WEC PROPRIETARY CLASS 3

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WCAP-13229

HEATUP AND COOLDOWN LIMIT CURVES FOR NORMAL OPERATION FOR KEWAUNEE

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1. INTRODUCTION

Heatup and cooldown limit curves are calculated using the most limiting value of RT_{NDT} (reference nil-ductility temperature) for the reactor vessel. The most limiting RT_{NDT} of the material in the core region of the reactor vessel is determined by using the preservice reactor vessel material fracture toughness properties and estimating the radiation-induced ΔRT_{NDT}. RT_{NDT} is designated as the higher of either the drop weight nil-ductility transition temperature (NDTT) or the temperature at which the material exhibits at least 50 ft-lb of impact energy and 35-mil lateral expansion (normal to the major working direction) minus 60°F.

RT_{NDT} increases as the material is exposed to fast-neutron radiation. Therefore, to find the most limiting RT_{NDT} at any time period in the reactor's life, ΔRT_{NDT} due to the radiation exposure associated with that time period must be added to the original unirradiated RT_{NDT}. The extent of the shift in RT_{NDT} is enhanced by certain chemical elements (such as copper and nickel) present in reactor vessel steels. The Nuclear Regulatory Commission (NRC) has published a method for predicting radiation embrittlement in Regulatory Guide 1.99 Rev. 2 (Radiation Embrittlement of Reactor Vessel Materials)[1]. Regulatory Guide 1.99, Revision 2 is used for the calculation of RT_{NDT} values at 1/4T and 3/4T locations (T is the thickness of the vessel at the beltline region).

2. FRACTURE TOUGHNESS PROPERTIES

The fracture-toughness properties of the ferritic material in the reactor coolant pressure boundary are determined in accordance with the NRC Regulatory Standard Review Plan[2]. The pre-irradiation fracture-toughness properties for the Kewaunee reactor vessel materials are presented in Table 1 in p.6.

3. CRITERIA FOR ALLOWABLE PRESSURE-TEMPERATURE RELATIONSHIPS

The ASME approach for calculating the allowable limit curves for various heatup and cooldown rates specifies that the total stress intensity factor, K_I, for the combined thermal and pressure stresses at any time during heatup or cooldown cannot be greater than the reference stress intensity factor, K_{IR}, for the metal temperature at that time. K_{IR} is obtained from the reference fracture toughness curve, defined in Appendix G to the ASME Code[3]. The K_{IR} curve is given by the following equation:

$$K_{IR} = 26.78 + 1.223 \exp [0.0145 (T-RT_{NDT} + 160)] \qquad (1)$$

where

K_{IR} = reference stress intensity factor as a function of the metal temperature T and the metal reference nil-ductility temperature RT_{NDT}

Therefore, the governing equation for the heatup-cooldown analysis is defined in Appendix G of the ASME Code[3] as follows:

$$C^*K_{IM} + K_{IT} \le K_{IR} \qquad (2)$$

where

K_{IM} = stress intensity factor caused by membrane (pressure) stress

K_{IT} = stress intensity factor caused by the thermal gradients

K_{IR} = function of temperature relative to the RT_{NDT} of the material

C = 2.0 for Level A and Level B service limits

C = 1.5 for hydrostatic and leak test conditions during which the reactor core is not critical

At any time during the heatup or cooldown transient, K_{IR} is determined by the metal temperature at the tip of the postulated flaw, the appropriate value for RT_{NDT}, and the reference fracture toughness curve. The thermal stresses resulting from the temperature gradients through the vessel wall are calculated and then the corresponding (thermal) stress intensity factors, K_{IT}, for the reference flaw are computed. From equation 2, the pressure stress intensity factors are obtained and from these the allowable pressures are calculated.

For the calculation of the allowable pressure versus coolant temperature during cooldown, the reference flaw of Appendix G to the ASME Code is assumed to exist at the inside of the vessel wall. During cooldown, the controlling location of the flaw is always at the inside of the wall because the thermal gradients produce tensile stresses at the inside, which increase with increasing cooldown rates. Allowable pressure-temperature relations are generated for both steady-state and finite cooldown rate situations. From these relations, composite limit curves are constructed for each cooldown rate of interest.

The use of the composite curve in the cooldown analysis is necessary because control of the cooldown procedure is based on the measurement of reactor coolant temperature, whereas the limiting pressure is actually dependent on the material temperature at the tip of the assumed flaw.

During cooldown, the 1/4 T vessel location is at a higher temperature than the fluid adjacent to the vessel ID. This condition, of course, is not true for the steady-state situation. It follows that, at any given reactor coolant temperature, the ΔT developed during cooldown results in a higher value of K_{IR} at the 1/4 T location for finite cooldown rates than for steady-state operation. Furthermore, if conditions exist so that the increase in K_{IR} exceeds K_{IT}, the calculated allowable pressure during cooldown will be greater than the steady-state value.

The above procedures are needed because there is no direct control on temperature at the 1/4 T location and, therefore, allowable pressures may unknowingly be violated if the rate of cooling is decreased at various intervals along a cooldown ramp. The use of the composite curve eliminates this problem and ensures conservative operation of the system for the entire cooldown period.

Three separate calculations are required to determine the limit curves for finite heatup rates. As is done in the cooldown analysis, allowable pressure-temperature relationships are developed for steady-state conditions as well as finite heatup rate conditions assuming the presence of a 1/4 T defect at the inside of the wall that alleviate the tensile stresses produced by internal pressure. The metal temperature at the crack tip lags the coolant temperature; therefore, the K_{IR} for the 1/4 T crack during heatup is lower than the K_{IR} for the 1/4 T crack during steady-state conditions at the same coolant temperature. During heatup, especially at the end of the transient, conditions may exist so that the effects of compressive thermal stresses and lower K_{IR}'s do not offset each other, and the pressure- temperature curve based on steady-state conditions no longer represents a lower bound of all similar curves for finite heatup rates when the 1/4 T flaw is considered. Therefore, both cases have to be analyzed in order to ensure that at any coolant temperature the lower value of the allowable pressure calculated for steady-state and finite heatup rates is obtained.

The second portion of the heatup analysis concerns the calculation of the pressure-temperature limitations for the case in which a 1/4 T deep outside surface flaw is assumed. Unlike the situation at the vessel inside surface, the thermal gradients established at the outside surface during heatup produce stresses which are tensile in nature and therefore tend to reinforce any pressure stresses present. These thermal stresses are dependent on both the rate of heatup and the time (or coolant temperature) along the heatup ramp. Since the thermal stresses at the outside are tensile and increase with increasing heatup rates, each heatup rate must be analyzed on an individual basis.

Following the generation of pressure-temperature curves for both the steady state and finite heatup rate situations, the final limit curves are produced by constructing a composite curve based on a point-by-point comparison of the steady-state and finite heatup rate data. At any given temperature, the allowable pressure is taken to be the lesser of the three values taken from the curves under consideration. The use of the composite curve is necessary to set conservative heatup limitations because it is possible for conditions to exist wherein, over the course of the heatup ramp, the controlling condition switches from the inside to the outside, and the pressure limit must at all times be based on analysis of the most critical criterion.

Finally, the 1983 Amendment to 10CFR50[4] has a rule which addresses the metal temperature of the closure head flange and vessel flange regions. This rule states that the metal temperature of the closure flange regions must exceed the material RT_{NDT} by at least 120°F for normal operation when the pressure exceeds 20 percent of the preservice hydrostatic test pressure (621 psig for Kewaunee).

The minimum allowable temperature is based upon the limiting initial RT_{NDT} in the vessel and closure flange regions for Kewaunee. Table 1 indicates that the initial RT_{NDT} of 60°F occurs in both the closure head flange and vessel flange of the Kewaunee reactor vessel, so the minimum allowable temperature of this region is 180°F at pressures greater than 621 psig. These limits are less restrictive than the limits shown in Figures 1 through 4.

4. HEATUP AND COOLDOWN PRESSURE-TEMPERATURE LIMIT CURVES

Pressure-temperature limit curves for normal heatup and cooldown of the primary Reactor Coolant System have been calculated using the methods discussed in Section 3. Figures 1 through 4 contain the heatup curves for 60 and 100 °F/hr for 20 and 34 EFPY, respectively. Figures 5 and 6 contain the cooldown curves up to 100°F/hr applicable to 20 and 34 EFPY, respectively. Margins of 10 °F and 60 psig are included in these figures to allow for possible instrumentation errors.

Allowable combinations of temperature and pressure for specific temperature change rates are below and to the right of the limit lines shown in Figures 1 through 6. This is in addition to other criteria which must be met before the reactor is made critical.

TABLE 1

KEWAUNEE REACTOR VESSEL TOUGHNESS TABLE (Unirradiated)

Material Description	CU (Weight %)	NI (Weight %)	Initial (a) RT_{NDT} (°F)
Closure Head Flange (b)	.16	.76	60
Vessel Flange (b)	.14	.68	60
Intermediate Shell Forging 122 x 208	.06	.71	60
Lower Shell Forging 123 x 167	.06	.75	20
Circumferential Weld	.283	.745	-56

a. The initial RT_{NDT} (I) values for the forgings are measured values and for the weld is a generic value. Values were obtained from Reference 5.

b. To be used when considering flange requirements for heatup/cooldown curves[4], the values are from Reference 5.

