ATTACHMENT 1

Consumers Power Company
Big Rock Point Plant
Docket 50-155

PROPOSED TECHNICAL SPECIFICATION PAGE CHANGES

January 10, 1990

4 Pages

MI1289-0609A-BT01

4.1.1 (Contd)

(i) Operating Requirements

1. The average rate of vessel temperature change during normal heatup or cooldown should not exceed 100°F/h when averaged over a one-hour period.

2. Control rod withdrawal during power operation shall be such that the average rate-of-change of reactor power is less than 50 MW_t per minute when power is less than 120 MW_t, less than 20 MW_t per minute when power is between 120 MT_t and 200 MT_t and 240 MW_t.

3. Reactor vessel pressure shall be limited in accordance with Figures 4.1, (a), (b) and (c).

4. The reactor shall not be made critical, with the exception of physic testing, at temperatures below the criticality limit shown on Figures 4.1(b) and 4.1(c).

5. The reactor water level shall not be permitted to decrease below the reactor vessel low water level set point at which reactor safety systems are actuated (Section 6.1.2) whenever fuel is in the reactor vessel. This requirement shall be considered a safety limit and decreases in reactor vessel water level below this set point shall be subject to the requirements of Section 10, Administrative Controls, Subsection 6.7, "Safety Limit Violation."

4.1.2 Primary Coolant Recirculation System

The primary coolant recirculation system shall consist of the reactor vessel, the steam drum, the reactor recirculation pumps, the interconnecting piping and valves, and the safety relief valves.

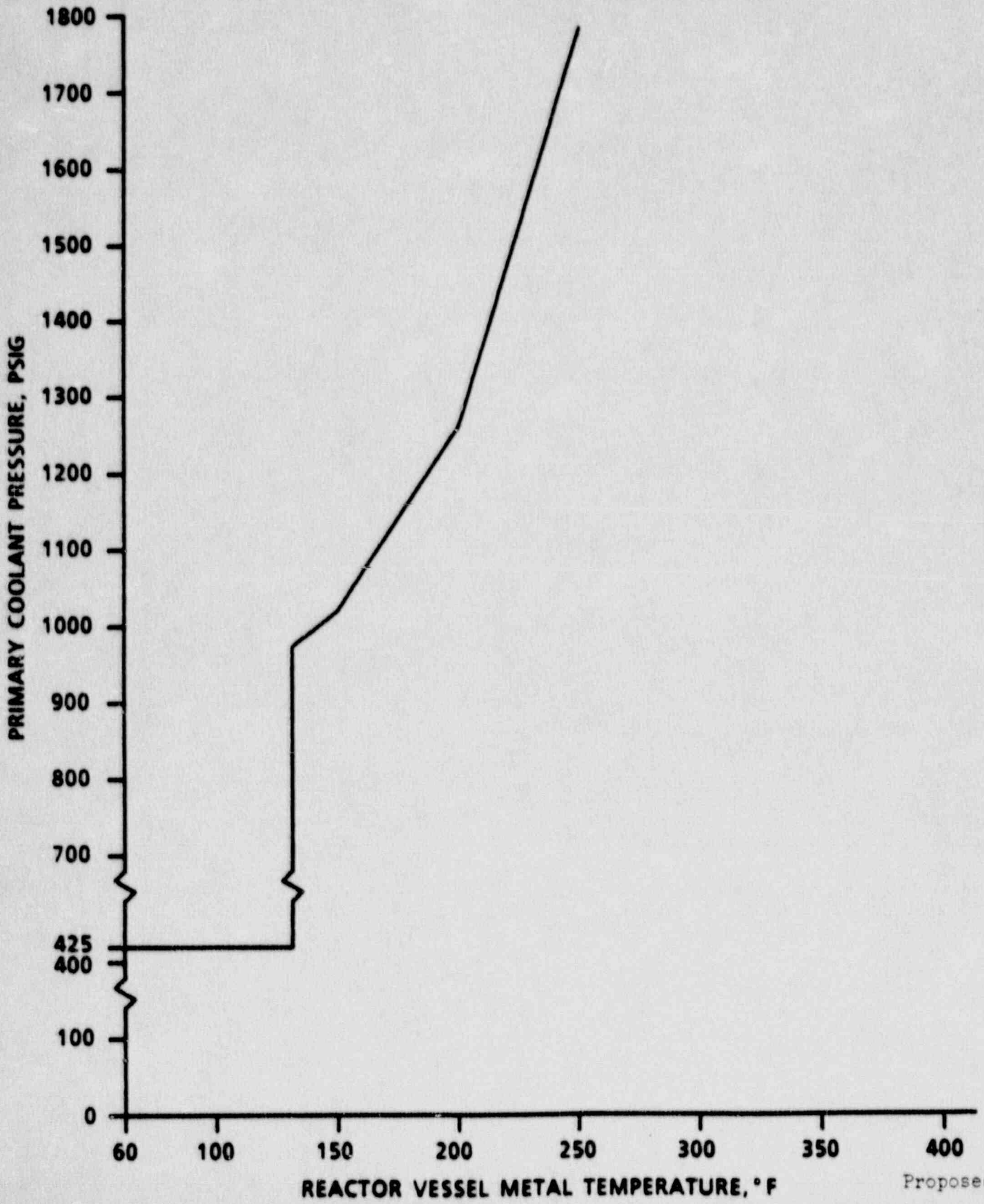
(a) Design Features Shall Be as Follows:

