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NOV 30 1988

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Gentlemen:

In the Matter of	)	Docket Nos. 50-259
Tennessee Valley Authority	)	50-260
	)	50-296
	)	50-327
	)	50-328
	)	50-390
	)	50-391

BROWNS FERRY NUCLEAR PLANT (BFN), SEQUOYAH NUCLEAR PLANT (SQN), AND WATTS BAR NUCLEAR PLANT (WBN) - RESPONSE TO GENERIC LETTER 88-11 - NRC POSITION ON RADIATION EMBRITTLEMENT OF REACTOR VESSEL MATERIALS AND ITS IMPACT ON PLANT OPERATIONS

This letter provides TVA's response to the subject generic letter. This generic letter requested licensees to (1) use the methodology described in revision 2 to Regulatory Guide (RG) 1.99, "Radiation Embrittlement of Reactor Vessel Materials," to predict the effect of neutron radiation on reactor vessel material as required by 10 CFR 50, Appendix G; (2) determine the impact of this RG on plant operations; and (3) determine what measures will be taken to alleviate operational difficulty because of implementation of the RG.

TVA has performed the necessary technical analysis and has compared the new curves with the current pressure-temperature (P-T) limit curves in each plant's technical specification. The comparison indicates that RG 1.99, revision 2, methodology has no immediate impact on plant operations and that the P-T curves for each plant are valid through the next two fuel cycles, with the exception of BFN unit 1. BFN unit 1 is defueled with a startup date to be determined. The details of this evaluation for each plant are provided in enclosure 1.

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Enclosure 2 provides a list of commitments made by TVA in this response. If you have any questions, please telephone D. L. Williams at (615) 632-7170.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

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ENCLOSURE 1

RESPONSE TO GENERIC LETTER 88-11 CONCERNING RADIATION EMBRITTLEMENT OF REACTOR VESSEL MATERIAL

TVA has performed the necessary technical analysis using the methodology provided in Regulatory Guide (RG) 1.99, revision 2, and provides the following responses for Browns Ferry Nuclear Plant (BFN), Sequoyah Nuclear Plant (SQN), and Watts Bar Nuclear Plant (WBN).

BFN

The pressure-temperature (P-T) limits for BFN are included in figure 3.6-1 of units 1, 2, and 3 technical specifications (TS). These limit curves were incorporated by BFN TS 191, supplement 1, submitted to the NRC on March 20, 1985, and approved by safety evaluation dated September 16, 1985. The curves are based on RG 1.99, revision 1, and the American Society of Mechanical Engineering (ASME), Section III, Appendix G, methodology and are valid through 12 effective full-power years (EFPY). Currently, unit 1 is at 6.14 EFPY of operation; unit 2 is at 5.54 EFPY; and unit 3 is at 4.68 EFPY.

The current curves for the three units are identical and based on the most limiting weld among the three units. The limiting weld is circumferential weld WF154 located in unit 1 and was assumed in the March 20, 1985 submittal, to be located approximately 28 inches below the core midplane. However, our review in response to this generic letter determined that the weld is actually 37 inches below the midplane. Thus, the assumption in the previous TS submittal resulted in extra conservatism in the P-T curves.

Using the RG 1.99, revision 2, methodology, P-T limits were determined for the limiting weld on each unit at the hydrostatic testing pressure of 1100 pounds per square inch (lb/in^2). A comparison was then made to the same limit derived from the TS curves. The evaluation shows that the TSs are currently bounding for units 2 and 3 at 1100 lb/in^2. Unit 1 is not bounded with present neutron exposure using revision 2 methodology because it exceeds the present curve by approximately 5 degrees Fahrenheit. Units 2 and 3 will be bounded by the present TS until approximately 10 EFPY, which is expected to carry the units through two operating cycles. Units 2 and 3 have more operating margin than unit 1 because the most limiting weld in those reactor vessels has less copper and nickel content and a lower initial nil-ductility transition temperature.

It is also projected that a minimum hydrostatic testing temperature of 200 degrees Fahrenheit will be reached on unit 1 at the end of cycle 12 and on units 2 and 3 at the end of cycle 18. It is recognized that testing at the minimum temperature of 200 degrees Fahrenheit may have an impact on plant operations. However, it is anticipated that industry experience and recommendations should be available by that time, to minimize this potential problem.

The three BFN units are currently shut down. Unit 2 is expected to restart in 1989. Units 1 and 3 are on administrative hold with projected restart dates to be determined. TVA does not expect the revision 2 methodology to have a significant impact before March 1, 1991; therefore, TVA will submit TS revisions before March 1, 1991, to comply with RG 1.99, revision 2. Unit 1 TS revisions will be submitted for approval before fuel load if the fuel load date occurs before March 1, 1991.

SQN

The present P-T limits for SQN are included in TS figures 3.4-2 and 3.4-3 of the respective unit. These curves are based upon the methodology described in Westinghouse WCAP-7924-A, "Basis for Heatup and Cooldown Limit Curves," and ASME Section III, Appendix G, and were computed so that the curves are valid through 9.2 EFPY for SQN unit 1 and 16 EFPY for SQN unit 2. These curves were approved by the NRC in safety evaluation, supplement 1, dated February 1980. The current EFPY of operation for each reactor vessel is approximately 2.9 for both SQN units 1 and 2.

Using the RG 1.99, revision 2, methodology and ASME, Section III, Appendix G, P-T limits were determined for the limiting material for each unit (the lower forging for SQN unit 1 and the intermediate forging for SQN unit 2). A comparison was then made to the existing TS curves. The present P-T curves are bounding for approximately 5 EFPY for both units. It is not anticipated that the low temperature overpressurization setpoints or the enable temperatures will result in an operational problem for the current licenses period of the units.

It is unlikely that RG 1.99, revision 2, will have a significant impact before March 1, 1991, or before the end of the current operating license period of the units. TVA will submit TS revisions for SQN units 1 and 2 by March 1, 1991, to comply with RG 1.99, revision 2.

WBN

The P-T limit curves to predict the effect of neutron radiation on reactor vessel material for WBN will be located in the respective unit's TS, figures 3.4-2 and 3.4-3. Preliminary calculations were performed using the RG 1.99, revision 2, methodology. It is not anticipated that the RG 1.99, revision 2, methodology will have an impact on plant operations for the operating license period. To comply with RG 1.99, revision 2, this revised methodology will be used to develop the initial P-T curves for the WBN TS that will be submitted to the NRC for approval before fuel load of unit 1.

