Entergy

Entergy Operations, Inc.
P.O. Box 756
Port Gibson, MS 39150
Tel 601 437-6470

W. K. Hughey
Director
Nuclear Safety & Regulatory
Affairs

June 26, 1997

U.S. Nuclear Regulatory Commission
Mail Station P1-37
Washington, D.C. 20555

Attention: Document Control Desk

Subject: Grand Gulf Nuclear Station
Docket No. 50-416
License No. NPF-29
Responses to NRC Questions Requested in a NRC letter dated April 10, 1997, related to Pressure-Temperature Limit Curves

Reference: NRC Letter to Grand Gulf Nuclear Station, Request for Additional Information Related to Pressure-Temperature Limits in the Technical Specifications, Grand Gulf Nuclear Station, Unit 1 (TAC NO. M97520) dated April 10, 1997 (GNRI-97/00067)

GNRO-97/00058

Gentlemen:

As requested in the NRC referenced letter, we are providing a written response to NRC questions concerning an amendment to the pressure-temperature curves.

Yours truly,

for

WKH/MJL
attachment: Attachment 1 - Responses to NRC Questions Requested in NRC letter dated April 10, 1997
Attachment 2 - General Electric Response to NRC Question 1.
cc: (See Next Page)

A001/1

cc: Ms. J. L. Heredity-Dixon, GGNS Senior Resident (w/a)
Mr. L. J. Smith (Wise Carter) (w/a)
Mr. N. S. Reynolds (w/a)
Mr. H. L. Thomas (w/o)
Mr. J. W. Yelverton (w/o)

Mr. E. W. Merschoff (w/a)
Regional Administrator
U.S. Nuclear Regulatory Commission
Region IV
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011

Mr. J. N. Donohew, Project Manager (w/2)
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Mail Stop 13H3
Washington, D.C. 20555

Dr. E. F. Thompson (w/a)
State Health Officer
State Board of Health
P. O. Box 1700
Jackson, Mississippi 39205

Attachment 1 to GNRO-97/00058

Responses to NRC Questions Requested in NRC letter dated April 10, 1997

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
RELATED TO PRESSURE-TEMPERATURE LIMITS IN TECHNICAL SPECIFICATIONS
ENTERGY OPERATIONS INC.
GRAND GULF NUCLEAR STATION
DOCKET NO. 50-416

The following information are the answers to NRC questions in an NRC RAI issued on April 10, 1997:

1. **General question:** Provide the methodology used to generate pressure-temperature (P-T) limits for the bottom head and the feedwater nozzle.

ANSWER:

Attachment 2 provides the response.

2. **Page 2 of 8:**

The detailed information needed to calculate the reported adjusted reference temperature (ART) of 57.57 DEG F can be found in your letter of May 2, 1996, from which the internal-diameter (ID) fluence of 2.5E18 n/cm^2 at 32 EFPY was reported. The May 2, 1996, letter indicated that this fluence value was from General Electric (GE) Report EAS-35-0387 (April 1987). The ID fluence value at 32 EFPY in the NRC reactor vessel integrity database (RVID), is 3.11 n/cm^2, which was reported to be the latest data in your letter dated May 5, 1994, in response to the NRC close-out letter regarding GL 92-01. The latter value is in line with all your recent submittals. Resolve this discrepancy.

ANSWER

The Fluence value in the letter dated May 5, 1994 (GL 92-01 close-out) was based on the upper bound fluence calculated for the GGNS vessel. The Margin Term in Reg. Guide 1.99 Rev. 2 includes the conservatism for fluence uncertainty in the form of σ_Δ (Standard Deviation for ΔRT_{NDT}). Therefore it was not necessary to use the upper bound fluence value for the determination of ART. The value of fluence at the vessel ID, as provided to you in the May 2, 1996 letter, at 32 EFPY is 2.5E18 n/cm^2.

3. **Page 3.4-31 to 3.4-35 of the Technical Specifications:**

Change of fluence should not affect the P-T limit curves which are controlled by the feedwater nozzle, as evidenced in the five figures of Figures 3.4.11-1. Explain the discrepancy between the current curves that are controlled by the feedwater nozzle for 10 EFPYs and the proposed curves that are controlled by the feedwater nozzle for various EFPY intervals.