Number of Recirculation Loops	2
Number of Recirculation Pumps per Loop	1
Approximate Internal Volume of System Excluding Reactor Core and Internals to Isolation Valves, Cubic Feet	3830
Approximate Volume of Coolant in System During 157 Mwt Operation, Cubic Feet	2689

BIG ROCK POINT NUCLEAR PLANT: PRESSURE-TEMPERATURE LIMITS EFFECTIVE TO 18 EFFECTIVE FULL POWER YEARS

FLANGE RT_{NDT} = 40°F HYDROSTATIC TEST CONDITION

HYDROTEST TEMPERATURE: 1475 PSIG @ 224°F
1525 PSIG @ 229°F

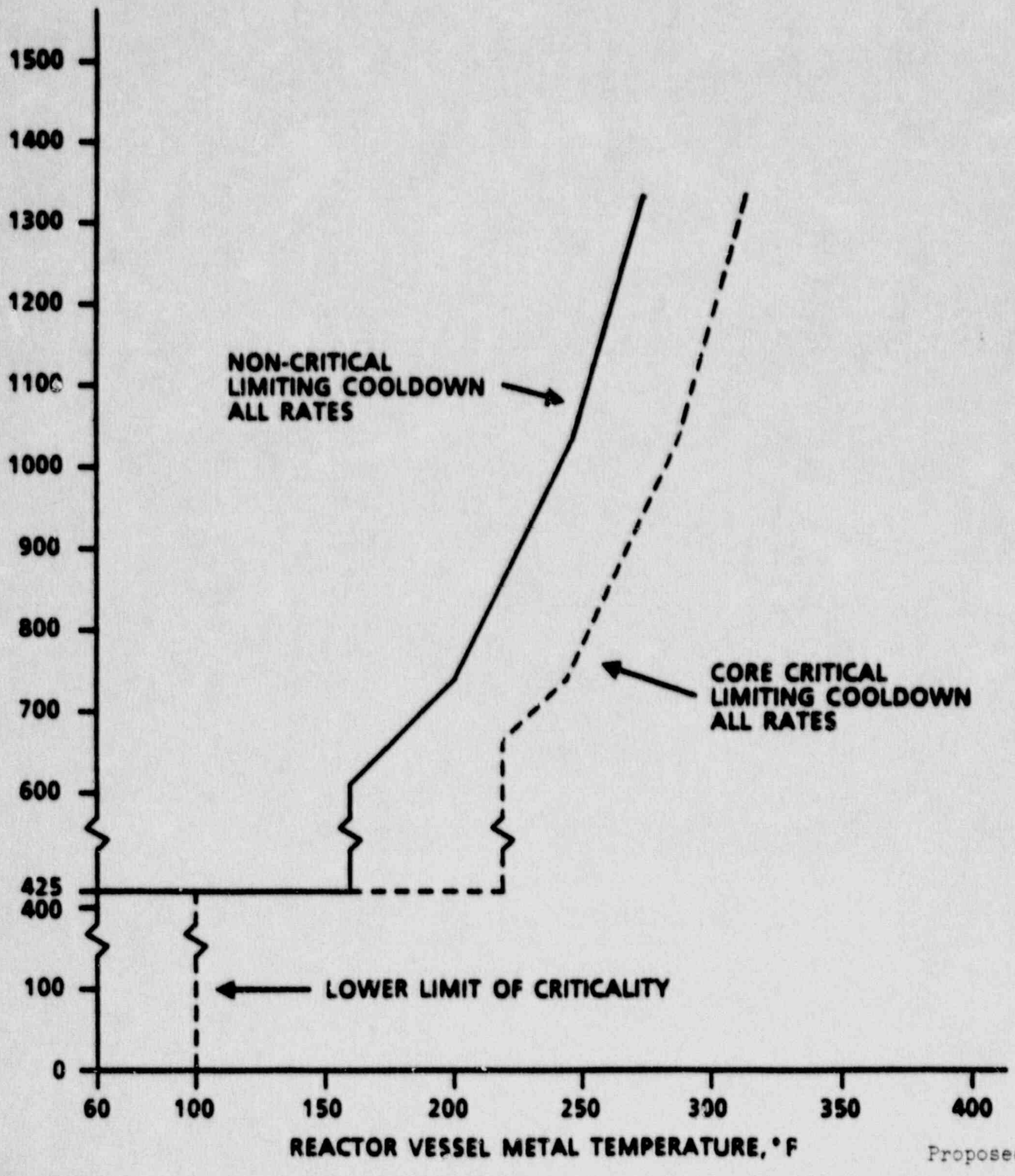


Proposed

BIG ROCK POINT NUCLEAR PLANT: PRESSURE-TEMPERATURE LIMITS EFFECTIVE TO 18 EFFECTIVE FULL POWER YEARS

FLANGE RT_{NDT} = 40°F COOLDOWN CONDITION

SOLID LINES ARE NON-CRITICAL CONDITION
DASHED LINES ARE CRITICAL CONDITION

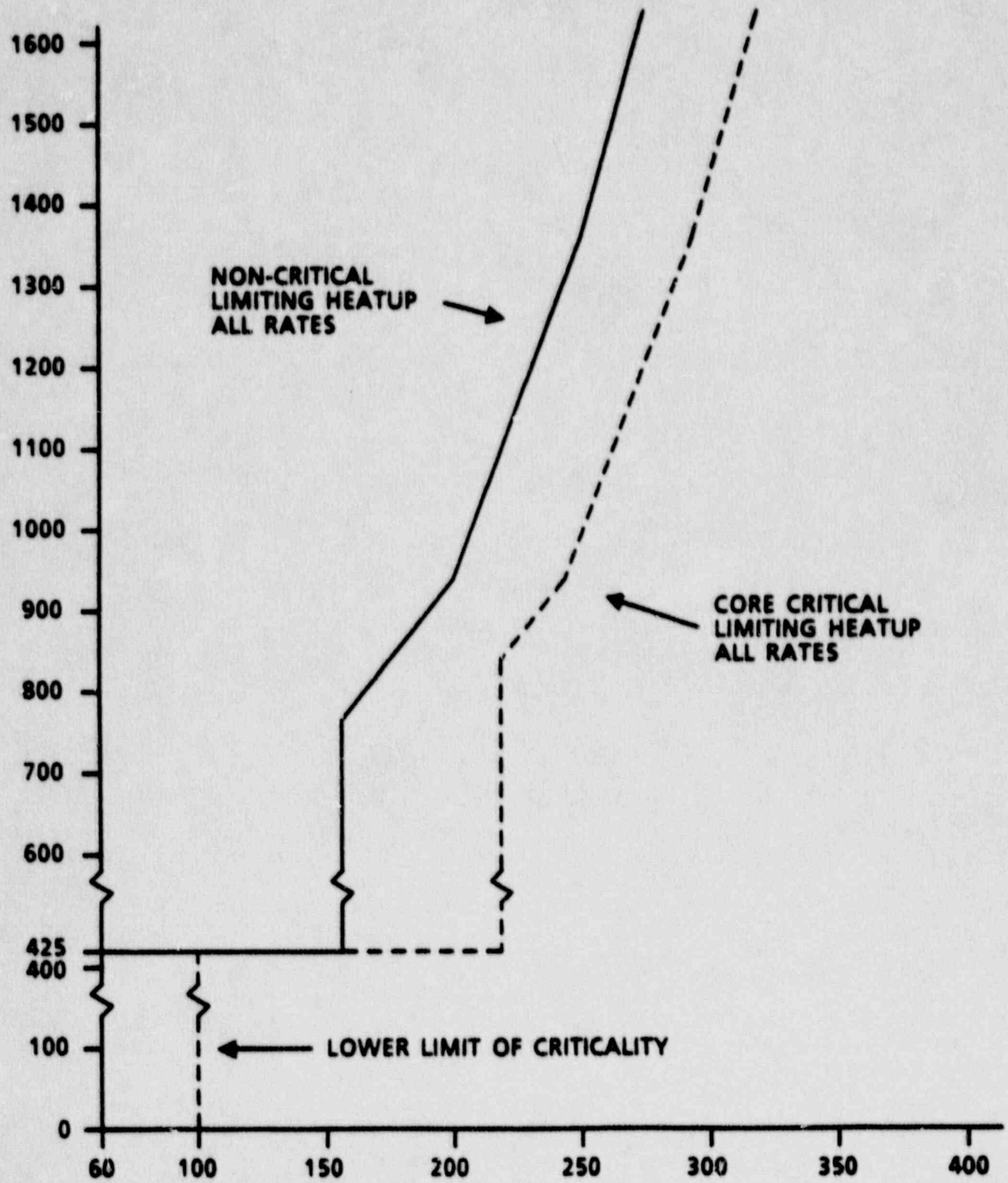


Proposed

BIG ROCK POINT NUCLEAR PLANT: PRESSURE-TEMPERATURE LIMITS EFFECTIVE TO 18 EFFECTIVE FULL POWER YEARS

FLANGE RT_{NDT} = 40°F HEATUP CONDITION

SOLID LINES ARE NON-CRITICAL CONDITION
DASHED LINES ARE CRITICAL CONDITION



Proposed

ATTACHMENT 2

Consumers Power Company
Big Rock Point Plant
Docket 50-155

EVALUATION OF GENERIC LETTER 88-11
ON BIG ROCK POINT TEMPERATURE/PRESSURE LIMITATIONS

January 10, 1990

20 Pages

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BIG ROCK POINT NUCLEAR PLANT
ENGINEERING ANALYSIS WORK SHEET