ENCLOSURE 2

GENERIC LETTER 88-11
RESPONSE FOR BFN, SQN, AND WBN
LIST OF COMMITMENTS

1. TVA will submit BFN units 1, 2, and 3 Technical Specification (TS) revisions by March 1, 1991, to comply with Regulatory Guide (RG) 1.99, revision 2.

2. BFN unit 1 TS revisions will be submitted for approval before fuel load if the fuel load date occurs before March 1, 1991.

3. TVA will submit TS revisions for SQN units 1 and 2 by March 1, 1991, to comply with RG 1.99, revision 2.

4. To comply with RG 1.99, revision 2, this methodology will be used to develop the initial P-T curves for the WBN TS that will be submitted to the NRC for approval before fuel load of unit 1.

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PRESSURE-TEMPERATURE LIMITS BASED ON REG. GUIDE 1.99 REV. 2
WBN UNITS 1 AND 2

computed ______ date ______
checked ______ date ______

WBN-MTB-011

1.0 PURPOSE

The purpose of this calculation is to assess the impact of Regulatory Guide 1.99 Rev. 2 on the pressure-temperature (P-T) limits for Watts Bar Nuclear Units 1 and 2 so as to respond to "NRC Position on Radiation Embrittlement of Reactor Vessel Materials and Its Impact on Plant Operations" (Generic Letter 88-11).

2.0 BACKGROUND

The NRC has developed new radiation embrittlement trend curves in Reg. Guide 1.99 Rev. 2 based on improved theory, including the effect of nickel on radiation embrittlement of reactor vessel steels, and an increased irradiated Charpy impact test data base. In general the trend curves predict larger RT_{NDT} shift values than does Reg. Guide 1.99 Rev.1. Accordingly, the P-T curves at WBN Units 1 and 2 need to be re-evaluated to 1) assess the effect of the new trend curves on the leak test limits and 2) the duration validity of the heat-up and cool-down curves that were based on Reg. Guide 1.99 Rev. 1.

3.0 ASSUMPTIONS

This analysis utilizes the procedures in ASME Section III Appendix G using the adjusted reference temperature calculated from Reg. Guide 1.99 Rev. 2 to shift the P-T limits in accordance with 10CFR50 Appendix G. Since these procedures are followed rigorously, no other assumptions outside the procedures are made.

PRESSURE-TEMPERATURE LIMITS BASED ON REG. GUIDE 1.99 REV. 2
WBN UNITS 1 AND 2

computed______date________
checked______date________

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4.0 SOURCE OF DESIGN INPUT

4.1 ASME Boiler and Pressure Vessel Code, Section III, Appendix G, 1986 Edition.

4.2 ASME Boiler and Pressure Vessel Code, Section III, Appendix A, 1986 Edition.

4.3 Westinghouse Electric Drawing Number 30738-1510.

4.4 Tennessee Valley Authority Watts Bar Unit No. 1 Reactor Vessel Radiation Surveillance Program, WCAP-9298, Westinghouse Electric Corporation, Pittsburgh PA., July 1978 (RIMS B46 88 1021 548).

4.5 Tennessee Valley Authority Watts Bar Unit No. 2 Reactor Vessel Radiation Surveillance Program, WCAP-9455, Westinghouse Electric Corporation, Pittsburgh PA., March 1979 (RIMS B46 88 1021 547).

4.6 Reactor Coolant System Appendix G Heatup/Cooldown Curve Calculator, SIR-88-030, Pacific Gas and Electric Co. and Structural Integrity Associates, Inc., October 3, 1988.

4.7 Analysis of Capsule T From the Tennessee Valley Authority Sequoyah Unit 1 Reactor Vessel Radiation Surveillance Program, WCAP-10340, Westinghouse Electric Corporation, Pittsburgh, PA., May 1983.

4.8 Radiation Embrittlement of Reactor Vessel Materials, Regulatory Guide 1.99 Rev. 2, May 1988.

4.9 10 Code of Federal Regulations Part 50 Appendix G.

4.10 WBN 1 and ~~3~~ 2 Technical Specifications.

5.0 DESIGN INPUT DATA

5.1 WBN Chemical Composition Data and Initial RT_{NDT} Values

PRESSURE-TEMPERATURE LIMITS BASED ON REG. GUIDE 1.99 REV. 2
WBN UNITS 1 AND 2

computed________date________
checked________date________

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By inspection of references 4.4 and 4.5, it was determined that the lower forgings (05 forging) were the controlling materials both both units since they contained the highest amounts of Cu and Ni for the respective reactor vessels along with the largest value of initial RT_{NDT}. These values are listed below.

	Cu (Percent)	Ni (Percent)	Initial RT_{NDT} (°F)
Unit 1	0.17	0.80	47
Unit 2	0.05	0.78	14

5.3 Standard Deviation Data

Since the controlling metals for both plants are forgings, the standard deviation of RT_{NDT}, σ_I , is 17°F or 0.5 times the mean value of RT_{NDT} whichever is smaller as required by reference 4.8. The precision of the tests used to determine the initial RT_{NDT} is estimated to be 10°F. Therefore, σ_I is estimated to be 10°F.