ANSWER:

The P-T curves for the Feedwater Nozzle controlled portion has not been affected by the change in fluence levels. Table I shows the temperatures at various pressures which encompass the portion of the P-T curve governed by the Feedwater Nozzles for Curve ''B'' of the P-T curves. The numbers in Boldface in Column 2 were used to generate Curve ''B'' for the 10 EFPY curve in the current TS. In the succeeding columns, (Values for 16 - 32 EFPY),the domain of control by the feedwater nozzle is shown to diminish. This is because as the accumulated fluence in the Beltline increases with increasing EFPY of operation, making the ART of the Beltline dictate the behavior of this curve. Table I shows that the values for the curves submitted in GNRO-96/00120 remain unchanged. In order to use a computer generated curve intermediate values were interpolated and fractions rounded to the next higher temperature. This process may have given the appearance that the Feedwater Nozzle controlled portion of the curve shows a small shift.

Table I for RAI Question 3

Pressure	Temperature {Degrees Fahrenheit} at Pressure: Curve "B"					
{psig}	10 EFPY {Current TS}	16 EFPY	20 EFPY	24 EFPY	28 EFPY	32 EFPY
525		130	130	130	130	130
550	**130**[a]	130	130	130	130	RV Beltline
575		130	130	130	RV Beltline	
600	**133**	**133**	**133**	**133**		
625		135	135	RV Beltline		
650		137	137			
675		139	139			
700	**142**	**142**	**142**			
725	**143**[b]	**143**	RV Beltline			
750		145				
775		146				
800	**147**	**147**				
825		RV Beltline				
850						
875						
900						
925	**RV Beltline**					

Numbers in boldface are the numbers for Feedwater Nozzle Control from the current TS Curves.

Notes:

a) Pressure of 560 psig in the current TS curve

b) Pressure of 740 psig in the current TS curve

4. **Page 3.4-31 to 3.4-32 of the Technical Specifications:**

Change of fluence should not affect the P-T limit curves which are controlled by the bottom head. However, the curves controlled by the bottom head vary among the current Figure 3.4.11-1 and the first two figures of the proposed Figure 3.4.11-1. Provide an explanation for this variation.

ANSWER:

The P-T curves for the Bottom Head controlled portion has not been affected by the change in fluence levels. Table II shows the temperatures at various pressures which encompass the portion of the P-T curve governed by the Bottom Head for Curve ''A'' of the P-T curves. The numbers in Boldface in Column 2 were used to generate Curve ''A'' for the 10 EFPY curve in the current TS. In the succeeding columns, (Values for 16 - 32 EFPY), the domain of control by the Bottom Head is shown to diminish. This is because as the accumulated fluence in the Beltline increases with increasing EFPY of operation, making the ART of the Beltline dictate the behavior of this curve. Table II shows that the values for the curves submitted in GNRO-96/00120 remain unchanged. In order to use a computer generated curve intermediate values were interpolated and fractions rounded to the next higher temperature. This process may have given the appearance that the Bottom Head controlled portion of the curve shows a small shift.

Table II for RAI Question 4

Pressure {psig}	Temperature { Degrees Fahrenheit} at Pressure: Curve "A"					
	10 EFPY {Current TS}	16 EFPY	20 EFPY	24 EFPY	28 EFPY	32 EFPY
725	100[a]	100		RV Beltline	b	c
750	100[a]	102	102			
775		105	RV Beltline			
800	**109**	**109**				
825		112				
850		114				
875		117				
900		120				
925	**123**	**123**				
950		126				
975		128				
1000	**131**	**131**				
1025		133				
1050		135				
1075		137				
1100	**140**	**140**				
1125		142				
1150		144				
1175		146				
1200	**148**	**148**				
1225		150				
1250		152				
1275		153				
1300		155				
1325		157				
1350		159				
1375	**161**	**161**				

Numbers in boldface are the numbers for Bottom Head Control from the current TS Curves.

NOTES:

a) Flange Limits
b) RV Beltline Control begins at RV pressure of 700 psig.
c) RV Beltline Control begins at RV pressure of 675 psig.

Attachment 2 to GNRO-97/00058

General Electric Rcsponse to NRC Question 1
in NRC letter
dated
April 10, 1997

GE Nuclear Energy

Technical Services Business
175 Curtner Avenue, M/C 785
San Jose, California 95125
(408) 925-5714

BDF9718
June 24, 1997

cc: B.J. Branlund
L. Patterson
W. Grimme
DRF B13-01869-077

Mr. W. K. Hughey
Director
Nuclear Safety and Regulatory Affairs
Entergy Operations, Inc.
Grand Gulf Nuclear Station
P.O. Box 756
Port Gibson, MS 39150

SUBJECT: Request for Additional Information
Regarding Entergy Operations,Inc. License Amendment
Request to Amend P-T Curves
Response to EOI/NRC Questions

REFERENCE: 1) Letter from E.C. Rucker to W.E. Grimme, "Contract Number NGC00186", dated June 18, 1997.

