	6.10	0.07	11.92	14.02	32.10	1.00	53.9	24.0	101.9	99.9	170.0	312.5
350	436.0	6.83	0.07	12.28	14.45	33.63	1.00	55.6	26.8	109.3	105.0	170.0	350
400	448.5	7.81	0.08	12.73	14.97	35.59	1.00	57.6	30.7	118.9	111.0	170.0	400
450	459.9	8.78	0.09	13.13	15.45	37.45	1.00	59.4	34.5	128.4	116.2	170.0	450
500	470.4	9.76	0.10	13.51	15.88	39.25	1.00	61.1	38.3	137.8	120.9	170.0	500
550	480.1	10.73	0.12	13.85	16.29	40.99	1.00	62.7	42.2	147.0	125.1	170.0	550
600	489.1	11.71	0.13	14.17	16.67	42.67	1.00	64.1	46.0	156.1	129.0	170.0	600
614	491.6	11.98	0.13	14.26	16.77	43.13	1.00	64.5	47.1	158.7	130.0	170.0	614
650	497.6	12.68	0.14	14.47	17.02	44.31	1.00	65.5	49.9	165.2	132.5	172.5	650
700	505.6	13.66	0.15	14.76	17.35	45.92	0.97	64.9	53.7	172.3	135.2	175.2	700
750	513.2	14.64	0.16	15.03	17.67	47.49	0.93	63.0	57.5	178.0	137.2	177.2	750
800	520.4	15.61	0.17	15.28	17.97	49.03	0.88	61.1	61.3	183.6	139.1	179.1	800
850	527.3	16.59	0.18	15.53	18.26	50.55	0.84	59.1	65.1	189.3	140.9	180.9	850
900	533.9	17.56	0.19	15.76	18.53	52.04	0.80	57.2	68.9	195.0	142.7	182.7	900
950	540.1	18.54	0.20	15.98	18.80	53.52	0.76	55.3	72.7	200.6	144.4	184.4	950
1000	546.2	19.51	0.21	16.20	19.05	54.97	0.73	53.4	76.5	206.3	146.1	186.1	1000
1050	552.0	20.49	0.22	16.40	19.29	56.40	0.69	51.4	80.3	212.0	147.7	187.7	1050
1100	557.6	21.47	0.23	16.60	19.52	57.82	0.66	49.5	84.1	217.6	149.3	189.3	1100
1150	563.0	22.44	0.24	16.79	19.75	59.23	0.63	47.6	87.8	223.3	150.8	190.8	1150
1200	568.2	23.42	0.25	16.98	19.97	60.62	0.59	45.6	91.6	228.9	152.2	192.2	1200
1250	573.3	24.39	0.26	17.16	20.18	61.99	0.56	43.7	95.4	234.6	153.7	193.7	1250
1300	578.2	25.37	0.27	17.33	20.38	63.36	0.53	41.8	99.2	240.2	155.0	195.0	1300

Table 14
Tabulated Values for SSES-2 Core Critical Curve (Curve C) for 30.2 EFPY

Inputs:

Plant =	SSES-2				
Component =	Upper Vessel				
ART_{NDT} =	30.0	°F			
σ_{pm} =	20.49	ksi @	1050 psig		
σ_{pb} =	0.22	ksi @	1050 psig	Base Temp	
σ_{sm} =	16.19	ksi @	546 °F		90 °F
σ_{sb} =	19.04	ksi @	546 °F		90 °F
σ_{ys} =	45.0	ksi			
M_m =	2.54				
Safety Factor =	2.0				
$F(a/r_n)$ =	1.6				
Temperature Adjustment =	0.0	°F			
Pressure Adjustment =	0.0	psig			
Hydro Test Pressure =	1563	psig			
Flange RT_{NDT} =	10.0	°F			