The leak limit curve shown in Figures 1 through 4 represents the minimum temperature requirements at the leak test pressure specified by applicable codes[2, 3]. The leak test limit curve was determined by methods of References 2 and 4.

The criticality limit curves shown in Figures 1 through 4, specify pressure-temperature limits for critical core operation to provide additional margin during actual power production as specified in Reference 4. The pressure-temperature limits for core operation (except for low power physics tests) are that the reactor vessel must be at a temperature equal to or higher than the minimum temperature required for the inservice hydrostatic test, and at least 40°F higher than the minimum pressure-temperature curve for heatup and cooldown calculated as described in Section 3. The maximum temperature for the inservice hydrostatic test for the Kewaunee reactor vessel is 381°F and 400°F for 20 and 34 EFPY respectively. A vertical line at 381°F and 400°F on the pressure-temperature curve for 20 EFPY and for 34 EFPY respectively, intersecting a curve 40°F higher than the pressure-temperature limit curve, constitutes the limit for core operation for the reactor vessel.

Figures 1 through 6 define limits for ensuring prevention of nonductile failure for the Kewaunee reactor vessel.

5. CALCULATION OF ADJUSTED REFERENCE TEMPERATURE

From Regulatory Guide 1.99 Rev. 2 [1] the adjusted reference temperature (ART) for each material in the beltline is given by the following expression:

$$ART = \text{Initial } RT_{NDT} + \Delta RT_{NDT} + \text{Margin} \quad (3)$$

Initial RT_{NDT} is the reference temperature for the unirradiated material as defined in paragraph NB-2331 of Section III of the ASME Boiler and Pressure Vessel Code. If measured values of initial RT_{NDT} for the material in question are not available, generic mean values for that class of material may be used if there are sufficient test results to establish a mean and standard deviation for the class.

ΔRT_{NDT} is the mean value of the adjustment in reference temperature caused by irradiation and should be calculated as follows:

$$\Delta RT_{NDT} = [CF] f^{(0.28-0.10 \log f)} \quad (4)$$

To calculate ΔRT_{NDT} at any depth (e.g., at 1/4T or 3/4T), the following formula must first be used to attenuate the fluence at the specific depth.

$$f_{(depth\ X)} = f_{surface}(e^{-.24x}) \quad (5)$$

where x (in inches) is the depth into the vessel wall measured from the vessel clad/base metal interface. The resultant fluence is then put into equation (4) to calculate ΔRT_{NDT} at the specific depth.

CF (°F) is the chemistry factor, a function of Copper and Nickel content. CF is obtained from Reference 1, in Table 1 for welds and in Table II for base metals (plates and forgings). Linear interpolation is permitted.

Applying Regulatory Guide 1.99 Revision 2 procedures to all the beltline region materials, it was found that the circumferential weld seam between the vessel intermediate and lower shell was the limiting material. Credible surveillance data is currently limited to the vessel beltline region circumferential weld between the vessel intermediate and lower shells. RT_{NDT} values for the circumferential weld were evaluated at 1/4T and 3/4T locations using chemistry factor values determined using Table I in Regulatory Guide 1.99 Revision 2 [1] and using surveillance capsule data.

The results of the RT_{NDT} values at 1/4T and 3/4T for all materials in the beltline region of Kewaunee are summarized in Table 2. Note the RT_{NDT} values shown in Table 2 were obtained using the Regulatory Guide 1.99 Revision 2 tables. The RT_{NDT} values using surveillance capsule data for the weld metal are shown in Table 2 with an * as a footnote. Sample calculations for RT_{NDT} are shown in Tables 3 and 4.

TABLE 2

SUMMARY OF ADJUSTED REFERENCE TEMPERATURE (ART) AT 1/4T and 3/4T LOCATION FOR 20 AND 34 EFPY

	20 EFPY RT_{NDT} AT		34 EFPY RT_{NDT} AT	
Component	1/4T (°F)	3/4T (°F)	1/4T (°F)	3/4T (°F)
Intermediate Shell Forging 122 x 208	136	128	139	131
Lower Shell Forging 123 x 167	96	88	99	91
Circumferential Weld *	248	202	267	222

* RT_{NDT} values using surveillance capsule data for the weld metal at 20 EFPY are 225.80°F and 184.34°F for 1/4T and 3/4T locations respectively, and at 34 EFPY are 243.07°F and 202.71°F for 1/4T and 3/4T locations respectively.

TABLE 3

CALCULATION OF ADJUSTED REFERENCE TEMPERATURES FOR LIMITING KEWAUNEE REACTOR VESSEL MATERIAL - CIRCUMFERENTIAL WELD - FOR 20 EFPY

Parameter	Regulatory Guide 1.99 - Revision 2 20 EFPY 1/4 T	 3/4 T
Chemistry Factor, CF (°F)	210.675	210.675
Fluence, f (10^{19} n/cm^2)[(a)]	1.591	0.729
Fluence Factor, FF	1.1282	0.9113
******************************		
ΔRT_{NDT} = CF x ff (°F)	238	192
Initial RT_{NDT}, I (°F)	-56	-56
Margin, M (°F) [(b)]	66	66
******************************		
Revision 2 to Regulatory Guide 1.99		
Adjusted Reference Temperature, ART = Initial RT_{NDT} + ΔRT_{NDT} + Margin	248	202

****

(a) Fluence, f, is based upon f_{surf} (10^{19} n/cm^2, E>1 Mev) = 2.35 at 20 EFPY. The Kewaunee reactor vessel wall thickness is 6.5 inches at the beltline region.

(b) Margin is calculated as, $M = 2\ [\sigma_I^2 + \sigma_\Delta^2]^{0.5}$. The standard deviation for the initial RT_{NDT} margin term (σ_I) is assumed to be 17°F since the initial RT_{NDT} is a generic value. The standard deviation for ΔRT_{NDT}, (σ_Δ) is 28°F for weld metal, except that σ_Δ need not exceed 0.50 times the mean value of ΔRT_{NDT}.

TABLE 4

CALCULATION OF ADJUSTED REFERENCE TEMPERATURES FOR LIMITING KEWAUNEE REACTOR VESSEL MATERIAL - C1RCUMFERENTIAL WELD - FOR 34 EFPY

	Regulatory Guide 1.99 - Revision 2	
	34 EFPY	
Parameter	1/4 T	3/4 T
Chemistry Factor, CF (°F)	210.675	210.675
Fluence, f (10^{19} n/cm^2)[(a)]	2.241	1.027
Fluence Factor, FF	I.2185	1.0075

****

ΔRT_{NDT} = CF x ff (°F)	257	212
Initial RT_{NDT}, I (°F)	-56	-56
Margin, M (°F) [(b)]	66	66

****

Revision 2 to Regulatory Guide 1.99

Adjusted Reference Temperature, ART = Initial RT_{NDT} + ΔRT_{NDT} + Margin	267	222

****

(a) Fluence, f, is based upon f_{surf} (10^{19} n/cm^2, E>1 Mev) = 3.31 at 34 EFPY. The Kewaunee reactor vessel wall thickness is 6.5 inches at the beltline region.

(b) Margin is calculated as, $M = 2\ [\sigma_I{}^2 + \sigma_\Delta{}^2]^{0.5}$. The standard deviation for the initial RT_{NDT} margin term (σ_I) is assumed to be 17°F since the initial RT_{NDT} is a generic value. The standard deviation for ΔRT_{NDT}, (σ_Δ) is 28°F for weld metal, except that σ_Δ need not exceed 0.50 times the mean value of ΔRT_{NDT}.