5.4 Reactor Vessel Dimensions

Vessel Inner Radius	=	86.5 inch	Ref. 4.3
Vessel Thickness	=	8.46 inch	
Cladding Thickness	=	0.156 inch	

6.0 COMPUTATIONS/ANALYSIS

6.1 Determination of the Minimum Pressure/Temperature Curves

Reference 4.6 was used to calculate the P-T limits for Watts Bar units 1 and 2. This computer program follows the procedures of Section III, Appendix G, Article G-2000, of the ASME Code to calculate the minimum hydrostatic test temperature and the heatup and cooldown curves for both reactor vessels. Details of the methodology can be found in Reference 4.6. The spread sheet requires reactor vessel dimensions, heatup and cooldown rates, and the present RT_{NDT} as input to the calculation. For irradiated material, RT_{NDT} is the ART (adjusted reference temperature) as defined in Reference 4.8, Surveillance Data Not Available.

$$ART = \text{Initial } RT_{NDT} + \Delta RT_{NDT} + \text{Margin}$$

$$\Delta RT_{NDT} = (CF)f^{(0.28 - 0.10\log f)}$$

The chemistry factor, CF, is taken from Table 1 (for ~~welds~~ forgings) of Reference 4.8 using the appropriate chemical composition values combined with linear interpolation. For WBN Unit 1:

CF = 132

For WBN Unit 2:

CF = 31

The cumulative surface fluence (f_{surf}) can be estimated using the results from the SQN surveillance program (Reference 4.7) for both units as follows:

$$\begin{aligned} f_{surf} &= 0.0940 \times 10^{19} \text{ nvt/EFPY} \\ &= 0.47 \times 10^{19} \text{ nvt for 5 EFPY} \\ &= 3.008 \times 10^{19} \text{ nvt for 32 EFPY} \end{aligned}$$

The fluence at 1/4T and 3/4T is given by equation 3 in Ref. 4.8

$$\begin{aligned} f = f_{surf}(e^{-0.24x}) &= f_{surf}(0.5963) \text{ at } 1/4T \\ &= f_{surf}(0.2121) \text{ at } 3/4T \end{aligned}$$

$$x_{1/4T} = 1/4(8.46 + 0.156) = 2.154 \text{ inch}$$
$$x_{3/4T} = 3/4(8.46 + 0.156) = 6.462 \text{ inch}$$

$$f_{1/4T} = 0.280 \times 10^{19} \text{ nvt for 5 EFPY}$$
$$f_{3/4T} = 0.0997 \times 10^{19} \text{ nvt for 5 EFPY}$$

$$f_{1/4T} = 1.79 \times 10^{19} \text{ nvt for 32 EFPY}$$

PRESSURE-TEMPERATURE LIMITS BASED ON REG. GUIDE 1.99 REV. 2
WBN UNITS 1 AND 2

computed______date______
checked______date______

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$f_{3/4T}$ = 0.638 x 10^{19} nvt for 32 EFPY

For WBN Unit 1:

$\Delta RT_{NDT}(1/4T)$ = 86.1°F for 5 EFPY
$\Delta RT_{NDT}(3/4T)$ = 54.9°F for 5 EFPY

$\Delta RT_{NDT}(1/4T)$ = 153.1°F for 32 EFPY
$\Delta RT_{NDT}(3/4T)$ = 115.4°F for 32 EFPY

Margin(1/4T) = $2\sqrt{10^2 + 17.0^2}$ = 39.4°F for 5 EFPY
Margin(3/4T) = $2\sqrt{10^2 + 17.0^2}$ = 39.4°F for 5 EFPY

Margin(1/4T) = $2\sqrt{10^2 + 17.0^2}$ = 39.4°F for 32 EFPY
Margin(3/4T) = $2\sqrt{10^2 + 17.0^2}$ = 39.4°F for 32 EFPY

ART = Initial RT_{NDT} + ΔRT_{NDT} + Margin

ART(1/4T) = 47.0 + 86.1 + 39.4 = 172.5°F for 5 EFPY
ART(3/4T) = 47.0 + 54.9 + 39.4 = 141.3°F for 5 EFPY

ART(1/4T) = 47.0 + 153.1 + 39.4 = 239.5°F for 32 EFPY
ART(3/4T) = 47.0 + 115.4 + 39.4 = 201.8°F for 32 EFPY

For WBN Unit 2:

$\Delta RT_{NDT}(1/4T)$ = 17.5°F for 5 EFPY
$\Delta RT_{NDT}(3/4T)$ = 12.9°F for 5 EFPY

$\Delta RT_{NDT}(1/4T)$ = 36.0°F for 32 EFPY
$\Delta RT_{NDT}(3/4T)$ = 27.1°F for 32 EFPY

Margin(1/4T) = $2\sqrt{10^2 + 8.75^2}$ = 26.6°F for 5 EFPY
Margin(3/4T) = $2\sqrt{10^2 + 6.45^2}$ = 11.9°F for 5 EFPY

Margin(1/4T) = $2\sqrt{10^2 + 17.0^2}$ = 39.4°F for 32 EFPY
Margin(3/4T) = $2\sqrt{10^2 + 13.6^2}$ = 33.7°F for 32 EFPY

ART = Initial RT_{NDT} + ΔRT_{NDT} + Margin

PRESSURE-TEMPERATURE LIMITS BASED ON REG. GUIDE 1.99 REV. 2
WBN UNITS 1 AND 2

computed ______ date ______
checked ______ date ______

WBN-MTB-011

ART(1/4T) = 14.0 + 17.5 + 26.6 = 58.1°F for 5 EFPY
ART(3/4T) = 14.0 + 12.8 + 11.9 = 38.8°F for 5 EFPY

ART(1/4T) = 14.0 + 36.0 + 39.4 = 89.4°F for 32 EFPY
ART(3/4T) = 14.0 + 27.1 + 33.7 = 74.8°F for 32 EFPY

These results were used as input to the Lotus 1-2-3 spread sheet (Reference 4.6). The resultant heatup and cooldown curves were compared with the present technical specification curve as shown in the following figures.

These results show that WBN Units 1 and 2 could operate approximately 5EFPY without a technical specification change.