Pressure P (psig)	Saturation Temperature (°F)	σ_{pm} (ksi)	σ_{pb} (ksi)	σ_{sm} (ksi)	σ_{sb} (ksi)	σ_{total} (ksi)	R	Kit ksi*inch[1/2]	Kip ksi*inch[1/2]	Total Kic ksi*inch[1/2]	Calculated Temperature T (°F)	Adjusted Temperature for P-T Curve (°F)	Adjusted Pressure for P-T Curve (psig)
-	-	-	-	-	-	-	-	-	-	-	-	70.0	0
50	297.3	0.98	0.01	7.36	8.65	17.00	1.00	33.3	3.8	41.0	-	70.0	50
95.5	334.7	1.86	0.02	8.69	10.22	20.79	1.00	39.3	7.3	54.0	30.0	70.0	96
100	337.7	1.95	0.02	8.79	10.34	21.11	1.00	39.8	7.7	55.1	32.8	72.8	100
150	365.8	2.93	0.03	9.79	11.52	24.27	1.00	44.3	11.5	67.3	54.9	94.9	150
200	387.9	3.90	0.04	10.58	12.44	26.96	1.00	47.9	15.3	78.5	69.1	109.1	200
250	406.2	4.88	0.05	11.23	13.20	29.36	1.00	50.8	19.2	89.1	79.6	119.6	250
300	422.1	5.85	0.06	11.79	13.86	31.57	1.00	53.3	23.0	99.4	88.0	128.0	300
312.5	425.7	6.10	0.07	11.92	14.02	32.10	1.00	53.9	24.0	101.9	89.9	129.9	312.5
312.5	425.7	6.10	0.07	11.92	14.02	32.10	1.00	53.9	24.0	101.9	89.9	170.0	312.5
350	436.0	6.83	0.07	12.28	14.45	33.63	1.00	55.6	26.8	109.3	95.0	170.0	350
400	448.5	7.81	0.08	12.73	14.97	35.59	1.00	57.6	30.7	118.9	101.0	170.0	400
450	459.9	8.78	0.09	13.13	15.45	37.45	1.00	59.4	34.5	128.4	106.2	170.0	450
500	470.4	9.76	0.10	13.51	15.88	39.25	1.00	61.1	38.3	137.8	110.9	170.0	500
550	480.1	10.73	0.12	13.85	16.29	40.99	1.00	62.7	42.2	147.0	115.1	170.0	550
600	489.1	11.71	0.13	14.17	16.67	42.67	1.00	64.1	46.0	156.1	119.0	170.0	600
650	497.6	12.68	0.14	14.47	17.02	44.31	1.00	65.5	49.9	165.2	122.5	170.0	650
700	505.6	13.66	0.15	14.76	17.35	45.92	0.97	64.9	53.7	172.3	125.2	170.0	700
750	513.2	14.64	0.16	15.03	17.67	47.49	0.93	63.0	57.5	178.0	127.2	170.0	750
757	514.3	14.77	0.16	15.06	17.71	47.71	0.92	62.7	58.0	178.7	127.4	170.0	757
800	520.4	15.61	0.17	15.28	17.97	49.03	0.88	61.1	61.3	183.6	129.1	170.0	800
825	523.9	16.10	0.17	15.41	18.12	49.79	0.86	60.1	63.2	186.5	130.0	170.0	825
850	527.3	16.59	0.18	15.53	18.26	50.55	0.84	59.1	65.1	189.3	130.9	170.9	850
900	533.9	17.56	0.19	15.76	18.53	52.04	0.80	57.2	68.9	195.0	132.7	172.7	900
950	540.1	18.54	0.20	15.98	18.80	53.52	0.76	55.3	72.7	200.6	134.4	174.4	950
1000	546.2	19.51	0.21	16.20	19.05	54.97	0.73	53.4	76.5	206.3	136.1	176.1	1000
1050	552.0	20.49	0.22	16.40	19.29	56.40	0.69	51.4	80.3	212.0	137.7	177.7	1050
1100	557.6	21.47	0.23	16.60	19.52	57.82	0.66	49.5	84.1	217.6	139.3	179.3	1100
1150	563.0	22.44	0.24	16.79	19.75	59.23	0.63	47.6	87.8	223.3	140.8	180.8	1150
1200	568.2	23.42	0.25	16.98	19.97	60.62	0.59	45.6	91.6	228.9	142.2	182.2	1200
1250	573.3	24.39	0.26	17.16	20.18	61.99	0.56	43.7	95.4	234.6	143.7	183.7	1250
1300	578.2	25.37	0.27	17.33	20.38	63.36	0.53	41.8	99.2	240.2	145.0	185.0	1300