MATERIAL PROPERTY BASIS

CONTROLLING MATERIAL: CIRCUMFERENTIAL WELD

INITIAL RT_{NDT}: -56°F

ART AT 20 EFPY: 1/4T = 248°F

3/4T = 202°F

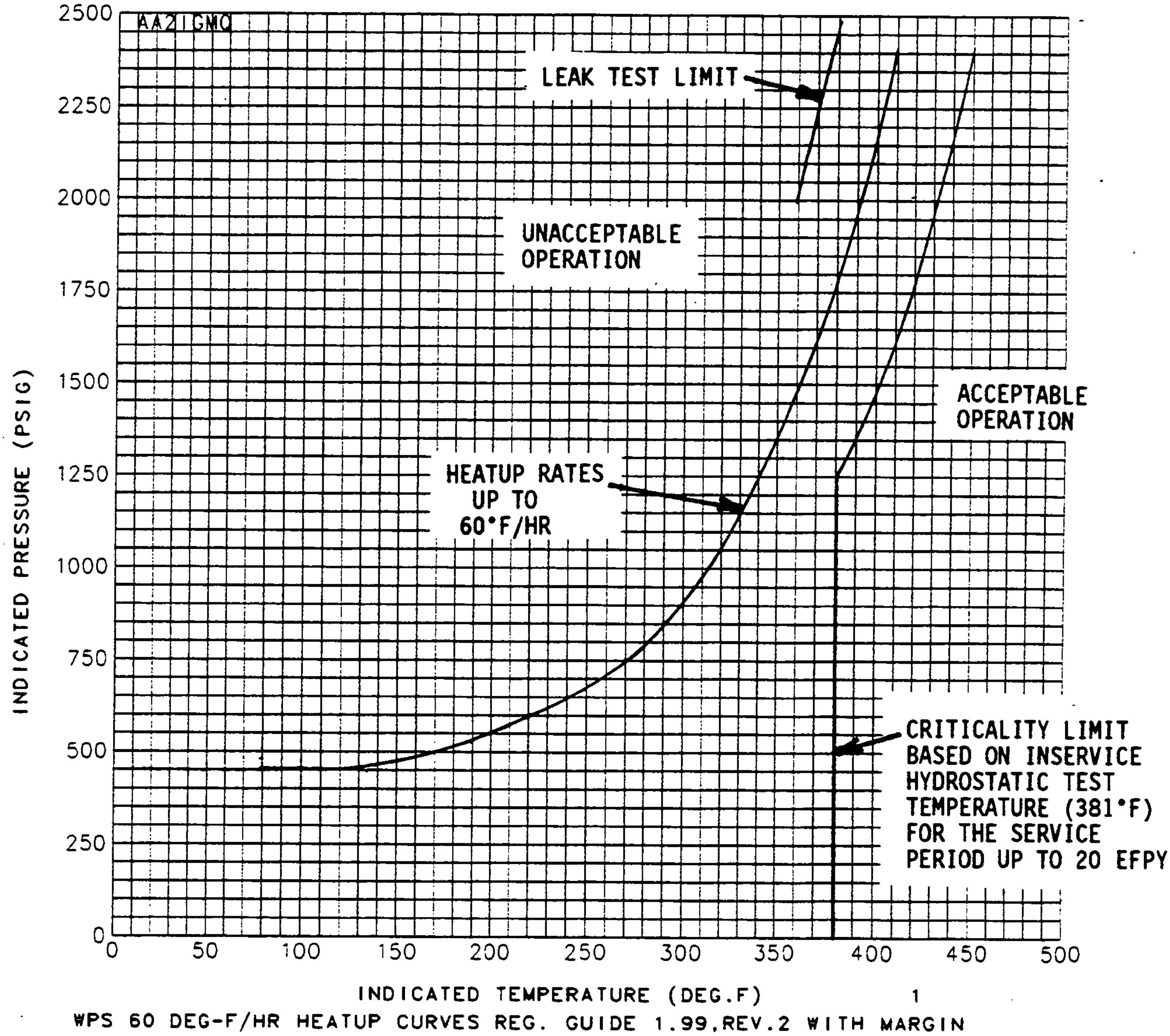

Figure 1. Kewaunee Reactor Coolant System Heatup Limitations (Heat up rate up to 60°F/hr) Applicable for the First 20 EFPY (With Margins of 10°F and 60 psig For Instrumentation Errors)

MATERIAL PROPERTY BASIS

CONTROLLING MATERIAL: CIRCUMFERENTIAL WELD

INITIAL RT_{NDT}: -56°F

ART AT 20 EFPY: 1/4T = 248°F

3/4T = 202°F

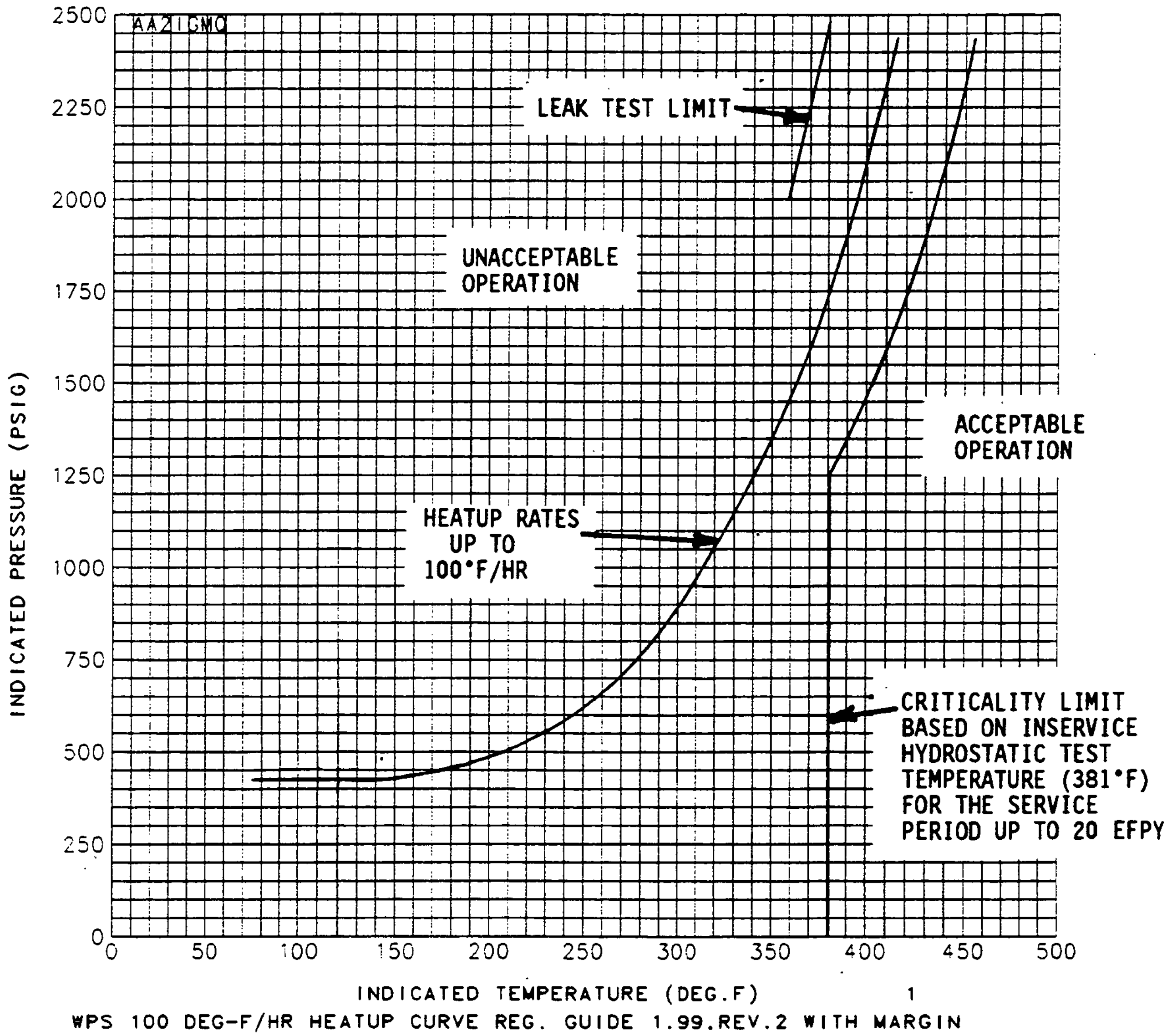

Figure 2. Kewaunee Reactor Coolant System Heatup Limitations (Heat up rate up to 100°F/hr) Applicable for the First 20 EFPY (With Margins of 10°F and 60 psig For Instrumentation Errors)