2) Middle South Energy Inc. Grand Gulf Nuclear Station, FSAR and TECH SPEC PRESSURE TEMPERATURE CURVES, MPGE-86/161.

Dear Mr. Hughey:

The purpose of this letter is to transmit GE's responses to the question presented in the Reference 1 communication. I have repeated the question in the attached response.

If you have any questions, please call me at (408) 925-5714 or Betty Branlund at (408) 925-1472.

My FAX number is (408) 925-4175.

Sincerely,

B D Frew

Brian Frew, Senior Engineer
RPV Surveillance Services

Question

Confirm that the methodology used to generate pressure-temperature (P-T) limits for the bottom head and feedwater nozzle is the same as that provided by Georgia Power Company in support of the recent P-T limits for the Hatch Units. Otherwise, submit this methodology for Grand Gulf.

Response:

When GE developed non-beltline P-T curves, the approach was to develop curves for a conservatively large BWR/6 (nominal 251-inch inside diameter) and then apply the curves generically to other vessels by using the appropriate RT_{NDT} values for those vessels. The one characteristic of the upper vessel and bottom head, that made the analysis different from a shell analysis like that for the beltline, was the presence of nozzles and control rod drive (CRD) penetration holes, with their associated stress concentrations and higher thermal stresses for certain transient conditions.

Only the methodology for the limiting curves is presented below. For the pressure test, the bottom head is the more limiting curve. For non-nuclear heatup and cooldown operating conditions, the upper vessel is the limiting curve in the pressure range of 560 to 925 psig (at higher pressures, the beltline curve is limiting).

Bottom Head Curve Methodology (Pressure Test)

The generic pressure test P-T curves for the bottom head are the same as those provided to Georgia Power in support of its recent P-T limits revision. The bottom head region was modeled using a finite element analysis of a BWR/6, 251" vessel to determine the K_I for an applied pressure of 1593 psig (1563 psig preservice hydrotest pressure plus 30 psig hydrostatic pressure at the bottom of the vessel). For 1593 psig, the K_I is 154.3 ksi$\sqrt{in}$. The generic pressure test P-T curve was generated by scaling the K_I of 154.3 ksi$\sqrt{in}$ by the nominal pressures and calculating the associated $(T\text{-}RT_{NDT})$:

Nominal Pressure (psig)	K_I (ksi$\sqrt{in}$)	$(T\text{-}RT_{NDT})$ (°F)
1563	154.3	161
1400	138.2	151
1200	118.5	138
1000	98.7	121
800	79.0	99
600	59.2	66
400	39.5	1

Applicability to Grand Gulf

The P-T curve is dependent on the K_I value calculated. The generic P-T curve values were based upon a BWR/6, 251 inch vessel. Since Grand Gulf is a BWR/6, 251 inch vessel, the generic P-T curve values are directly applicable to Grand Gulf.

As discussed below, the highest RT_{NDT} for the bottom head materials is 10°F. The generic pressure test P-T curve is applied to the Grand Gulf bottom head by shifting the P vs. $(T-RT_{NDT})$ values above to reflect the RT_{NDT} value of 10°F.

The resulting P-T values are below:

Nominal Pressure (psig)	Bottom Head Temperature (°F)
1400	161
1200	148
1000	131
800	109
600	76
400	11

Fracture Toughness (RT_{NDT})

The highest RT_{NDT} for the bottom head plates is 10°F, based on fracture toughness purchase requirements and QA documentation confirming that there were no bottom head plate values greater than 10°F. The bottom head welds have RT_{NDT} values less than -20°F, based on the vessel purchase specification requirements and QA documentation confirming that there were no bottom head weld RT_{NDT} values greater than -20°F.

Upper Vessel Curve Methodology (Non-Nuclear Heatup/Cooldown)

The methodology for the non-nuclear heatup/cooldown curves was not provided in the Hatch submittal. Therefore, as requested, the methodology is described below.

The feedwater nozzle was selected to represent non-beltline components for fracture toughness analysis because the thermal conditions are the most severe experienced in the vessel. In addition to the more severe pressure and piping load stresses resulting from the nozzle discontinuity, the feedwater nozzle region experiences relatively cold feedwater flow in hotter vessel coolant.