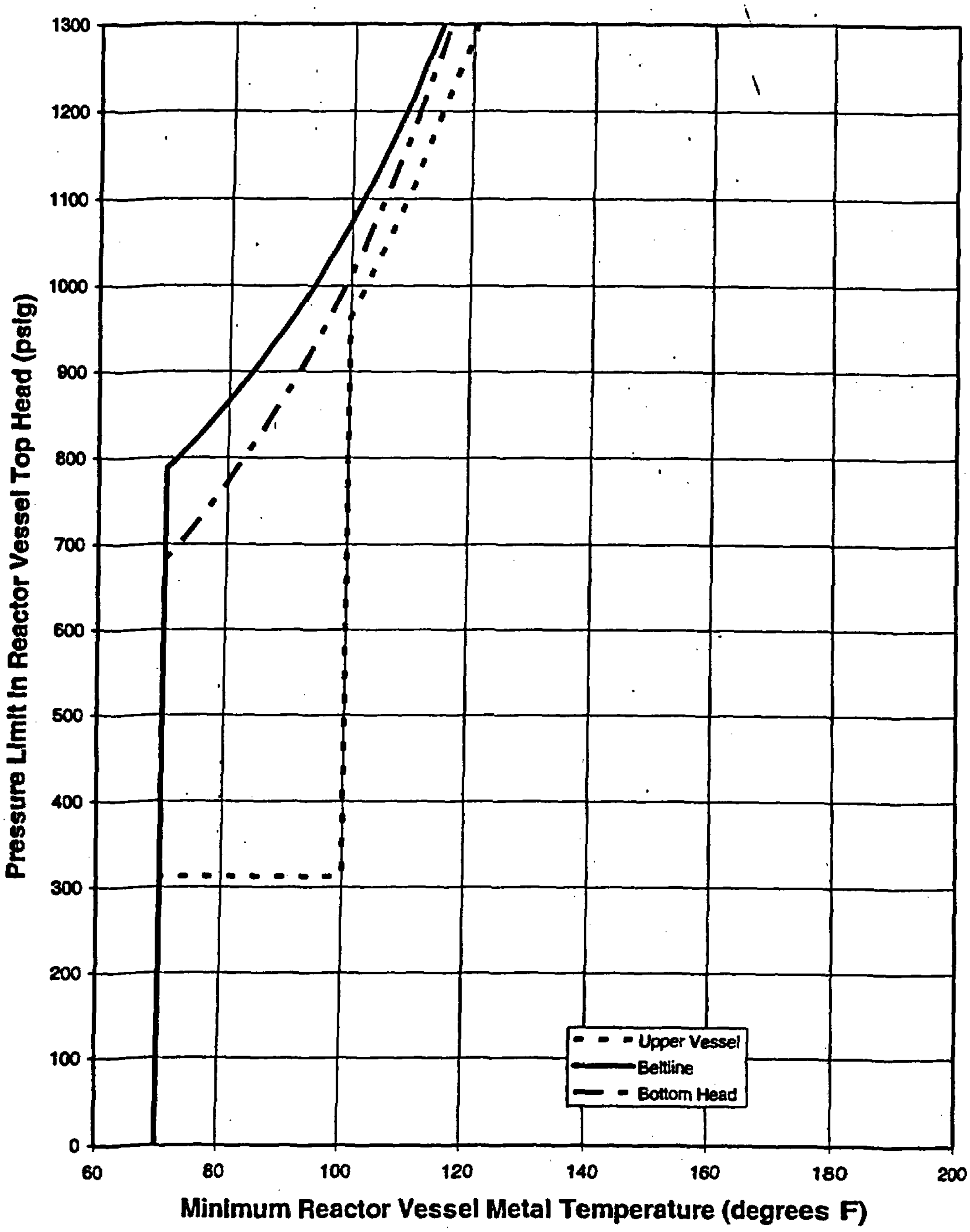

Figure 1
SSES-1 Pressure Test P-T Curve (Curve A) for 35.7 EFPY