MATERIAL PROPERTY BASIS

CONTROLLING MATERIAL: CIRCUMFERENTIAL WELD

INITIAL RT_{NDT}: -56°F

ART AT 34 EFPY: 1/4T = 267°F

3/4T = 222°F

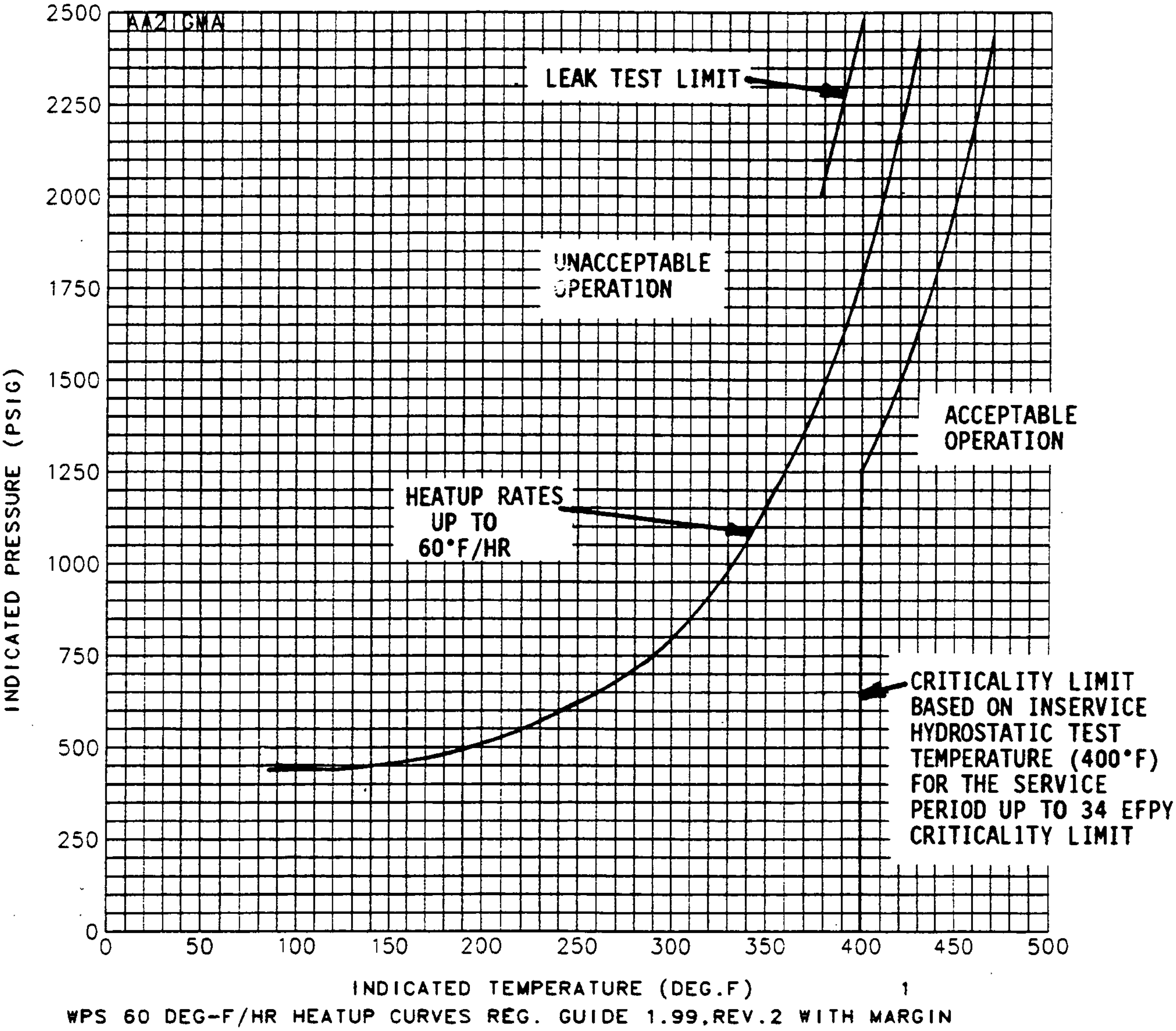

Figure 3. Kewaunee Reactor Coolant System Heatup Limitations (Heat up rate up to 60 °F/hr) Applicable for the First 34 EFPY (With Margins of 10°F and 60 psig For Instrumentation Errors)

MATERIAL PROPERTY BASIS

CONTROLLING MATERIAL: CIRCUMFERENTIAL WELD

INITIAL RT_{NDT}: -56°F

ART AT 34 EFPY: 1/4T = 267°F

3/4T = 222°F

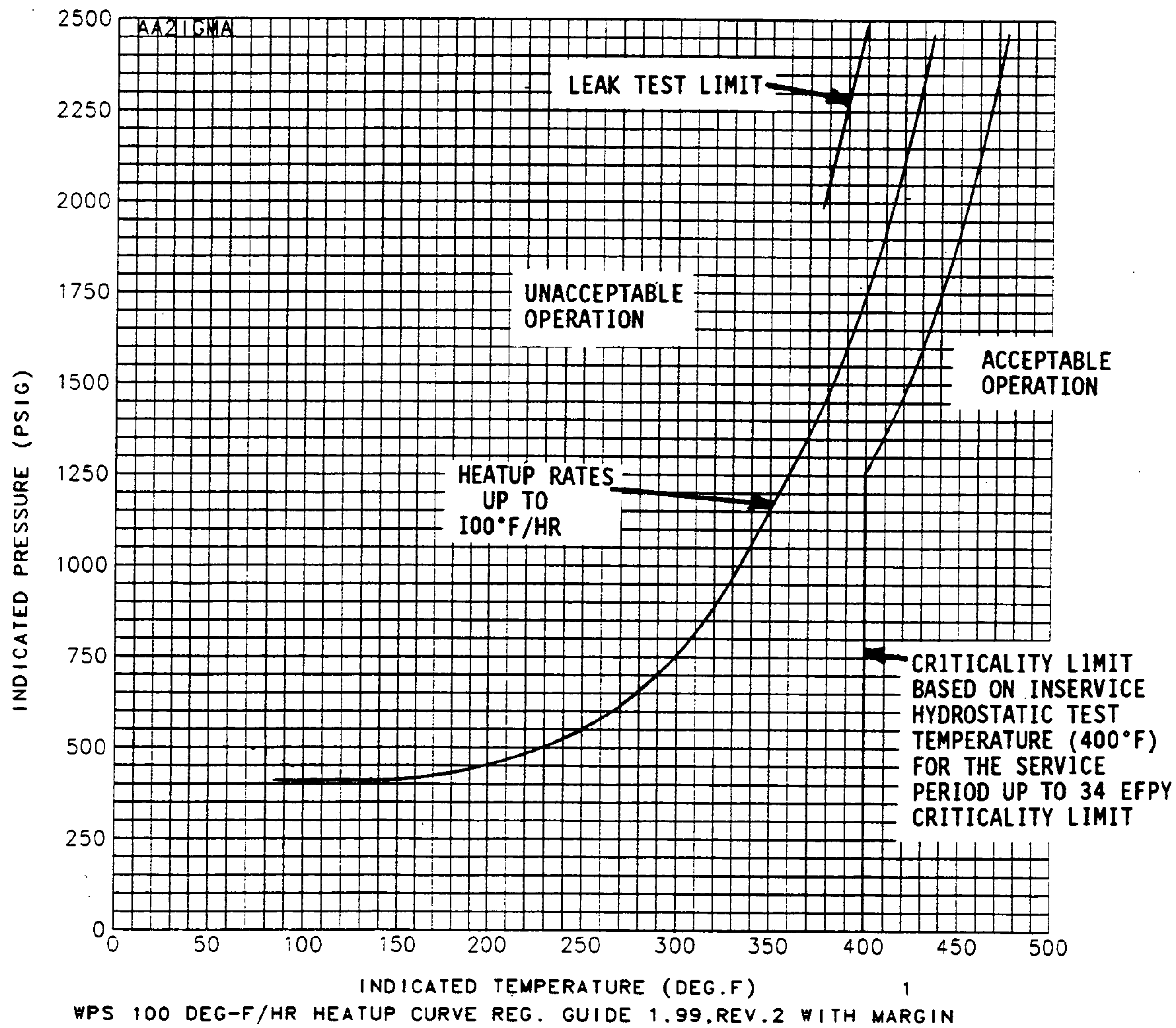

Figure 4. Kewaunee Reactor Coolant System Heatup Limitations (Heat up rate up to 100 °F/hr) Applicable for the First 34 EFPY (With Margins of 10°F and 60 psig For Instrumentation Errors)