Title EVALUATION OF GENERIC LETTER 88-11 ON BIG ROCK POINT TEMPERATURE-PRESSURE LIMITATIONS

INITIATION AND REVIEW

Rev #	Description	Initiated By	Initiated Date	Rev Method Check (✓) Alt Calc	Rev Method Check (✓) Det Rvw	Rev Method Check (✓) Qual Test	Technically Rev'd By	Technically Rev'd Date
0	Original Issue	[signature]	12/14/89		✓		RG Jenkins [signature]	12/14/89

REFERENCES:
1) Generic Letter 88-11
2) Reg Guide 1.99, Rev 2, May 1988
3) WCAP-97, September 1980
4) MTEB 5-2
5) 10CFR50.61
6) Combustion Engineering Dwg. E-201-794-8
7) Memo, Jenk 41-77
8) Standard Review Plan 5.3.2
9) ASME Sect III, Appendix G
10) ASME Sect III, Appendices, Table I-2.1
11) Strength of Materials II, S. Timoshenko, 3rd Edition D. VanNostrand Company, Inc., 1968

OBJECTIVE: To assess the impact of Generic Letter 88-11 requirements on the pressure-temperature limitations of Big Rock Point.

ASSUMPTIONS:
1) Fluence at 18 EFPY is derived by simple ratio of data contained in Ref. 3 above.
2) Temperature T is vessel metal temperature taken from thermocouples on reactor O.D.

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CALCULATIONS:

Per equation (1) of Generic Letter 88-11, the Adjusted Reference Temperature (ART) is the sum of the initial reference temperature RT_{NDT}, the change in reference temperature at any given time ΔRT_{NDT}, and the statistical margin to accomodate scatter in experimental data. This is then expressed as:

(EQ.1)

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

EQ.1 must be evaluated for both weld metal and base metal (plate) of the reactor vessel. Initial RT_{NDT} for weld and base metals are given below.

Weld: Initial RT_{NDT} = -56°F (Ref. 5)
Base Plate: Initial RT_{NDT} = +30°F (Ref. 4)
Flange: Initial RT_{NDT} = +40°F

The margin (M) for both the initial and change of RT_{NDT} are derived by the following formula:

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(EQ.2)

$$\text{Margin} = M = 2\sqrt{\sigma_I^2 + \sigma_\Delta^2}$$

Where σ_I = standard deviation for initial RT_{NDT} and

σ_Δ = standard deviation for the change in RT_{NDT} (ΔRT_{NDT})

The values for σ_I and σ_Δ are given below:

Weld: $\sigma_I = 17°F$

$\sigma_\Delta = 28°F$

Base Plate: $\sigma_I = 17°F$

$\sigma_\Delta = 17°F$

ΔRT_{NDT} is derived in both cases (weld & base plate) by:

(EQ.3)

$$\Delta RT_{NDT} = (CF) f^{[.28 - .10 \operatorname{Log} f]}$$

Where CF = Chemistry Factor (Ref 2)

f = fluence (10^{19} n/cm², E>1MeV)

CF is taken from Table 1 for weld metal and Table 2 for base metal.

Both tables are in Reference 2.

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Fluence f is calculated at the 1/4 and 3/4 thickness locations of the reactor vessel wall.