Stresses are taken from finite element analysis done specifically for fracture toughness analysis purposes. Analyses were performed for all feedwater nozzle transients that involve rapid temperature changes. The most severe of these was normal operation with cold 40°F feedwater injection.

The non-beltline curves based on feedwater nozzle limits were calculated according to the methods for nozzles in Appendix 5 of the Welding Research Council (WRC) Bulletin 175.

The stress intensity factor for a nozzle flaw under primary stress conditions is given in WRC Bulletin 175 Appendix 5 by the expression for a flaw at a hole in a flat plate:

$$K_{Ip} = SF \bullet \sigma \bullet (\pi a)^{1/2} \bullet F(a/r_n) \qquad (1)$$

where: SF is the safety factor applied per WRC Bulletin 175 recommended ranges, and $F(a/r_n)$ is the shape correction factor.

Finite element analysis of a nozzle corner flaw was performed to determine appropriate values of $F(a/r_n)$ for Equation 1. These values are shown in Figure A5-1 of WRC Bulletin 175 .

The stresses used in Equation 1 were taken from BWR/6 design stress reports for the feedwater nozzle. Since Grand Gulf is a BWR/6, the use of the methodology is appropriate. The stresses considered are primary membrane, σ_{pm} and primary bending, σ_{pb}. Secondary membrane, σ_{sm} and secondary bending, σ_{sb} stresses are included in the total K_I by using ASME Appendix G [2] methods for secondary portion, K_{Is}:

$$K_{Is} = M_m \bullet (\sigma_{sm} + 2/3 \bullet \sigma_{sb}) \qquad (2)$$

In the case where the total stress exceeded yield stress, a plasticity correction factor was applied based on the recommendations of WRC Bulletin 175 Section 5.C.3. However, the correction was not applied to primary membrane stresses. K_{Ip} and K_{Is} are added to obtain the total value of stress intensity factor, K_I.

The safety factors applied to primary stresses were 1.3 for pressure test conditions and 1.6 for core not critical heatup/cooldown conditions.

Once K_I was calculated, the following relationship was used to determine $(T - RT_{NDT})$. The highest RT_{NDT} for the appropriate non-beltline components was then used to establish the P-T curves.

$$(T - RT_{NDT}) = \ln [(K_I - 26.78) / 1.233] / 0.0145 - 160 \qquad (3)$$

Note that the above equation contains an error which was present in the ASME Code at the time the curves were generated. Changing the coefficient 1.233 to the correct value of 1.223 results in a increase of 0.56°F in $(T - RT_{NDT})$, which is not considered significant. The correct value was used to generate the Hatch Curves.

The non-beltline core not critical heatup/cooldown curve was based on the feedwater nozzle generic analysis, where feedwater injection of 40°F into the vessel while at operating conditions (551.4°F and 1050 psig) was the limiting normal or upset condition from a brittle fracture perspective. The feedwater nozzle corner stresses were obtained from finite element analysis. These stresses, and other inputs used in the generic calculations, are shown below:

σ_{pm} = 20.49 ksi	σ_{sm} = 16.19 ksi	σ_{ys} = 45.0 ksi	t = 7.5 inch
σ_{pb} = 0.22 ksi	σ_{sb} = 19.04 ksi	a = 1.88 inch	r_n = 6.94 inch

In this case, the total stress, 55.94 ksi, exceeds the yield stress σ_{ys}, so the correction factor, R, is calculated according to the following equation:

$$R = [\sigma_{ys} - \sigma_{pm} + ((\sigma_{total} - \sigma_{ys}) / 30)] / (\sigma_{total} - \sigma_{pm}) \quad (4)$$

For the stresses given, the Ratio, R = 0.70. Therefore, all the stresses are adjusted by the factor 0.70, except for σ_{pm}. The resulting stresses are:

σ_{pm} = 20.49 ksi	σ_{sm} = 11.33 ksi
σ_{pb} = 0.15 ksi	σ_{sb} = 13.33 ksi

The value of M_m from Figure G-2214-1, was based on a thickness of 7.5 inches, hence, $t^{1/2} = 2.74$. The stress to yield ratio, σ/σ_{ys}, was conservatively assumed to be 1.0. The resulting value obtained was:

$$M_m = 2.84$$

The value $F(a / r_n)$ is taken from Figure A5-1 of WRC Bulletin 175 for an a/r_n of 0.27.

$$F(a / r_n) = 1.6$$

K_{Ip} is calculated from Equation 1:

$$K_{Ip} = 1.6 \bullet (20.49 + 0.15) \bullet (\pi \bullet 1.88)^{1/2} \bullet 1.6$$
$$K_{Ip} = 128.4 \text{ ksi-in}^{1/2}$$

K_{Is} is calculated from Equation 2:

$$K_{Is} = 2.84 \bullet (11.33 + 2/3 \bullet 13.33)$$
$$K_{Is} = 57.4 \text{ ksi-in}^{1/2}$$

The total K_I is therefore 186 ksi-in$^{1/2}$.