7.0 SUMMARY OF RESULTS

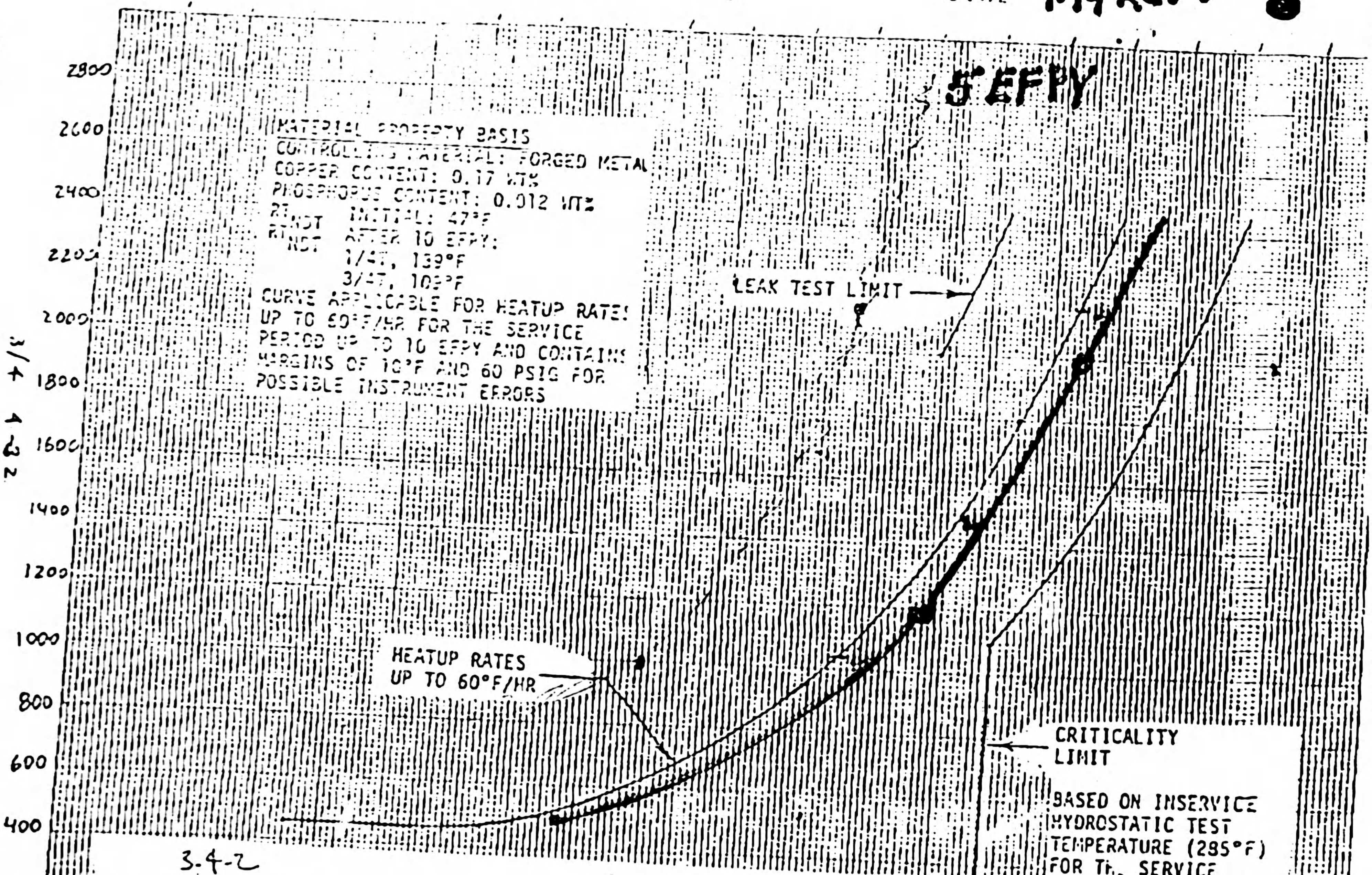
The results of this calculation indicate that:

1) WBN Units 1 and 2 can run for the approximately 5 EFPY without changing the technical specifications.

2) WBN Units 1 and 2 will not be affected by significantly by Reg. Guide 1.99 Rev. 2 throughout their original design lives.