The attenuation of f through the vessel wall is derived by:

(EQ.4)

$$f_x = f_{surface} [e^{-24x}] \quad \text{(Ref. 2)}$$

Where x is the depth in inches from the wetted surface (Vessel ID) to the 1/4t & 3/4t locations.

The data from Big Rock Point to support the above equations is as follows:

DATA

Initial RT_{NDT} = -56°F (Weld)

Initial RT_{NDT} = +30°F (Base Plate)

Flange RT_{NDT} = +40°F (Closure Flange)

Weld % Cu = .27 (Ref. 3)

Weld % Ni = .10 (Ref. 3)

Base Plate % Cu = .10 (Ref. 3)

Base Plate % Ni = .18 (Ref. 3)

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Weld CF = 127°F (Interpolation, Table 1, Ref. 2)

Base CF = 56°F (Interpolation, Table 1, Ref. 2)

Weld Margin = $2\sqrt{28^2 + 17^2}$ = 66°F

Base Plate Margin = $2\sqrt{17^2 + 17^2}$ = 48°F

EFPY to 2/79 = 8.625

f_{cap} to 2/79 = 2.27 (10^{19} n/cm², E>1Mev, Ref. 3)

f_{cap}/EFPY = 2.27/8.625 = .263 x 10^{19} n/cm²/EFPY

f_{cap}/At 18 EFPY = .263 x 10^{19} 18 = 4.737 x 10^{19} n/cm²

Beltline Wall Thickness = t = 5.40625 inches

1/4t = .25 (5.40625) = 1.3516 inches

3/4t = .75 (5.40625) = 4.0547 inches

Operating Pressure = 1335 psig

Pressure Measurement Error = ±15 psi

Temperature Measurement Error = ±5°F

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FLUENCE CALCULATIONS

From Equation 4:

$f_x = F_{surf}\ [e^{-.24x}]$

$f1/4 = 4.737\ [e^{-.24(1.3516)}]$

$f1/4 = 4.737\ [e^{-.3244}]$

$f1/4 = 4.737\ [.723]$

$\underline{f1/4 = 3.425}$ $(\times 10^{19}\ n/cm^2,\ E>1Mev)$

$f3/4 = 4.737\ [e^{-.24(4.0547)}]$

$f3/4 = 4.737\ [e^{-.9731}]$

$f3/4 = 4.737\ [.3779]$

$\underline{f3/4 = 1.790}$ $(\times 10^{19}\ n/cm^2,\ E>1Mev)$

Weld ΔRT_{NDT} from Equation 3:

ΔRT_{NDT} for 1/4 t weld $= C.F_{WELD}\ [f_{1/4}\ (.28 - .10 \log f_{1/4})]$

$= 127\ [3.425\ (.28 - .10 \log 3.425)]$

$= 127\ [3.425^{.2265}]$

$= 127\ [1.322]$

$= 167.85 \sim \underline{168°F}$

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ΔRT_{NDT} for 3/4 t weld $= CF_{WELD}\ [f_{3/4}\ (.28 - .10 \log f_{3/4})]$

$= 127\ [1.790\ (.28 - .10 \log 1.790)]$

$= 127\ [1.790^{.255}]$

$= 127\ [1.160]$

$= 147.3 \sim \underline{147°F}$

ΔRT_{NDT} for 1/4 t base plate $= CF_{BASE}\ [f_{1/4}\ (.28 - .10 \log f_{1/4})]$

$= 56\ [3.425\ (.28 - .10 \log 3.425)]$

$= 56\ [3.425^{.2265}]$

$= 56\ [1.322]$

$= \underline{74°F}$

ΔRT_{NDT} for 3/4 t base plate $= CF_{BASE}\ [f_{1/4}\ (.28 - .10 \log f_{3/4})]$

$= 56\ [1.79\ (.28 - .10 \log 1.79)]$

$= 56\ [1.79^{.255}]$

$= 56\ (1.16)$

$= 64.9 \sim \underline{65°F}$

Weld Margin $= 2\sqrt{\sigma_I^2 + \sigma_\Delta^2}$

$= 2\sqrt{28^2 + 17^2}$

$= 2\sqrt{1073}$

$= 2\ (32.76)$

$= 65.5 \sim \underline{66°F}$

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Base Plate Margin $= 2\sqrt{17^2 + 17^2}$