MATERIAL PROPERTY BASIS

CONTROLLING MATERIAL: CIRCUMFERENTIAL WELD

INITIAL RT_{NDT}: -56°F

ART AT 20 EFPY: 1/4T = 248°F

3/4T = 202°F

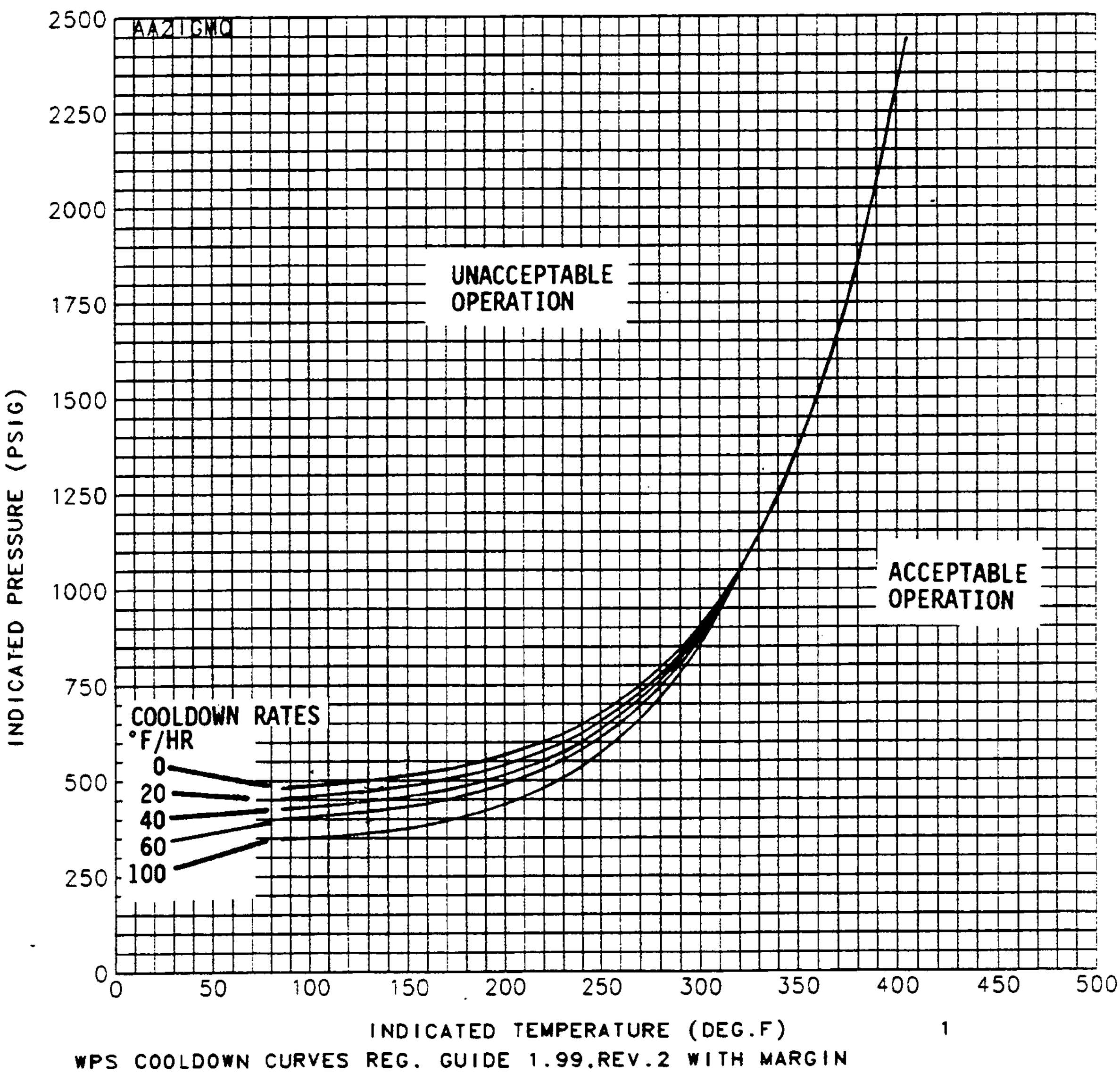

Figure 5. Kewaunee Reactor Coolant System Cooldown Limitations (Cooldown rates up to and 100°F/hr) Applicable for the First 20 EFPY (With Margins of 10°F and 60 psig For Instrumentation Errors)

MATERIAL PROPERTY BASIS

CONTROLLING MATERIAL: CIRCUMFERENTIAL WELD
INITIAL RT_{NDT}: -56°F
ART AT 34 EFPY: 1/4T = 268°F
3/4T = 222°F

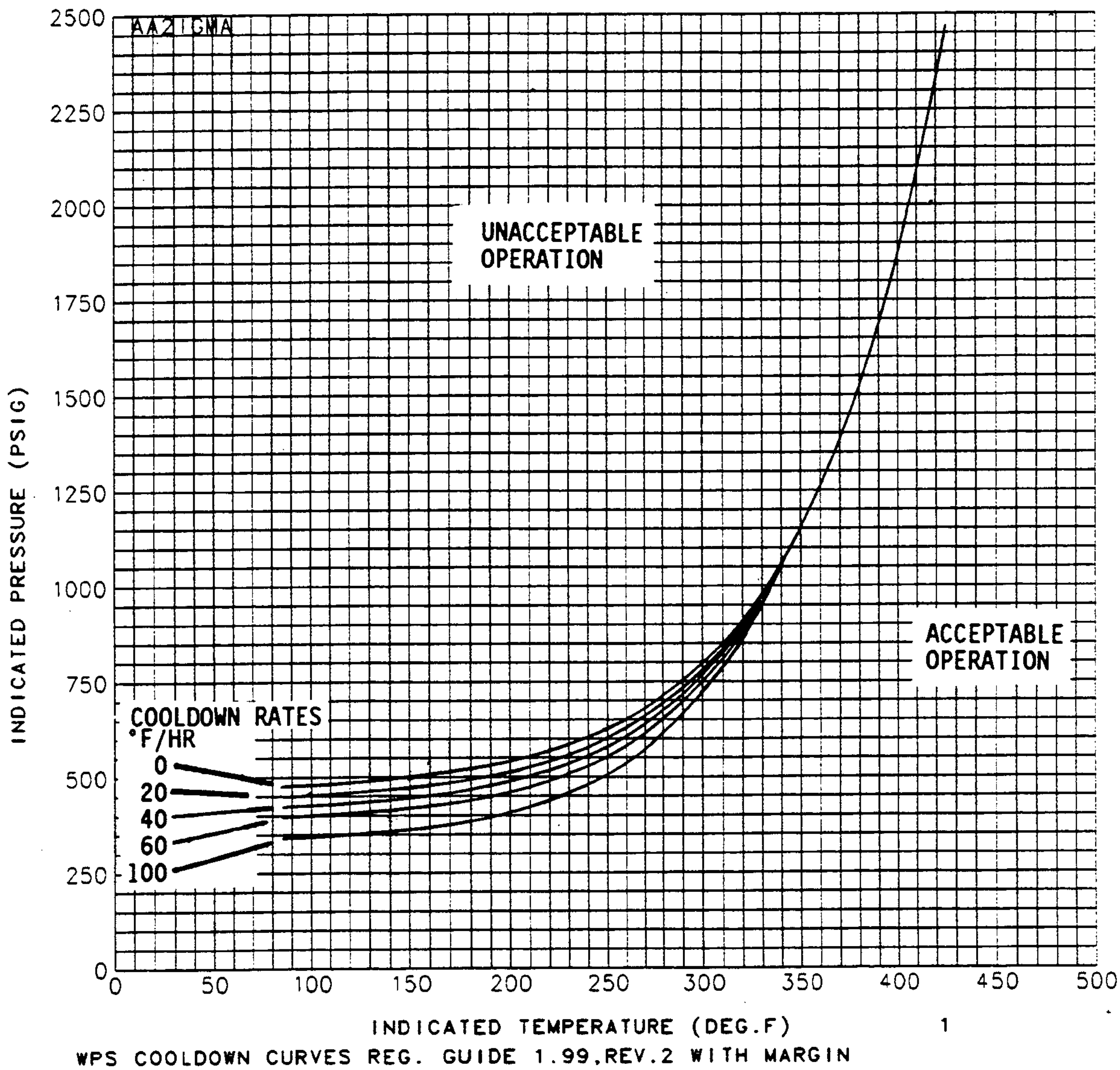

Figure 6. Kewaunee Reactor Coolant System Cooldown Limitations (Cooldown rates up to and 100°F/hr) Applicable for the First 34 EFPY (With Margins of 10°F and 60 psig For Instrumentation Errors)

6. REFERENCES

1 Regulatory Guide 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials", U.S. Nuclear Regulatory Commission, May, 1988.

2 "Fracture Toughness Requirements", Branch Technical Position MTEB 5-2, Chapter 5.3.2 in Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition, NUREG-0800, 1981.

3 ASME Boiler and Pressure Vessel Code, Section III, Division 1 - Appendixes, "Rules for Construction of Nuclear Power Plant Components, Appendix G, Protection Against Nonductile Failure", pp. 558-563, 1986 Edition, American Society of Mechanical Engineers, New York, 1986.

4 Code of Federal Regulations, 10CFR50, Appendix G, "Fracture Toughness Requirements", U.S. Nuclear Regulatory Commission, Washington, D.C., Federal Register, Vol. 48 No. 104, May 27, 1983.

5 WCAP-12020, "Analysis of Capsule P from the Wisconsin Public Service Corporation Kewaunee Nuclear Plant Reactor Vessel Radiation Surveillance Program", S.E. Yanichko, et al., November 1988. (Westinghouse Proprietary Class 3)

APPENDIX A

DATA POINTS FOR HEATUP AND COOLDOWN CURVES

(With Margins of 10°F and 60 psig for Instrumentation Errors)

WPS 60 DEG-F/HR HEATUP CURVES REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

THE FOLLOWING DATA WERE CALCULATEDFOR THE INSERVICE HYDROSTATIC LEAK TEST.