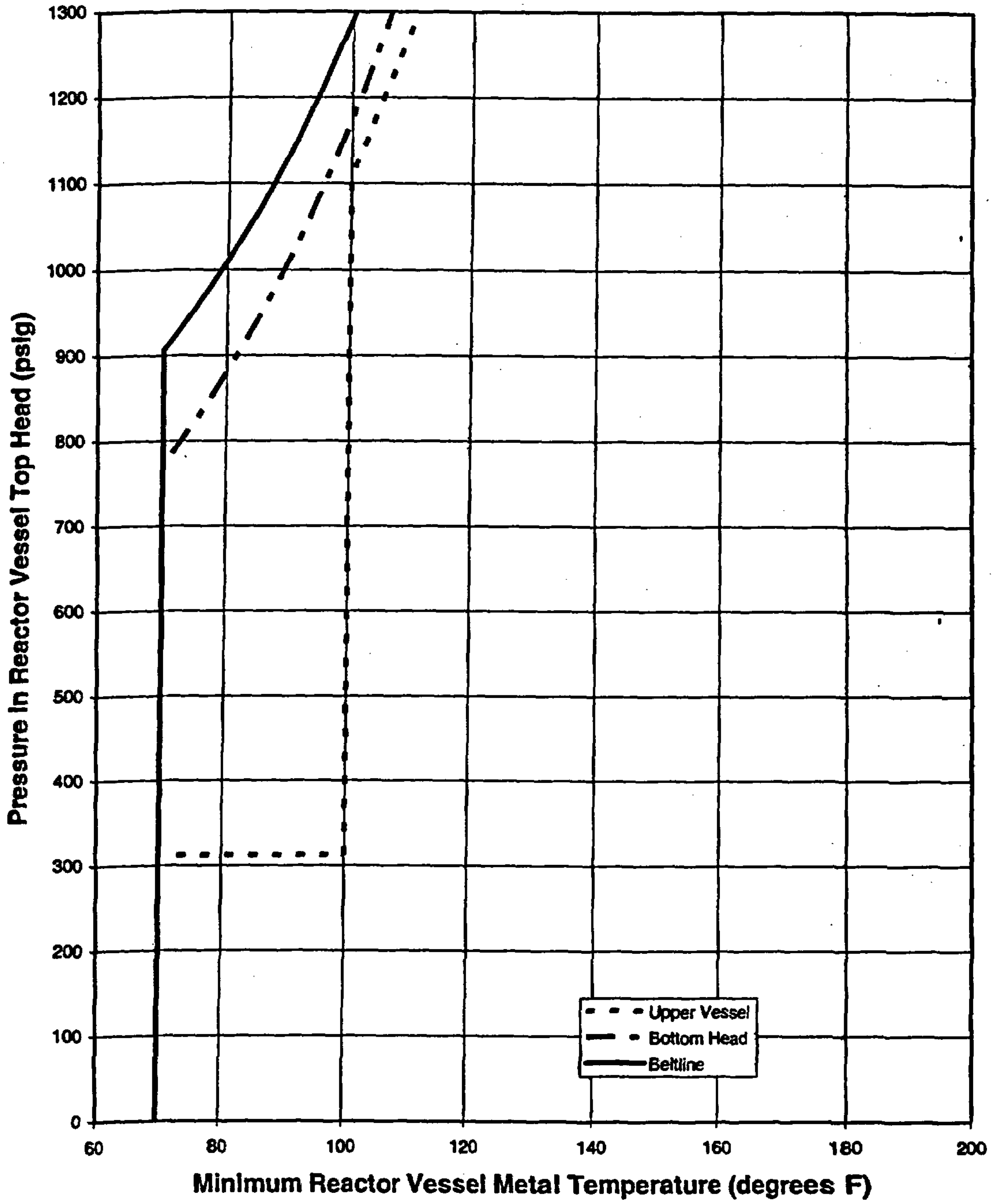

Figure 2
SSES-2 Pressure Test P-T Curve (Curve A) for 30.2 EFPY