$= 2\sqrt{578}$

$= 2 \quad (24)$

$= \underline{48°F}$

RT_{NDT} FOR 18 EFPY & f = 4.737 x 10^{19} n/cm^2 E>1Mev

RT_{NDT} for 1/4t weld = Initial RT_{NDT} + ΔRT_{NDT} + Margin

= -56°F + 168°F + 66°F

= 178°F

RT_{NDT} for 3/4t weld = - 56°F + 147°F + 66°F

= 157°F

RT_{NDT} for 1/4t base plate = 30°F + 65°F + 48°F

= 143°F

RT_{NDT} for 3/4t base plate = 30°F + 48°F + 48°F

= 126°F

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HEAT-UP/COOLDOWN/HYDRO TEST EQUATIONS

Per Reference 8, Section 3.C, the expression for heat-up and cooldown pressure-temperature limits is as follows:

(EQ.5)

$$K_I = 2K_I \text{ (pressure)} + K_I \text{ (thermal)} < K_{IR}$$

or

$$K_{IR} > 2K_I \text{ (pressure)} + K_I \text{ (thermal)}$$

From Reference 9, K_{IR} is also expressed as:

$$K_{IR} = 26.78 + 1.233 \exp [.0145\ T-RT_{NDT} + 160]$$

Since the reactor vessel experiences membrane hoop stress that is pressure induced and thermal stress from through wall temperature gradients, the stress intensity factors for those parameters are given as:

$$K_I \text{ (pressure} = K_{IM} \text{ and}$$

$$K_I \text{ (temperature)} = K_{IT}$$

Therefore,

(EQ.6)

$$K_{IR} > 2K_{IM} + K_{IT}$$

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From Reference 9,

$K_{IM} = M_M$ (Membrane Stress)

and

$K_{IT} = M_t$ (ΔT_{max}) where ΔT_{max} is the magnitude of the through wall temperature gradient.

Therefore,

$$K_{IR} > 2\ M_M \text{ (Membrane Stress)} + M_t\ (\Delta T_{max})$$

The temperature gradient profile (data) for BRP is in Table 1.

From Reference 9, Figure 6-2214-2,

$M_t = .268$

To determine M_M, the ratio of $\sigma/\sigma y$ must be determined.

(EQ.7)

$$\text{Since } \sigma = \frac{a^2 P_I}{b^2 - a^2}\left(1 + \frac{b^2}{r^2}\right) \text{ (Ref. 11)}$$

Where P_I = Internal Pressure = 1335 psig

$a = r_I$ = Inside Vessel Radius = 53.0625 inches

$b = r_O$ = Outside Vessel Radius = 58.46875 inches

$r = r_{1/4}$ = Radius at 1/4t = 54.414 inches

and

$r_{3/4t}$ = Radius at 3/4t = 57.117 inches

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Therefore:

$$\sigma_{1/4t} = \frac{(53.0625)^2 P_I}{(58.46875^2 - 53.0625^2)} \left(1 + \frac{58.46875^2}{54.414^2}\right)$$

$$= \frac{2815.629}{602.966} P_I \left(1 + \frac{3418.5947}{2960.8834}\right)$$

$$= 4.6696 P_I (1 + 1.1546)$$
$$= 4.6696 P_I (2.1546)$$
$$= 10.061 P_I$$

$$\sigma_{3/4t} = \frac{(53.0625)^2 P_I}{(58.46875^2 - 53.0625^2)} \left(1 + \frac{58.46875^2}{57.117^2}\right)$$

$$= \frac{2815.629}{602.966} P_I \left(1 + \frac{3418.5947}{3262.3517}\right)$$

$$= 4.6696 P_I (1 + 1.0479)$$
$$= 9.5628 P_I$$

σ_y for SA-302 B MOD at 585°F is taken from Ref. 10 as

$43.8 + [44.5 - 43.8]\ .15 = 43.905 \sim$ 43.9 KSI

Now $\sigma/\sigma_y = \frac{13.431}{43.9} \sim .306$

Therefore from Ref. 9,

$M_M = 2.22$

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Rewriting Equations 6 & 7:

$$K_{IR} > 2K_{IM} + K_{IT}$$

or

$$K_{IR} > 2\,\sigma_M\,M_M + \Delta T_{max}\,M_T$$

Therefore at 1/4T:

$$K_{IR} > 2(10.061)\,P_I M_M + \Delta T_{max}\,M_T$$

and

at 3/4T:

$$K_{IR} > 2(9.563)\,P_I M_M + \Delta T_{max}\,M_T$$

Solving for P:

For 1/4T:

$$P \le \frac{K_{IR} - M_T \Delta T_{max}}{2(10.061)\,M_M}$$

For 3/4T:

$$P \le \frac{K_{IR} - M_T \Delta T_{max}}{2(9.563)\,M_M}$$

Substituting the values of M_M & M_T and multipling by 1000 (ksi to psi), the equation becomes:

At 1/4T:

$$P \le \left[\frac{K_{IR} - \Delta T_{max}\,(.268)}{(20.122)\,(2.22)}\right](1000) \le 22.386\,K_{IR} - 6.0\,\Delta T_{max}$$

At 3/4T:

$$P \le \left[\frac{K_{IR} - \Delta T_{max}\,(.268)}{(19.126)\,(2.22)}\right](1000) \le 23.552\,K_{IR} - 6.312\,\Delta T_{max}$$

Since the tolerance on pressure is ± 15 psig the heat up/cooldown equation is written as follows:

At 1/4T: $P \leq 22.386\ K_{IR} - 6.0\ \Delta T_{max} - 15$

At 3/4T: $P \leq 23.552\ K_{IR} - 6.312\ \Delta T_{max} - 15$

B. IN-SERVICE HYDROSTATIC TESTING - CRITICALITY TEMPERATURE

Since the hydro is performed with the core not critical, heatup rates are low and thermal gradients through the wall are negligible. Therefore, the isothermal heatup condition will be employed for the test pressure limits.

Only heatup rates need to be considered for the hydro and, according to Reference 8, the equations for K_{IR} during the hydro are:

$$K_{IR} = 26.78 + 1.233 \exp [0.0145 (T - RT_{NDT} + 160)]$$

(EQ.8)

$$K_{IR} > 1.5\ M_M\ \sigma_M$$

Therefore, using Equations 7 and 8:

At 1/4T: $P \leq 29.848\ K_{IR} - 15$ for 0°F/HR heat up

At 3/4T: $P \leq 31.403\ K_{IR} - 15$

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TABLE 1

HEAT UP/COOL DOWN TEMPERATURE GRADIENTS

Temperature Change Rate °F/HR	$\Delta T_{1/4}$ °F	$\Delta T_{3/4}$ °F	ΔT_{max} °F
0	0	0	0
20	2.71	4.92	5.19
40	5.42	9.84	10.39
60	8.12	14.76	15.58
80	10.83	19.68	20.77
100	13.54	24.60	25.96

$\Delta T_{1/4}$ = Absolute value of temperature difference between inside of reactor vessel wall and a point one-quarter of the way through the vessel wall.

$\Delta T_{3/4}$ = Absolute value of temperature difference between inside of reactor vessel wall and a point three-quarters of the way through the vessel wall.

ΔT_{max} = Absolute value of temperature difference between inside of reactor vessel wall and a point on the vessel outer diameter.

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FORMULA SUMMARY

Since the base metal RT_{NDT} is less than the weld metal RT_{NDT}, only weld metal formulas are given as they are limiting. Notes: The ΔT_{max} term has been deleted since the 1/4t section is in compression upon heat-up; 2) 1/4t is always limiting for cooldown.

Weld Metal

Heat up @ 1/4t: $K_{IR} = 26.78 + 1.233 \text{ EXP } [.0145 (T_M - 177 + 160 - 5 + (\Delta T_{max} - \Delta T_{1/4}))]$

$P = 22.386 K_{IR} - 15$

Heat up @ 3/4t: $K_{IR} = 26.78 + 1.233 \text{ EXP } [.0145 (T_M - 156 + 160 - 5 + (\Delta T_{max} - \Delta T_{3/4}))]$

$P = 23.552 K_{IR} - 6.312 \Delta T_{max} - 15$

Cooldown @ 1/4t: $K_{IR} = 26.78 + 1.233 \text{ EXP } [.0145 (T_M - 177 + 160 - 5 - (\Delta T_{max} - \Delta T_{1/4}))]$

$P = 22.386 K_{IR} - 6.0 \Delta T_{max} - 15$

Cooldown @ 3/4t: $K_{IR} = 26.78 + 1.233 \text{ EXP } [.0145 (T_M - 156 + 160 - 5 - (\Delta T_{max} - \Delta T_{3/4}))]$

$P = 22.552 K_{IR} - 6.312 \Delta T_{max} - 15$

Hydro-Test @ 1/4t: $K_{IR} = 26.78 + 1.233 \text{ EXP } [.0145 (T_M - 177 + 160 - 5)]$
(0°F/HR)

$P = 29.848 K_{IR} - 15$

Hydro-Test @ 3/4t: $K_{IR} = 26.78 + 1.233 \text{ EXP } [.0145 (T_M - 156 + 160 - 5)]$
(0°F/HR)

$P = 31.403 K_{IR} - 15$

NOTE: 5°F is added to temperature term to accomodate the temperature measurement tolerance.