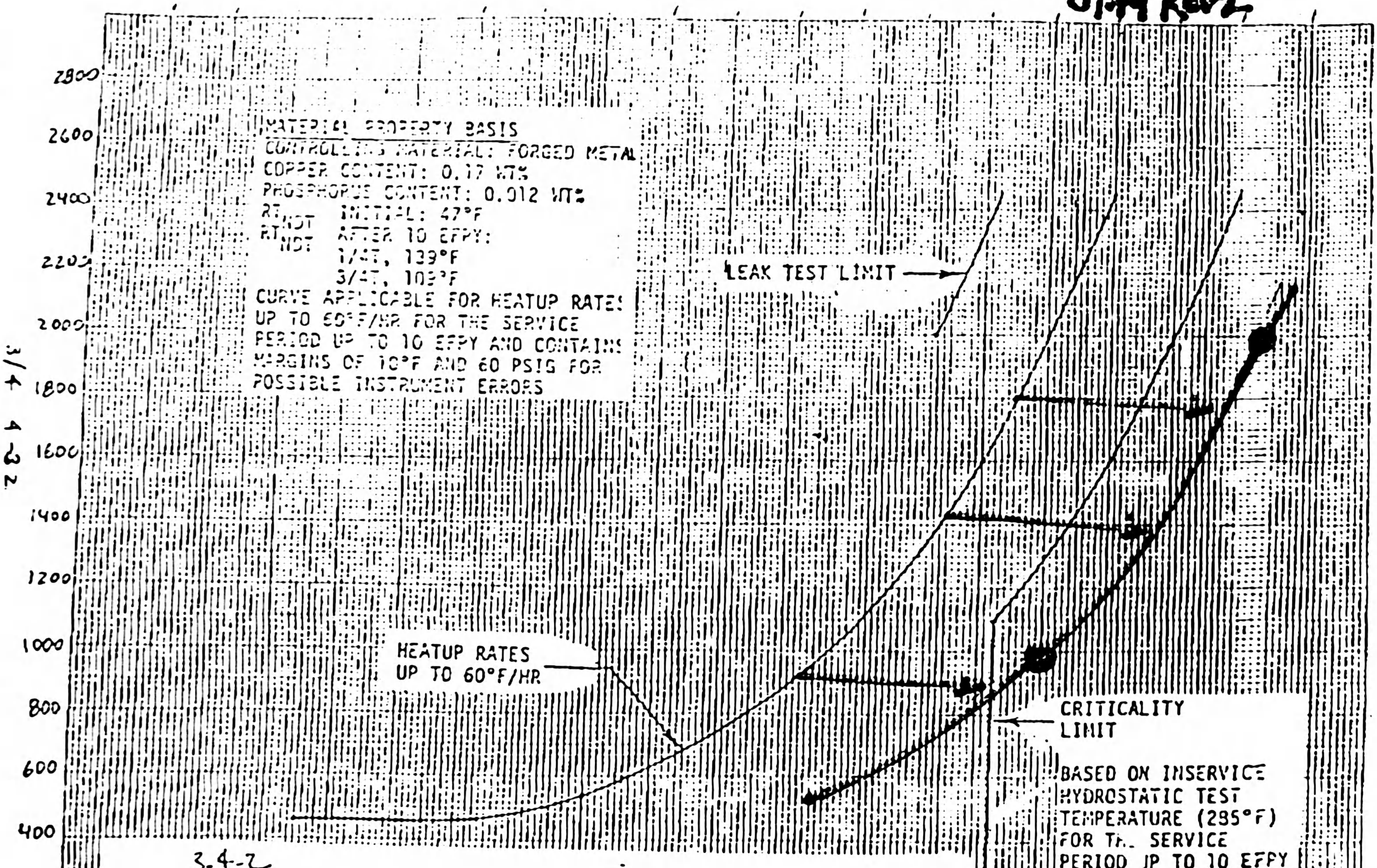
Reg Guide 1.99 Rev 2

46 1472



3.4-2

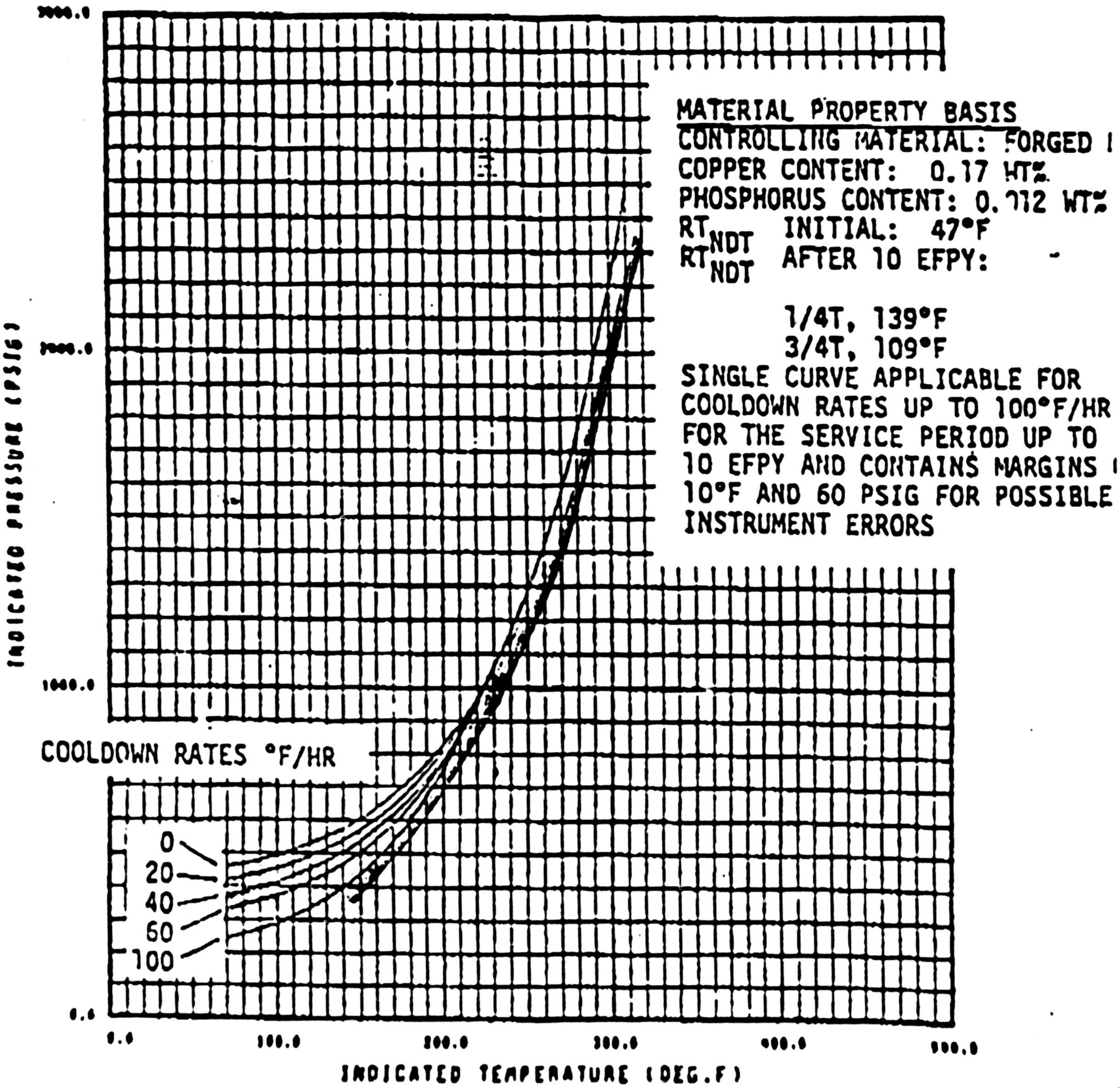
FIGURE 1 - WATTS BAR UNIT 1 REACTOR COOLANT SYSTEM HEATUP LIMITATIONS APPLICABLE FOR 10 EFPY