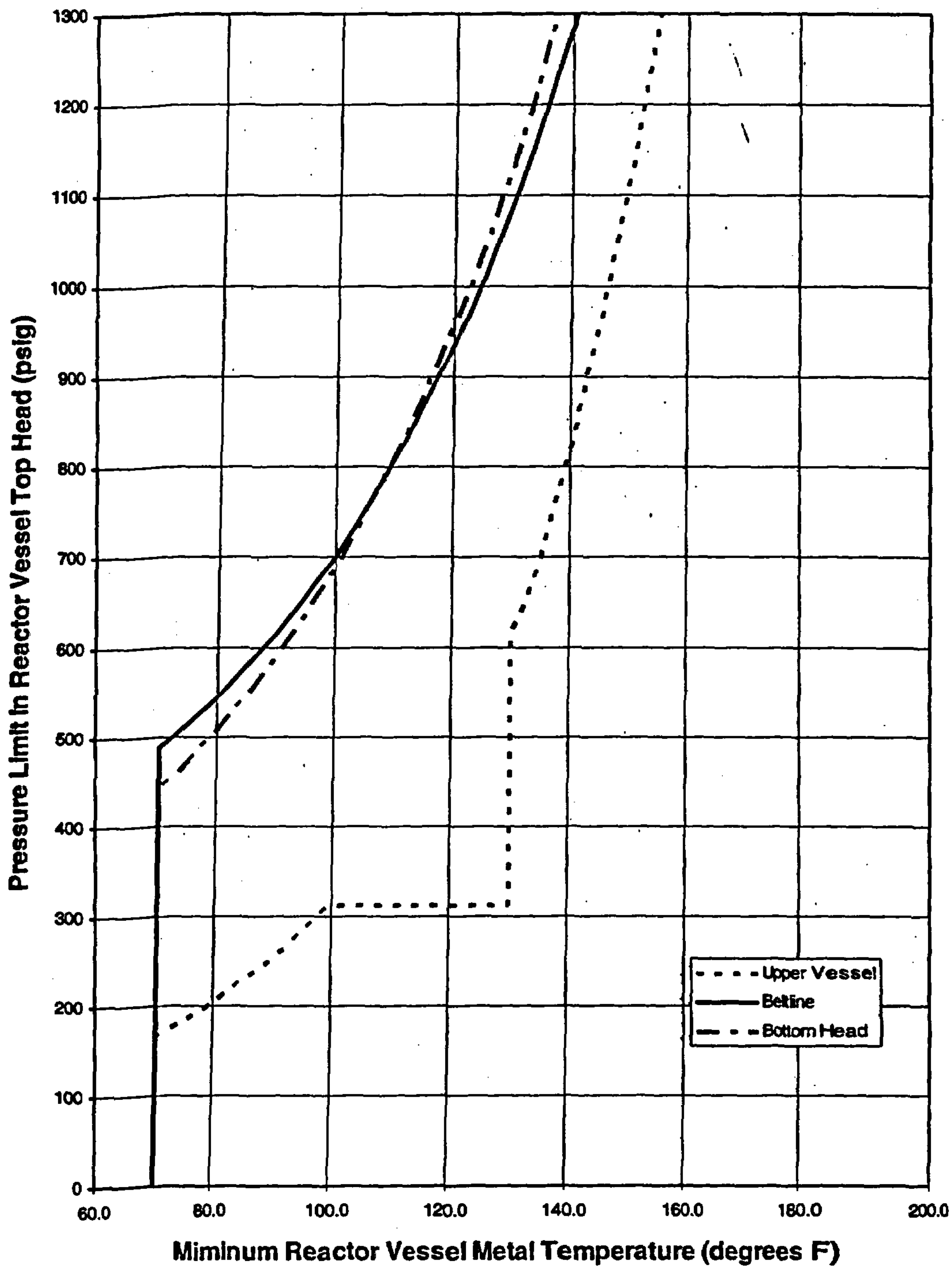

Figure 3
SSES-1 Core Not Critical Curve (Curve B) for 35.7 EFPY