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TABLE 2 - HEAT UP

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WELD METAL - 1/4T LOCATION

Pressure (psig) at Metal Temperature (°F)

Temperature Change Rate °F/Hr	60°F	100°F	150°F	200°F	250°F	275°F
0	632 (28.9)	670 (30.6)	761 (34.7)	949 (43.1)	1337 (60.4)	1666 (75.1)
20	634 (29.0)	673 (30.7)	767 (35.0)	962 (43.7)	1365 (61.6)	1706 (76.9)
40	636 (29.1)	676 (30.9)	774 (35.3)	976 (44.3)	1393 (62.9)	1747 (78.7)
60	637 (29.2)	679 (31.0)	781 (35.6)	990 (44.9)	1423 (64.3)	1789 (80.6)
80	639 (29.3)	683 (31.2)	788 (35.9)	1005 (45.6)	1454 (65.6)	1834 (82.6)
100	641 (29.3)	686 (31.4)	795 (36.2)	1021 (46.3)	1485 (67.0)	1879 (84.6)

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TABLE 3 - HEAT UP

WELD METAL @ 3/4T LOCATION

Pressure (psig) at Metal Temperature (°F)

Temperature Change Rate °F/Hr	60°F	100°F	150°F	200°F	250°F
0	684 (29.7)	737 (32.0)	867 (37.5)	1135 (48.9)	1689 (72.4)
20	651 (29.7)	705 (32.0)	835 (37.5)	1105 (48.9)	1661 (72.6)
40	619 (29.7)	673 (32.0)	804 (37.6)	1074 (49.0)	1632 (72.7)
60	586 (29.7)	640 (32.0)	772 (37.6)	1043 (49.1)	1604 (72.9)
80	554 (29.7)	608 (32.0)	740 (37.6)	1013 (49.2)	1575 (73.1)
100	521 (29.7)	576 (32.1)	748 (37.7)	982 (49.3)	1547 (73.3)

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TABLE 4 COOL DOWN

WELD METAL - 1/4T LOCATION

Pressure (psig) at Metal Temperature (°F)

Temperature Change Rate °F/Hr	60°F	100°F	150°F	200°F	250°F	275°F
0	632 (28.9)	670 (30.6)	761 (34.7)	949 (43.1)	1337 (60.4)	1666 (75.1)
20	599 (28.8)	635 (30.5)	723 (34.4)	905 (42.5)	1279 (59.2)	1596 (73.4)
40	566 (28.8)	601 (30.3)	686 (34.1)	861 (41.9)	1222 (58.1)	1528 (71.7)
60	533 (28.7)	567 (30.2)	649 (33.9)	818 (41.4)	1166 (57.0)	1461 (70.2)
80	501 (28.6)	533 (30.1)	612 (33.6)	775 (40.9)	1111 (55.9)	1396 (68.6)
100	468 (28.6)	500 (30.0)	576 (33.4)	733 (40.4)	1057 (54.9)	1332 (67.1)

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TABLE 5 - COOL DOWN

WELD METAL - 3/4T LOCATION

Pressure (psig) at Metal Temperature (°F)

Temperature Change Rate °F/Hr	60°F	100°F	150°F	200°F	250°F	275°F
0	684 (29.7)	737 (32.0)	867 (37.5)	1135 (48.9)	1689 (72.4)	2158 (92.3)
20	651 (29.7)	704 (31.9)	833 (37.4)	1101 (48.8)	1652 (72.2)	2120 (92.1)
40	617 (29.7)	671 (31.9)	800 (37.4)	1066 (48.7)	1615 (72.0)	2081 (91.8)
60	584 (29.6)	637 (31.9)	766 (37.4)	1031 (48.6)	1578 (71.8)	2042 (91.5)
80	551 (29.6)	604 (31.9)	732 (37.3)	996 (48.5)	1541 (71.7)	2003 (91.3)
100	518 (29.6)	571 (31.9)	698 (37.3)	961 (48.4)	1504 (71.5)	1965 (91.0)

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TABLE 6 - HYDRO TEST

WELD METAL - 1/4T LOCATION

Pressure (psig) at Metal Temperature (°F)

Temperature Change Rate °F/Hr	60°F	100°F	150°F	200°F	250°F
0	848 (28.9)	898 (30.6)	1019 (34.7)	1270 (43.1)	1788 (60.4)

WELD METAL - 3/4T LOCATION

Pressure (psig) at Metal Temperature (°F)

Temperature Change Rate °F/Hr	60°F	100°F	150°F	200°F	250°F
0	917 (29.7)	988 (32.0)	1161 (37.5)	1519 (48.9)	2253 (72.4)

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