MINIMUM INSERVICE LEAK TEST TEMPERATURE (20.000 EFPY)

PRESSURE (PSI)	TEMPERATURE (DEG.F)
2000	359
2485	381

PRESSURE (PSI)	PRESSURE STRESS (PSI)	1.5 K1M (PSI SQ.RT.IN.)
2000	22045	80751
2485	27235	100677

FORM F506

WPS 60 DEG-F/HR HEATUP CURVES REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

COMPOSITE CURVE PLOTTED FOR HEATUP PROFILE 2 HEATUP RATE(S) (DEG.F/HR) = 60.0

IRRADIATION PERIOD = 20.000 EFP YEARS
FLAW DEPTH = (1-AOWIN)T

	INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)
1	85.000	~~480.18~~	23	195.000	540.45	45	305.000	937.34
2	90.000	~~469.15~~	24	200.000	550.99	46	310.000	972.94
3	95.000	~~461.06~~ } 451.73	25	205.000	562.37	47	315.000	1011.16
4	100.000	~~455.69~~	26	210.000	574.45	48	320.000	1052.23
5	105.000	~~452.86~~	27	215.000	587.62	49	325.000	1096.56
6	110.000	451.73	28	220.000	600.01	50	330.000	1144.01
7	115.000	452.03	29	225.000	610.52	51	335.000	1194.76
8	120.000	453.25	30	230.000	621.78	52	340.000	1245.41
9	125.000	455.37	31	235.000	633.79	53	345.000	1296.77
10	130.000	458.07	32	240.000	646.85	54	350.000	1351.88
11	135.000	461.43	33	245.000	660.87	55	355.000	1410.92
12	140.000	465.22	34	250.000	675.79	56	360.000	1473.89
13	145.000	469.57	35	255.000	692.01	57	365.000	1541.87
14	150.000	474.31	36	260.000	709.41	58	370.000	1614.58
15	155.000	479.48	37	265.000	727.99	59	375.000	1692.30
16	160.000	485.16	38	270.000	748.14	60	380.000	1775.59
17	165.000	491.39	39	275.000	769.57	61	385.000	1864.71
18	170.000	498.09	40	280.000	792.86	62	390.000	1960.00
19	175.000	505.37	41	285.000	817.63	63	395.000	2062.06
20	180.000	513.19	42	290.000	844.52	64	400.000	2170.90
21	185.000	521.66	43	295.000	873.18	65	405.000	2287.19
22	190.000	530.62	44	300.000	904.15	66	410.000	2411.47

WPS 100 DEG-F/HR HEATUP CURVE REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

THE FOLLOWING DATA WERE CALCULATEDFOR THE INSERVICE HYOROSTATIC LEAK TEST.

MINIMUM INSERVICE LEAK TEST TEMPERATURE (20.000 EFPY)

PRESSURE (PSI)	TEMPERATURE (DEG.F)
2000	359
2485	381

PRESSURE (PSI)	PRESSURE STRESS (PSI)	1.5 K1M (PSI SQ.RT.IN.)
2000	22045	80751
2485	27235	100677

22

FORM F506

WPS 100 DEG-F/HR HEATUP CURVE REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

COMPOSITE CURVE PLOTTED FOR HEATUP PROFILE 2 HEATUP RATE(S) (DEG.F/HR) = 100.0

IRRADIATION PERIOD = 20.000 EFP YEARS
FLAW DEPTH = (1-AOWIN)T

	INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)			INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)
1	85.000	~~480.18~~		24	200.000	485.75	46	310.000	972.94
2	90.000	~~468.90~~		25	205.000	494.91	47	315.000	1011.16
3	95.000	~~455.82~~		26	210.000	504.80	48	320.000	1052.23
4	100.000	~~445.51~~	423.08	27	215.000	515.51	49	325.000	1096.56
5	105.000	~~437.80~~		28	220.000	526.93	50	330.000	1144.01
6	110.000	~~432.03~~		29	225.000	539.40	51	335.000	1194.76
7	115.000	~~427.96~~		30	230.000	552.82	52	340.000	1249.13
8	120.000	~~425.18~~		31	235.000	567.30	53	345.000	1296.21
9	125.000	423.08		32	240.000	582.73	54	350.000	1346.77
10	130.000	423.10		33	245.000	599.51	55	355.000	1400.90
11	135.000	423.49		34	250.000	617.54	56	360.000	1458.84
12	140.000	424.59		35	255.000	636.80	57	365.000	1520.94
13	145.000	426.46		36	260.000	657.68	58	370.000	1587.50
14	150.000	428.93		37	265.000	679.95	59	375.000	1658.63
15	155.000	432.05		38	270.000	704.09	60	380.000	1734.92
16	160.000	435.62		39	275.000	729.83	61	385.000	1816.42
17	165.000	439.88		40	280.000	757.67	62	390.000	1903.67
18	170.000	444.67		41	285.000	787.46	63	395.000	1996.96
19	175.000	450.05		42	290.000	819.39	64	400.000	2096.77
20	180.000	455.97		43	295.000	853.92	65	405.000	2203.24
21	185.000	462.51		44	300.000	890.85	66	410.000	2317.04
22	190.000	469.63		45	305.000	930.49	67	415.000	2438.30
23	195.000	477.42							

WPS 60 DEG-F/HR HEATUP CURVES REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

THE FOLLOWING DATA WERE CALCULATEDFOR THE INSERVICE HYDROSTATIC LEAK TEST.

MINIMUM INSERVICE LEAK TEST TEMPERATURE (34.000 EFPY)

PRESSURE (PSI)	TEMPERATURE (DEG.F)
2000	378
2485	400

PRESSURE (PSI)	PRESSURE STRESS (PSI)	1.5 K1M (PSI SQ.RT.IN.)
2000	22045	80751
2485	27235	100677

FORM F506

WPS 60 DEG-F/HR HEATUP CURVES REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

COMPOSITE CURVE PLOTTED FOR HEATUP PROFILE 2 HEATUP RATE(S) (DEG.F/HR) = 60.0

IRRADIATION PERIOD = 34.000 EFP YEARS
FLAW DEPTH = (1-AOWIN)T

	INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)
1	85.000	~~475.24~~	25	205.000	519.53	48	320.000	910.44
2	90.000	~~459.82~~	26	210.000	528.44	49	325.000	944.25
3	95.000	~~451.38~~ 439.94	27	215.000	538.19	50	330.000	980.41
4	100.000	~~445.49~~	28	220.000	548.66	51	335.000	1019.23
5	105.000	~~442.17~~	29	225.000	559.95	52	340.000	1060.90
6	110.000	~~440.98~~	30	230.000	572.07	53	345.000	1105.68
7	115.000	439.94	31	235.000	585.00	54	350.000	1153.80
8	120.000	440.35	32	240.000	599.03	55	355.000	1205.51
9	125.000	441.57	33	245.000	612.71	56	360.000	1255.82
10	130.000	443.29	34	250.000	624.01	57	365.000	1307.77
11	135.000	445.58	35	255.000	636.33	58	370.000	1363.51
12	140.000	448.22	36	260.000	649.58	59	375.000	1423.21
13	145.000	451.32	37	265.000	663.78	60	380.000	1487.24
14	150.000	454.73	38	270.000	678.94	61	385.000	1555.81
15	155.000	458.55	39	275.000	695.40	62	390.000	1629.42
16	160.000	462.69	40	280.000	713.06	63	395.000	1708.11
17	165.000	467.25	41	285.000	731.90	64	400.000	1792.30
18	170.000	472.15	42	290.000	752.33	65	405.000	1882.52
19	175.000	477.51	43	295.000	774.09	66	410.000	1978.97
20	180.000	483.14	44	300.000	797.70	67	415.000	2082.11
21	185.000	489.39	45	305.000	822.86	68	420.000	2192.45
22	190.000	496.08	46	310.000	850.11	69	425.000	2309.93
23	195.000	503.34	47	315.000	879.22	70	430.000	2435.45
24	200.000	511.12						

FORM F506

WPS 100 DEG-F/HR HEATUP CURVE REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

THE FOLLOWING DATA WERE CALCULATEDFOR THE INSERVICE HYDROSTATIC LEAK TEST.

MINIMUM INSERVICE LEAK TEST TEMPERATURE (34.000 EFPY)

PRESSURE (PSI)	TEMPERATURE (DEG.F)
2000	378
2485	400

PRESSURE (PSI)	PRESSURE STRESS (PSI)	1.5 K1M (PSI SQ.RT.IN.)
2000	22045	80751
2485	27235	100677

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FORM F506

WPS 100 DEG-F/HR HEATUP CURVE REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

COMPOSITE CURVE PLOTTED FOR HEATUP PROFILE 2 HEATUP RATE(S) (DEG.F/HR) = 100.0

IRRADIATION PERIOD = 34.000 EFP YEARS
FLAW DEPTH = (1-AOWIN)T

	INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)
1	85.000	~~475.53~~	25	205.000	458.55	49	325.000	922.65
2	90.000	~~459.69~~	26	210.000	465.78	50	330.000	964.74
3	95.000	~~446.42~~	27	215.000	473.63	51	335.000	1009.94
4	100.000	~~435.81~~	28	220.000	481.99	52	340.000	1058.46
5	105.000	~~427.00~~ 409.50	29	225.000	491.15	53	345.000	1105.68
6	110.000	~~421.48~~	30	230.000	501.02	54	350.000	1153.80
7	115.000	~~416.88~~	31	235.000	511.69	55	355.000	1205.51
8	120.000	~~413.47~~	32	240.000	523.16	56	360.000	1258.99
9	125.000	~~411.28~~	33	245.000	535.43	57	365.000	1306.62
10	130.000	~~409.95~~	34	250.000	548.75	58	370.000	1357.69
11	135.000	409.50	35	255.000	563.11	59	375.000	1412.36
12	140.000	409.68	36	260.000	578.40	60	380.000	1471.04
13	145.000	410.55	37	265.000	595.03	61	385.000	1533.77
14	150.000	411.92	38	270.000	612.90	62	390.000	1601.08
15	155.000	413.86	39	275.000	631.97	63	395.000	1673.01
16	160.000	416.24	40	280.000	652.64	64	400.000	1750.16
17	165.000	419.12	41	285.000	674.68	65	405.000	1832.58
18	170.000	422.43	42	290.000	698.58	66	410.000	1920.81
19	175.000	426.20	43	295.000	724.06	67	415.000	2015.15
20	180.000	430.40	44	300.000	751.64	68	420.000	2115.89
21	185.000	434.99	45	305.000	781.10	69	425.000	2223.53
22	190.000	440.12	46	310.000	812.87	70	430.000	2338.35
23	195.000	445.75	47	315.000	846.91	71	435.000	2460.67
24	200.000	451.87	48	320.000	883.46			