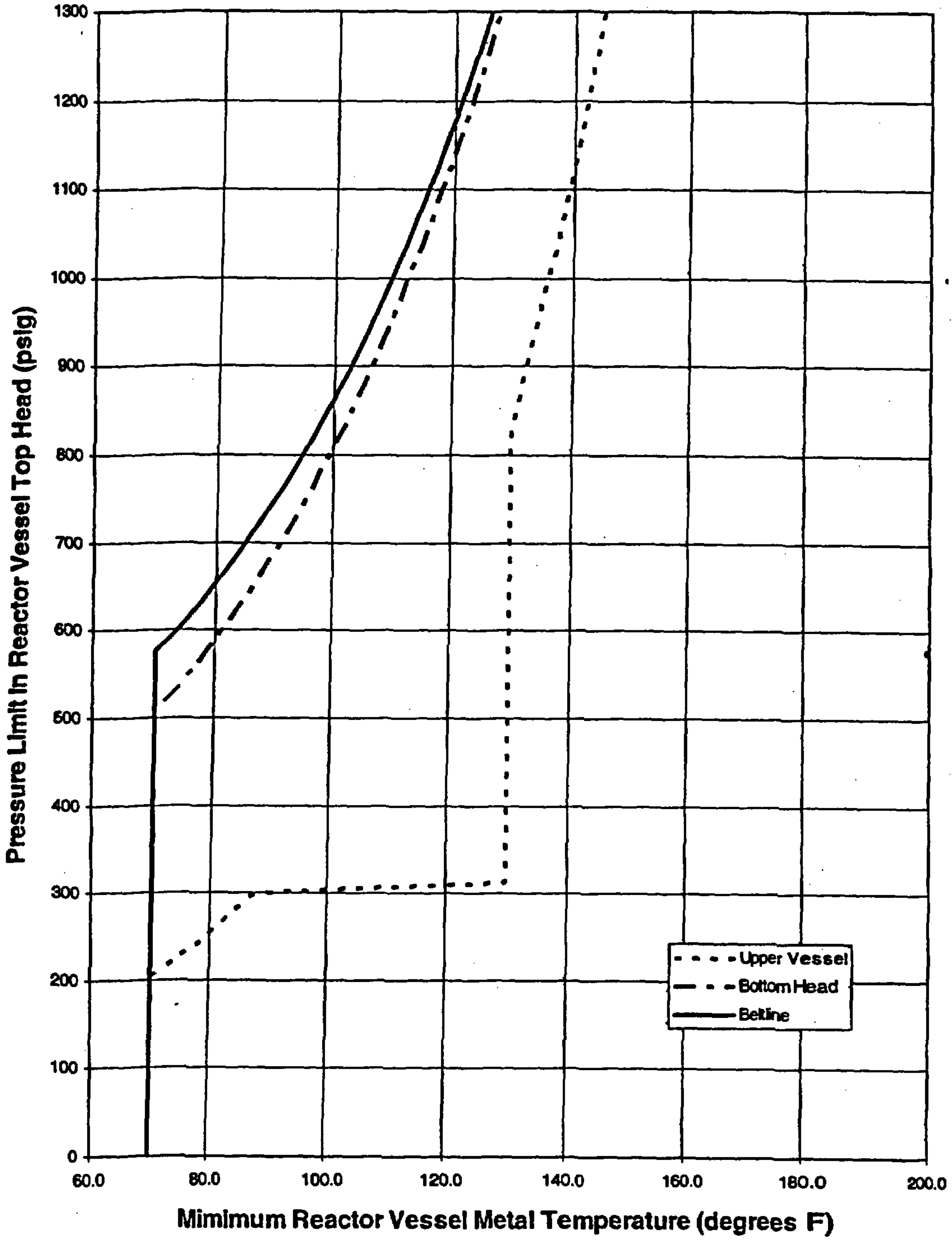

Figure 4
SSES-2 Core Not Critical Curve (Curve B) for 30.2 EFPY