3.4-2

FIGURE 1 - WATTS BAR UNIT 1 REACTOR COOLANT SYSTEM HEATUP LIMITATIONS APPLICABLE FOR 10 EFPY

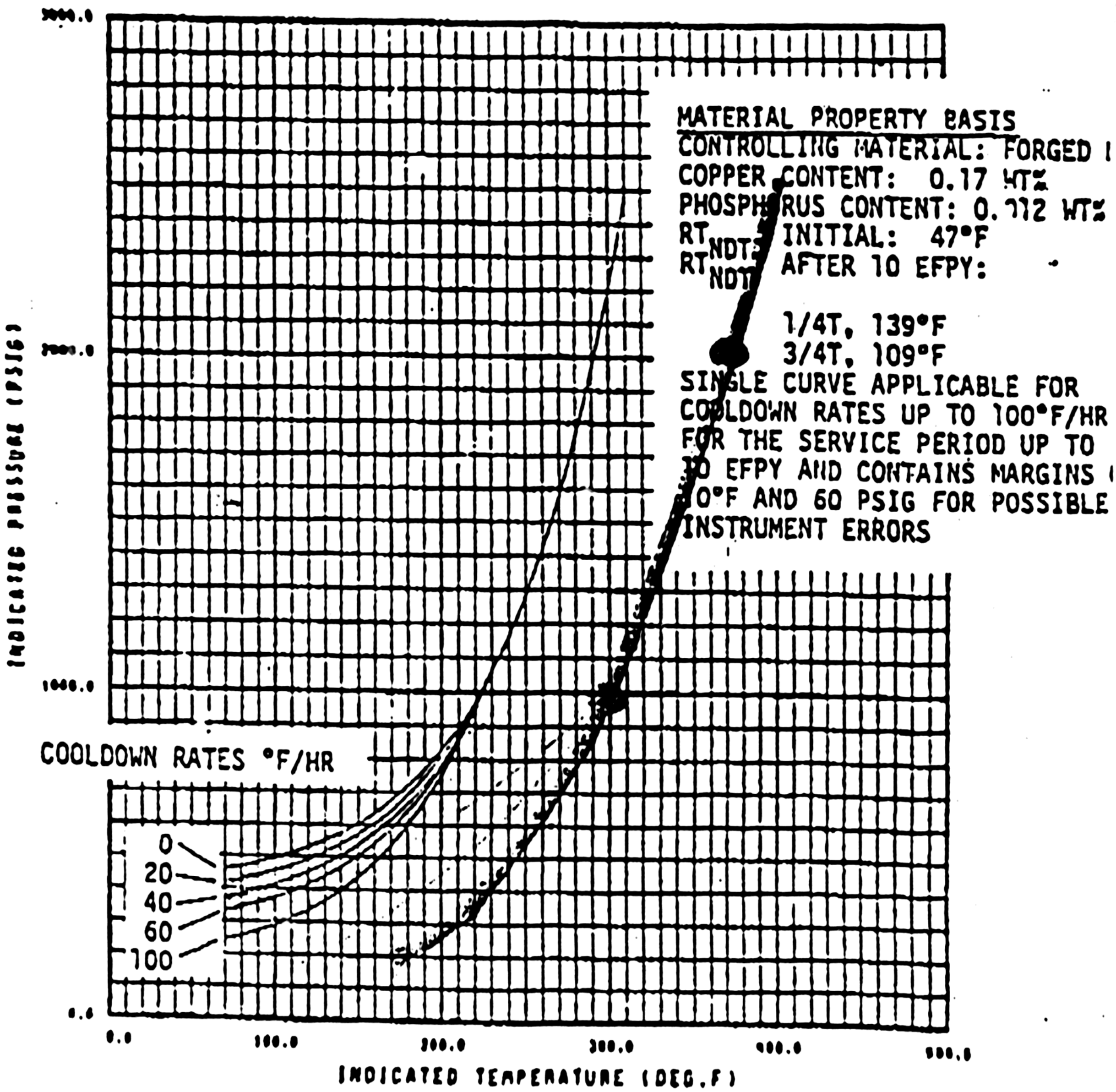
5 EFPY
Reg Guide 1.99 Rev 2



3.4-3

FIGURE 8 - WATTS BAR UNIT 1 REACTOR COOLANT SYSTEM COOLDOWN LIMITATIONS APPLICABLE FOR 10 EFPY

32 EFPY
Reg Guide 1.99 Rev 2



3.4-3

FIGURE - WATTS BAR UNIT 1 REACTOR COOLANT SYSTEM COOLDOWN LIMITATIONS APPLICABLE FOR 10 EFPY

Watts Bar 2

32 EFPY
Reg. Guide 1.99 Rev:

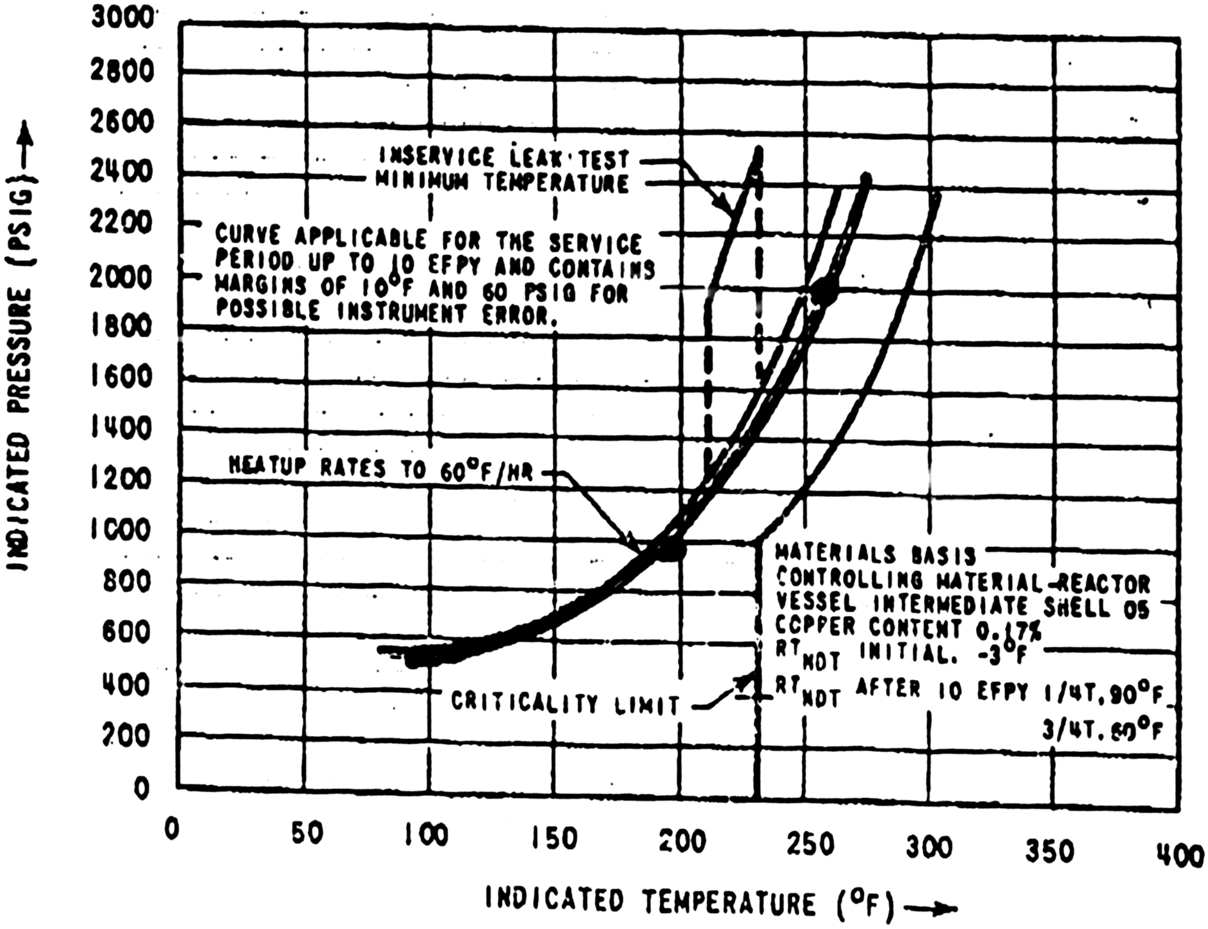


Figure 3.4-2. Reactor Coolant System Pressure/Temperature Limitations.