The total K_I is substituted into Equation 3 to solve for $(T - RT_{NDT})$:

$$(T - RT_{NDT}) = \ln[(186 - 26.78) / 1.233] / 0.0145 - 160$$

$$(T - RT_{NDT}) = 175°F$$

(If the correct coefficient 1.223 was used, $(T - RT_{NDT})$ is 176°F)

The generic curve was generated by calculating the K_I at multiple pressures and using the K_I value at each pressure to calculate the $(T - RT_{NDT})$ for each pressure. These values were then plotted and a curve drawn through the points. From the curve, the $(T - RT_{NDT})$ can be determined for each pressure. The following table is a listing of the values used to generate the curve:

Feedwater Nozzle K_I and $(T - RT_{NDT})$ as a Function of Pressure

Nominal Pressure (psig)	**K_I (ksi-in$^{1/2}$)**	**$(T - RT_{NDT})$ (°F)**
1400	213	186
1050	186	175
700	159	162
350	103	125
150	66	79

The highest non-beltline RT_{NDT} for a discontinuity in the upper vessel region is -20°F, the purchase specification limiting value for nozzles. The generic curve is applied to the Grand Gulf upper vessel by shifting P vs. $(T-RT_{NDT})$ values from the generic curve to reflect the nozzle RT_{NDT} value of -20°F.

Nominal Pressure (psig)	**Vessel Metal Temperature (°F)**
1400	166
1050	155
700	142
350	105
150	59

The values in the above table are plotted in Figure 1 ('generic values') along with the limiting values for curve BB' ('Grand Gulf values') identified as 'FW nozzle limits' in Table 1 of Reference 2.

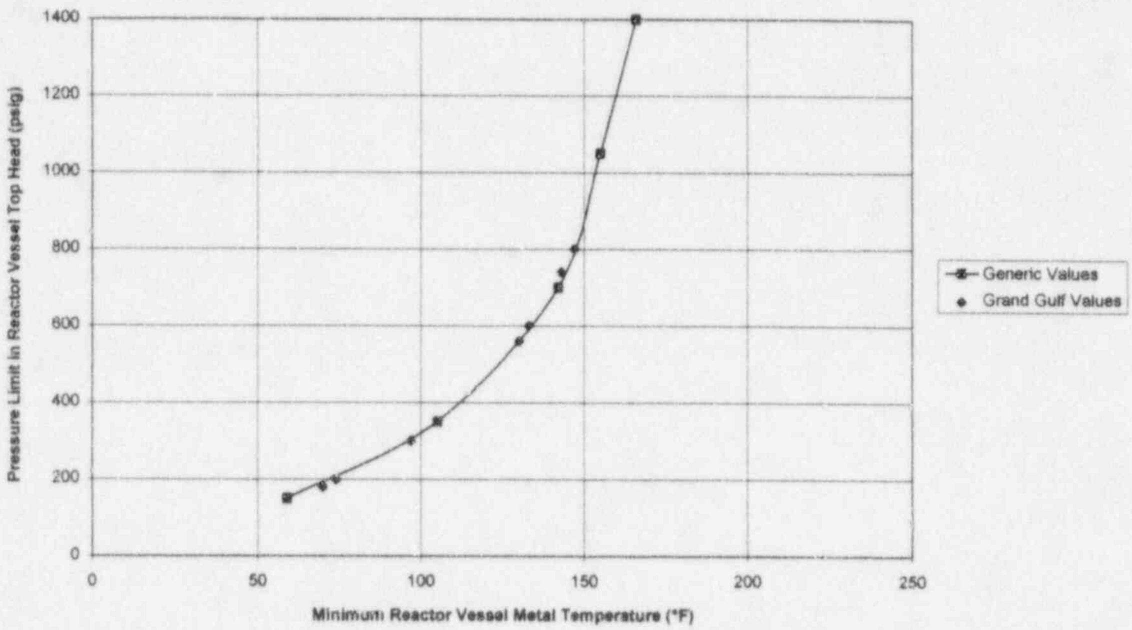

Figure 1: Upper Vessel Pressure-Temperature Limits