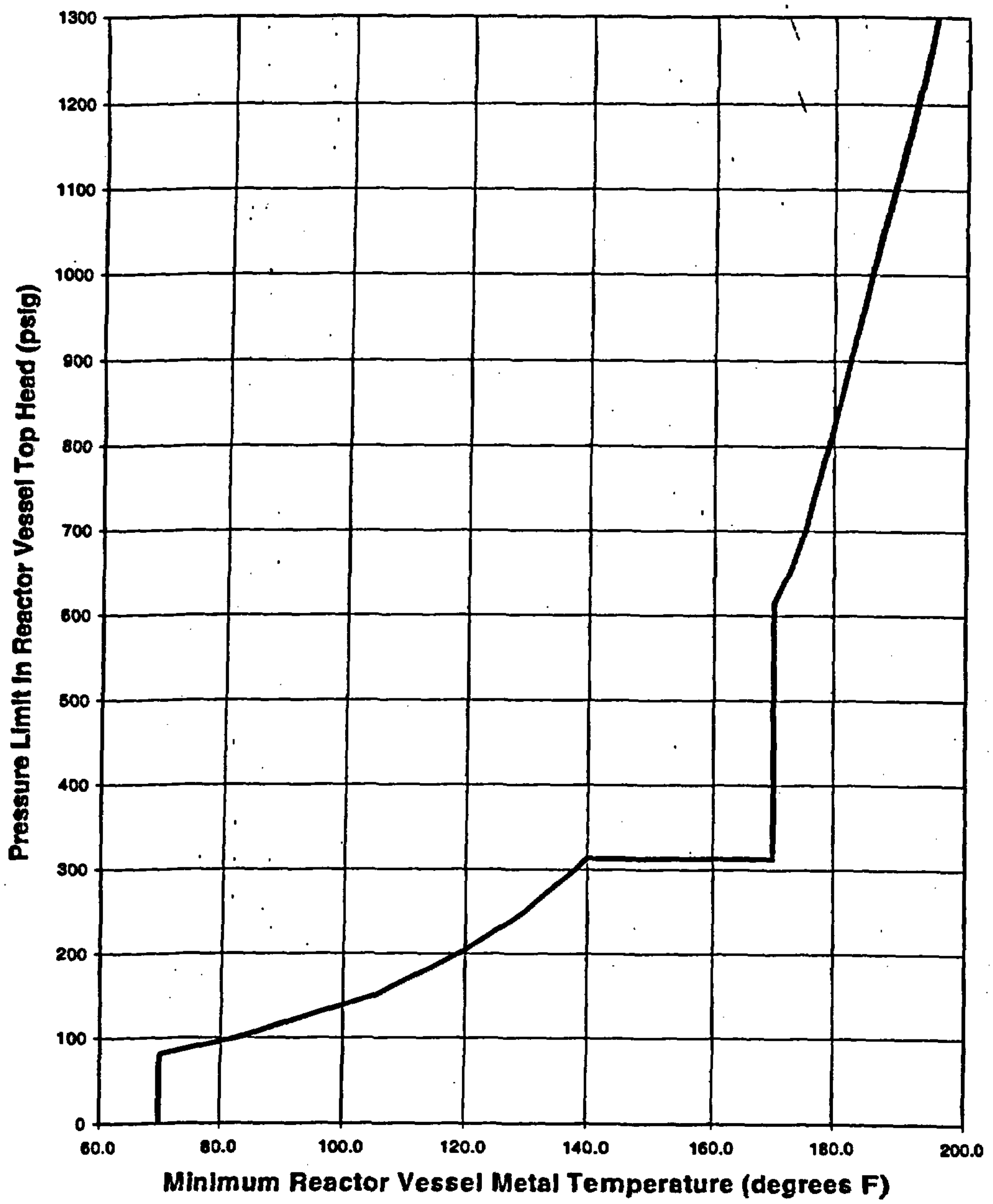

Figure 5
SSES-1 Core Critical Curve (Curve C) for 35.7 EFPY