Watts Bar 2
32 EFPY
Reg Guide 1.99 Rev 2

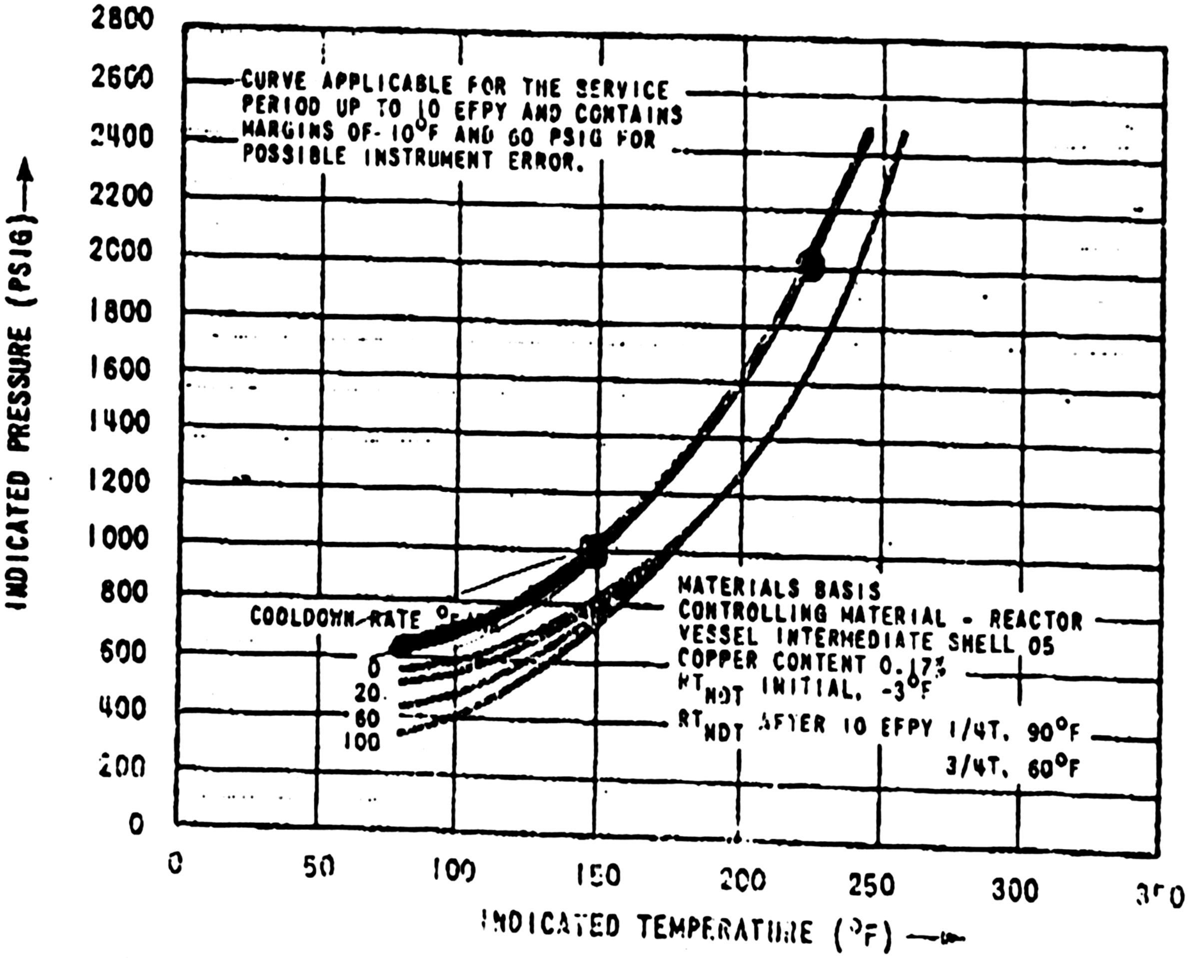


Figure 3.4-3. Reactor Coolant System Temperature Limits versus Cooldown Rates

Watts Bar 2

Reg Guide 1.99 Rev 2
5 EFPY

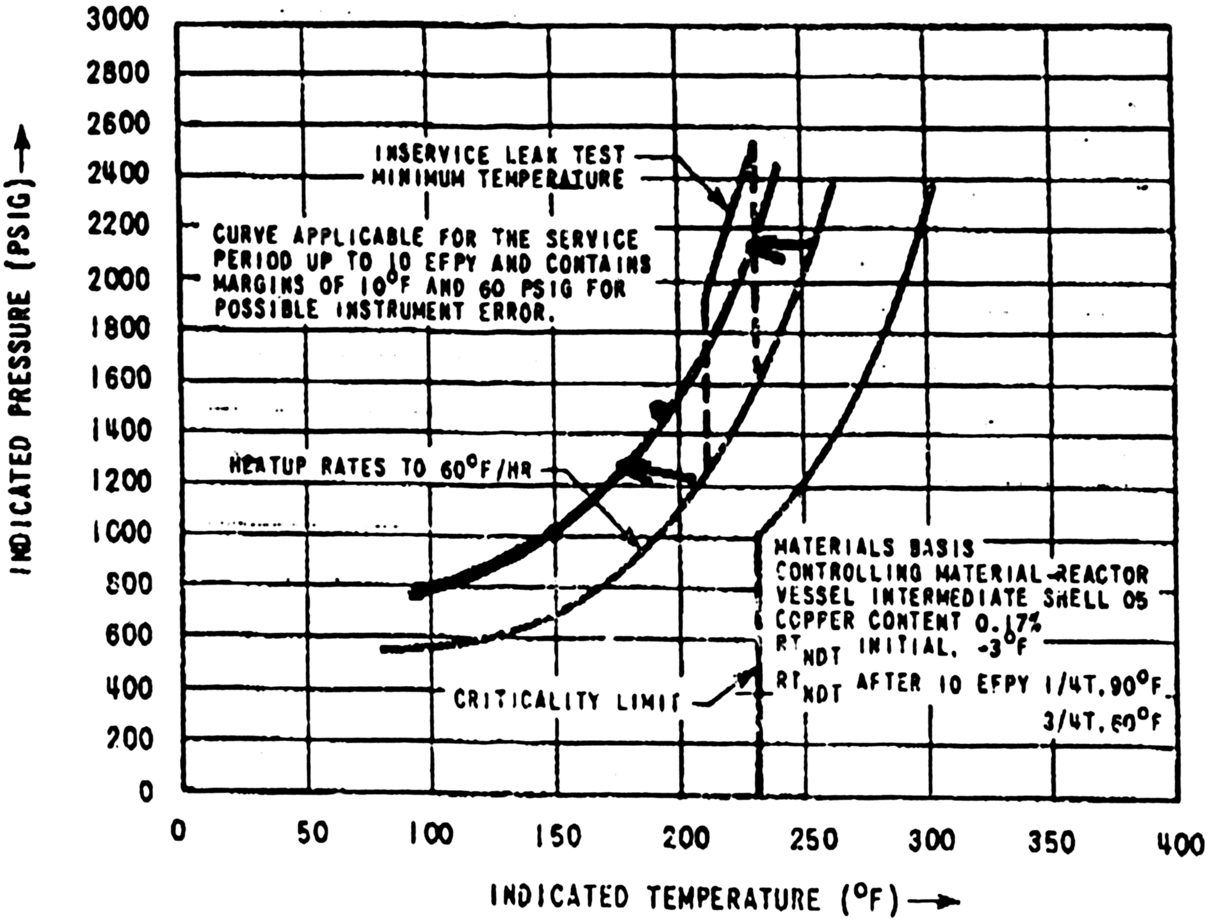