WPS COOLDOWN CURVES REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

THE FOLLOWING DATA WERE PLOTTED FOR COOLDOWN PROFILE 1 (STEADY-STATE COOLDOWN)

IRRADIATION PERIOD = 20.000 EFP YEARS
FLAW DEPTH = AOWIN T

	INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)
1	85.000	480.18	23	195.000	557.65	45	305.000	937.34
2	90.000	481.67	24	200.000	564.97	46	310.000	972.94
3	95.000	483.27	25	205.000	572.81	47	315.000	1011.16
4	100.000	484.99	26	210.000	581.14	48	320.000	1052.23
5	105.000	486.83	27	215.000	590.23	49	325.000	1096.56
6	110.000	488.82	28	220.000	600.01	50	330.000	1144.01
7	115.000	490.95	29	225.000	610.52	51	335.000	1194.76
8	120.000	493.25	30	230.000	621.78	52	340.000	1249.52
9	125.000	495.72	31	235.000	633.79	53	345.000	1308.29
10	130.000	498.37	32	240.000	646.85	54	350.000	1371.22
11	135.000	501.22	33	245.000	660.87	55	355.000	1438.71
12	140.000	504.29	34	250.000	675.79	56	360.000	1511.19
13	145.000	507.59	35	255.000	692.01	57	365.000	1588.81
14	150.000	511.13	36	260.000	709.41	58	370.000	1672.01
15	155.000	514.94	37	265.000	727.99	59	375.000	1761.06
16	160.000	519.04	38	270.000	748.14	60	380.000	1856.58
17	165.000	523.44	39	275.000	769.57	61	385.000	1958.88
18	170.000	528.06	40	280.000	792.86	62	390.000	2068.07
19	175.000	533.15	41	285.000	817.63	63	395.000	2184.88
20	180.000	538.63	42	290.000	844.52	64	400.000	2309.58
21	185.000	544.52	43	295.000	873.18	65	405.000	2442.82
22	190.000	550.85	44	300.000	904.15			

WPS COOLDOWN CURVES REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

THE FOLLOWING DATA WERE PLOTTED FOR COOLDOWN PROFILE 2 (20 DEG-F / HR COOLDOWN)

IRRADIATION PERIOD = 20.000 EFP YEARS
FLAW DEPTH = AOWIN T

	INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)
1	85.000	454.14	18	170.000	502.08	35	255.000	671.33
2	90.000	455.57	19	175.000	507.27	36	260.000	689.48
3	95.000	457.12	20	180.000	512.87	37	265.000	708.96
4	100.000	458.78	21	185.000	518.90	38	270.000	729.75
5	105.000	460.60	22	190.000	525.38	39	275.000	752.29
6	110.000	462.54	23	195.000	532.25	40	280.000	776.36
7	115.000	464.65	24	200.000	539.77	41	285.000	802.40
8	120.000	466.92	25	205.000	547.87	42	290.000	830.28
9	125.000	469.38	26	210.000	556.59	43	295.000	860.31
10	130.000	472.03	27	215.000	565.97	44	300.000	892.58
11	135.000	474.89	28	220.000	575.93	45	305.000	927.21
12	140.000	477.96	29	225.000	586.79	46	310.000	964.41
13	145.000	481.18	30	230.000	598.48	47	315.000	1004.36
14	150.000	484.76	31	235.000	611.06	48	320.000	1047.58
15	155.000	488.62	32	240.000	624.44	49	325.000	1093.76
16	160.000	492.77	33	245.000	639.00	50	330.000	1143.41
17	165.000	497.25	34	250.000	654.67			

WPS COOLDOWN CURVES REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

THE FOLLOWING DATA WERE PLOTTED FOR COOLDOWN PROFILE 3 (40 DEG-F / HR COOLDOWN)

IRRADIATION PERIOD = 20.000 EFP YEARS
FLAW DEPTH = AOWIN T

	INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)
1	85.000	427.70	18	170.000	475.76	34	250.000	633.40
2	90.000	429.07	19	175.000	480.98	35	255.000	650.95
3	95.000	430.58	20	180.000	486.70	36	260.000	669.76
4	100.000	432.19	21	185.000	492.89	37	265.000	689.95
5	105.000	433.89	22	190.000	499.54	38	270.000	711.76
6	110.000	435.79	23	195.000	506.74	39	275.000	735.13
7	115.000	437.89	24	200.000	514.47	40	280.000	760.37
8	120.000	440.13	25	205.000	522.84	41	285.000	787.46
9	125.000	442.59	26	210.000	531.69	42	290.000	816.49
10	130.000	445.22	27	215.000	541.40	43	295.000	847.99
11	135.000	448.09	28	220.000	551.83	44	300.000	881.66
12	140.000	451.18	29	225.000	563.10	45	305.000	917.85
13	145.000	454.54	30	230.000	575.05	46	310.000	956.73
14	150.000	458.15	31	235.000	588.12	47	315.000	998.79
15	155.000	462.07	32	240.000	602.15	48	320.000	1043.82
16	160.000	466.28	33	245.000	617.28	49	325.000	1092.19
17	165.000	470.85						

FORM F506

WPS COOLDOWN CURVES REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

THE FOLLOWING DATA WERE PLOTTED FOR COOLDOWN PROFILE 4 (60 DEG-F/HR COOLDOWN)

IRRADIATION PERIOD = 20.000 EFP YEARS
FLAW DEPTH = AQWIN T

	INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)
1	85.000	400.78	18	170.000	449.03	34	250.000	612.37
2	90.000	402.09	19	175.000	454.48	35	255.000	630.48
3	95.000	403.55	20	180.000	460.34	36	260.000	650.12
4	100.000	405.12	21	185.000	466.70	37	265.000	671.13
5	105.000	406.87	22	190.000	473.54	38	270.000	693.91
6	110.000	408.74	23	195.000	480.85	39	275.000	718.27
7	115.000	410.82	24	200.000	488.82	40	280.000	744.69
8	120.000	413.04	25	205.000	497.46	41	285.000	772.93
9	125.000	415.49	26	210.000	506.74	42	290.000	803.49
10	130.000	418.13	27	215.000	516.78	43	295.000	836.27
11	135.000	421.02	28	220.000	527.46	44	300.000	871.43
12	140.000	424.12	29	225.000	539.14	45	305.000	909.32
13	145.000	427.52	30	230.000	551.69	46	310.000	950.25
14	150.000	431.17	31	235.000	565.25	47	315.000	994.12
15	155.000	435.07	32	240.000	579.69	48	320.000	1041.25
16	160.000	439.35	33	245.000	595.44	49	325.000	1091.96
17	165.000	444.01						

WPS COOLDOWN CURVES REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

THE FOLLOWING DATA WERE PLOTTED FOR COOLDOWN PROFILE 5 (100 DEG-F/HR COOLDOWN)

IRRADIATION PERIOD = 20.000 EFP YEARS
FLAW DEPTH = AOWIN T

	INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)
1	85.000	345.82	18	170.000	394.65	34	250.000	570.35
2	90.000	346.96	19	175.000	400.39	35	255.000	590.09
3	95.000	348.33	20	180.000	406.57	36	260.000	611.48
4	100.000	349.82	21	185.000	413.31	37	265.000	634.41
5	105.000	351.50	22	190.000	420.58	38	270.000	659.25
6	110.000	353.32	23	195.000	428.47	39	275.000	685.92
7	115.000	355.35	24	200.000	436.89	40	280.000	714.73
8	120.000	357.56	25	205.000	446.13	41	285.000	745.74
9	125.000	360.01	26	210.000	456.09	42	290.000	779.02
10	130.000	362.66	27	215.000	466.88	43	295.000	814.91
11	135.000	365.59	28	220.000	478.40	44	300.000	853.72
12	140.000	368.75	29	225.000	490.99	45	305.000	895.38
13	145.000	372.24	30	230.000	504.54	46	310.000	940.15
14	150.000	376.00	31	235.000	519.22	47	315.000	988.40
15	155.000	380.06	32	240.000	534.89	48	320.000	1040.19
16	160.000	384.51	33	245.000	551.97	49	325.000	1095.98
17	165.000	389.39						