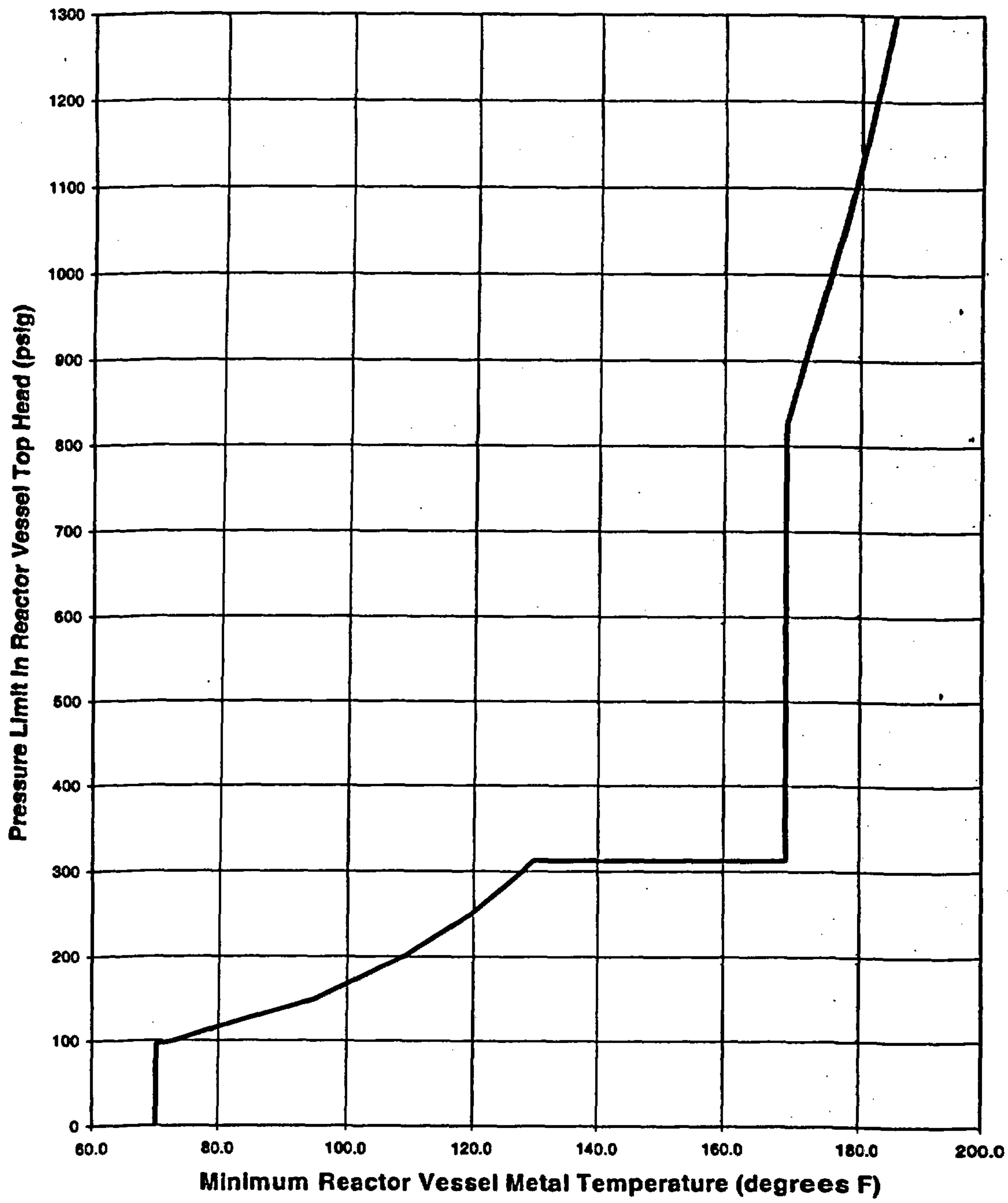

Figure 6
SSES-2 Core Critical Curve (Curve C) for 30.2 EFPY