Figure 3.4-2. Reactor Coolant System Pressure/Temperature Limitations.

Reg Guide 1.99 Rev2
5 EFPY

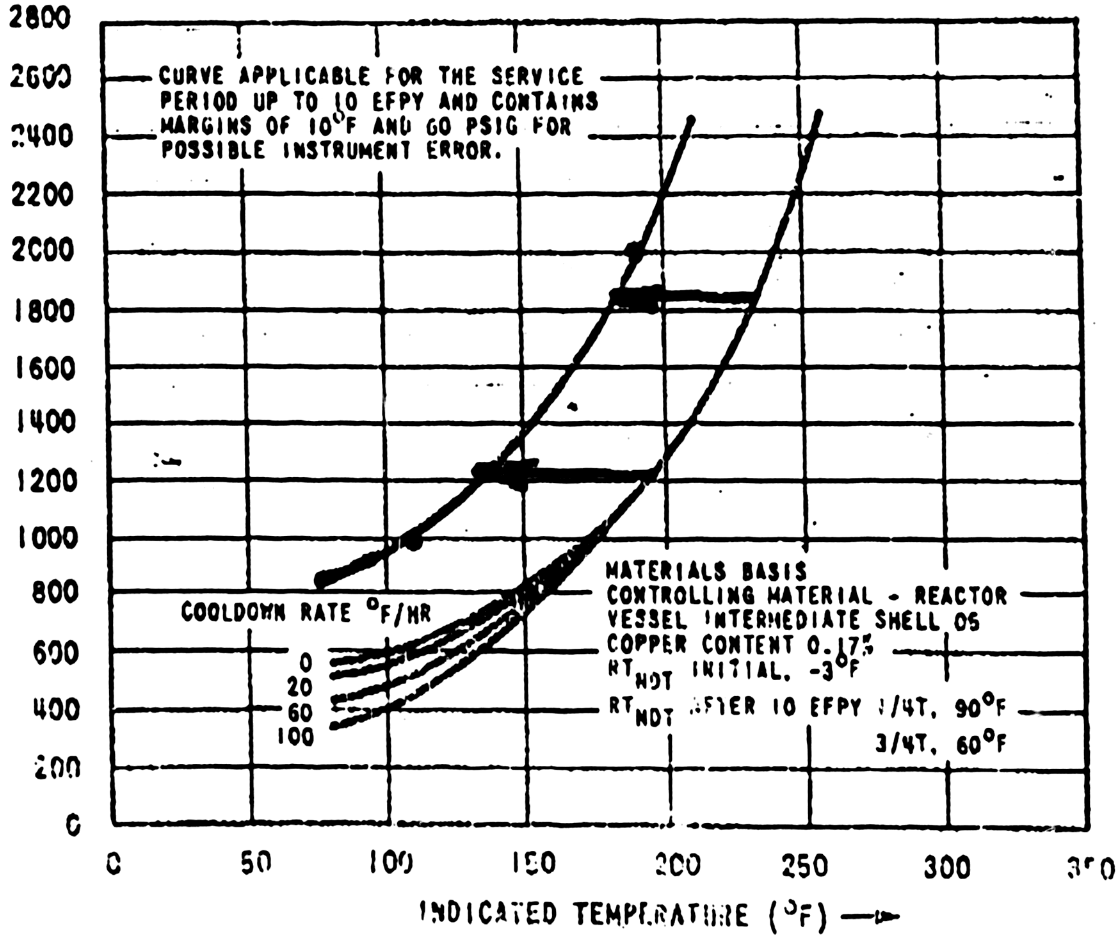


Figure 3.4-3. Reactor Coolant System Temperature Limits versus Cooldown Rates