WPS COOLDOWN CURVES REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

THE FOLLOWING DATA WERE PLOTTED FOR COOLDOWN PROFILE 1 (STEADY-STATE COOLDOWN)

IRRADIATION PERIOD = 34.000 EFP YEARS
FLAW DEPTH = AOWIN T

	INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)
1	85.000	475.53	24	200.000	539.77	47	315.000	879.22
2	90.000	476.66	25	205.000	545.75	48	320.000	910.44
3	95.000	477.87	26	210.000	552.17	49	325.000	944.25
4	100.000	479.07	27	215.000	559.07	50	330.000	980.41
5	105.000	480.47	28	220.000	566.50	51	335.000	1019.23
6	110.000	481.98	29	225.000	574.45	52	340.000	1060.90
7	115.000	483.60	30	230.000	582.91	53	345.000	1105.68
8	120.000	485.34	31	235.000	592.13	54	350.000	1153.80
9	125.000	487.22	32	240.000	602.05	55	355.000	1205.51
10	130.000	489.23	33	245.000	612.71	56	360.000	1261.02
11	135.000	491.40	34	250.000	624.01	57	365.000	1320.51
12	140.000	493.73	35	255.000	636.33	58	370.000	1384.18
13	145.000	496.23	36	260.000	649.58	59	375.000	1452.80
14	150.000	498.92	37	265.000	663.78	60	380.000	1526.12
15	155.000	501.82	38	270.000	678.94	61	385.000	1605.04
16	160.000	504.93	39	275.000	695.40	62	390.000	1689.44
17	165.000	508.28	40	280.000	713.06	63	395.000	1779.76
18	170.000	511.87	41	285.000	731.90	64	400.000	1876.50
19	175.000	515.74	42	290.000	752.33	65	405.000	1980.09
20	180.000	519.90	43	295.000	774.09	66	410.000	2090.79
21	185.000	524.36	44	300.000	797.70	67	415.000	2209.22
22	190.000	529.05	45	305.000	822.86	68	420.000	2335.64
23	195.000	534.22	46	310.000	850.11	69	425.000	2470.47

WPS COOLDOWN CURVES REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

THE FOLLOWING DATA WERE PLOTTED FOR COOLDOWN PROFILE 2 (20 DEG-F / HR COOLDOWN)

IRRADIATION PERIOD = 34.000 EFP YEARS
FLAW DEPTH = ADWIN T

	INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)
1	85.000	449.19	19	175.000	488.99	37	265.000	641.67
2	90.000	450.24	20	180.000	493.21	38	270.000	657.59
3	95.000	451.39	21	185.000	497.76	39	275.000	674.50
4	100.000	452.63	22	190.000	502.66	40	280.000	692.93
5	105.000	453.98	23	195.000	507.93	41	285.000	712.68
6	110.000	455.43	24	200.000	513.62	42	290.000	733.82
7	115.000	457.00	25	205.000	519.74	43	295.000	756.67
8	120.000	458.70	26	210.000	526.20	44	300.000	781.14
9	125.000	460.53	27	215.000	533.29	45	305.000	807.54
10	130.000	462.51	28	220.000	540.93	46	310.000	835.88
11	135.000	464.66	29	225.000	549.15	47	315.000	866.21
12	140.000	466.96	30	230.000	558.01	48	320.000	899.10
13	145.000	469.46	31	235.000	567.53	49	325.000	934.25
14	150.000	472.14	32	240.000	577.64	50	330.000	972.07
15	155.000	475.05	33	245.000	588.67	51	335.000	1012.61
16	160.000	478.17	34	250.000	600.54	52	340.000	1056.28
17	165.000	481.44	35	255.000	613.29	53	345.000	1103.13
18	170.000	485.07	36	260.000	626.89	54	350.000	1153.59

WPS COOLDOWN CURVES REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

THE FOLLOWING DATA WERE PLOTTED FOR COOLDOWN PROFILE 3 (40 DEG-F / HR COOLDOWN)

IRRADIATION PERIOD = 34.000 EFP YEARS
FLAW DEPTH = AOWIN T

	INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)
1	85.000	422.55	19	175.000	462.01	37	265.000	619.70
2	90.000	423.53	20	180.000	466.29	38	270.000	636.09
3	95.000	424.62	21	185.000	470.94	39	275.000	653.92
4	100.000	425.79	22	190.000	475.93	40	280.000	672.89
5	105.000	427.08	23	195.000	481.23	41	285.000	693.54
6	110.000	428.47	24	200.000	487.04	42	290.000	715.68
7	115.000	430.01	25	205.000	493.33	43	295.000	739.44
8	120.000	431.65	26	210.000	500.09	44	300.000	765.06
9	125.000	433.46	27	215.000	507.41	45	305.000	792.60
10	130.000	435.31	28	220.000	515.26	46	310.000	822.09
11	135.000	437.44	29	225.000	523.75	47	315.000	854.07
12	140.000	439.71	30	230.000	532.76	48	320.000	888.27
13	145.000	442.21	31	235.000	542.62	49	325.000	925.07
14	150.000	444.89	32	240.000	553.22	50	330.000	964.58
15	155.000	447.81	33	245.000	564.66	51	335.000	1007.09
16	160.000	450.95	34	250.000	576.81	52	340.000	1052.78
17	165.000	454.36	35	255.000	590.08	53	345.000	1101.94
18	170.000	458.03	36	260.000	604.34			

WPS COOLDOWN CURVES REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

THE FOLLOWING DATA WERE PLOTTED FOR COOLDOWN PROFILE 4 (60 DEG-F/HR COOLDOWN)

IRRADIATION PERIOD = 34.000 EFP YEARS
FLAW DEPTH = AOWIN T

	INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)
1	85.000	395.42	19	175.000	434.58	37	265.000	597.63
2	90.000	396.32	20	180.000	438.93	38	270.000	614.83
3	95.000	397.35	21	185.000	443.68	39	275.000	633.25
4	100.000	398.45	22	190.000	448.77	40	280.000	653.22
5	105.000	399.69	23	195.000	454.32	41	285.000	674.58
6	110.000	401.03	24	200.000	460.27	42	290.000	697.74
7	115.000	402.51	25	205.000	466.75	43	295.000	722.51
8	120.000	404.11	26	210.000	473.70	44	300.000	749.36
9	125.000	405.89	27	215.000	481.13	45	305.000	778.07
10	130.000	407.80	28	220.000	489.24	46	310.000	809.11
11	135.000	409.91	29	225.000	498.02	47	315.000	842.43
12	140.000	412.17	30	230.000	507.45	48	320.000	878.21
13	145.000	414.67	31	235.000	517.67	49	325.000	916.73
14	150.000	417.35	32	240.000	528.52	50	330.000	958.11
15	155.000	420.28	33	245.000	540.39	51	335.000	1002.89
16	160.000	423.44	34	250.000	553.15	52	340.000	1050.57
17	165.000	426.90	35	255.000	566.94	53	345.000	1102.15
18	170.000	430.61	36	260.000	581.62			

WPS COOLDOWN CURVES REG. GUIDE 1.99,REV.2 WITH MARGIN 03/19/92

THE FOLLOWING DATA WERE PLOTTED FOR COOLDOWN PROFILE 5 (100 DEG-F/HR COOLDOWN)

IRRADIATION PERIOD = 34.000 EFP YEARS
FLAW DEPTH = AOWIN T

	INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)		INDICATED TEMPERATURE (DEG.F)	INDICATED PRESSURE (PSI)
1	85.000	340.00	19	175.000	378.75	36	260.000	536.34
2	90.000	340.76	20	180.000	383.22	37	265.000	553.73
3	95.000	341.65	21	185.000	388.18	38	270.000	572.44
4	100.000	342.63	22	190.000	393.54	39	275.000	592.54
5	105.000	343.76	23	195.000	399.38	40	280.000	614.29
6	110.000	344.99	24	200.000	405.68	41	285.000	637.66
7	115.000	346.39	25	205.000	412.55	42	290.000	662.95
8	120.000	347.85	26	210.000	419.94	43	295.000	690.09
9	125.000	349.56	27	215.000	427.99	44	300.000	719.27
10	130.000	351.42	28	220.000	436.56	45	305.000	750.97
11	135.000	353.50	29	225.000	445.97	46	310.000	784.87
12	140.000	355.74	30	230.000	456.10	47	315.000	821.41
13	145.000	358.24	31	235.000	467.09	48	320.000	860.85
14	150.000	360.94	32	240.000	478.82	49	325.000	903.26
15	155.000	363.93	33	245.000	491.64	50	330.000	948.82
16	160.000	367.15	34	250.000	505.44	51	335.000	997.93
17	165.000	370.71	35	255.000	520.38	52	340.000	1050.45
18	170.000	374.54						