Enclosure 11

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Vogtle Electric Generating Plant Unit 1 Heatup and Cooldown Limit Curves for Normal Operation

Westinghouse

WESTINGHOUSE NON-PROPRIETARY CLASS 3

WCAP-15068, Revision 3

Vogtle Electric Generating Plant Unit 1 Heatup and Cooldown Limit Curves for Normal Operation

T. J. Laubham

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Approved: _________________
J. Ghergurovich, Manager
Reactor Component Design & Analysis

Westinghouse Electric Company, LLC
Energy Systems
P.O. Box 355
Pittsburgh, PA 15230-0355

PREFACE

This report has been technically reviewed and verified by:

Reviewer: K. G. Knight [signature]

Record of Revision

Revision 1:

Updated all pressure-temperature curves using the 1996 App. G to Section XI of the ASME Code, K_{Ic} from Code Case N-640 and the removal of the flange requirement per WCAP-15315. All calculations for adjusted reference temperature remain unchanged from Revision 0. Text has been updated to support the use of the '96 App. G, K_{Ic} and elimination of the flange notch.

Revision 2:

The reference to WCAP-14040-NP-A, Revision 2 has been revised to WCAP-14040-A, Revision 4 to reflect the latest NRC approved version. The reference to WCAP-15315 has been revised to WCAP-16142 to reflect the Vogtle Units 1 and 2 flange elimination justification rather than the generic flange elimination justification contained in WCAP-15315. In addition, the thermal stress intensity factors were added for the highest heatup and cooldown rate.

Revision 3:

In Table 4-4, the measured 30 ft-lb transition temperature shift for the surveillance program weld metal in Capsule Y has been adjusted to read 7.7°F. This is the ΔRT_{NDT} without the ratio of 1.02 applied. The ΔRT_{NDT} value for Capsule Y of the Intermediate Shell Plate B8805-3 (Transverse Orientation) was revised from 15.9°F to read 15.2°F. Also, note (b) was added to provide an explanation for the 0°F 30 ft-lb transition temperature shifts. The material description for the Lower Shell Longitudinal Welds in Table 4-5 has been revised to be 101-142A, B, & C. In Table 4-6, the ΔRT_{NDT} with and without the ratio of 1.02 applied are presented for the Surveillance Weld Metal. Reference 11, WCAP-16142, was updated to Revision 1 as well.

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EXECUTIVE SUMMARY

The purpose of this report is to generate pressure-temperature limit curves for Vogtle Electric Generating Plant Unit 1 for normal operation at 26 and 36 EFPY using the methodology from the 1996 ASME Boiler and Pressure Vessel Code, Section XI, Appendix G. Regulatory Guide 1.99, Revision 2 is used for the calculation of Adjusted Reference Temperature (ART) values at the 1/4T and 3/4T location. The 1/4T and 3/4T values are summarized in Table 4-14 and were calculated using the intermediate shell plate B8805-2 (i.e. the limiting beltline region material). The pressure-temperature limit curves were generated without margins for instrumentation errors for heatup rates of 60 and 100°F/hr and cooldown rates of 0, 20, 40, 60 and 100°F/hr. These curves can be found in Figures 5-1 through 5-4. The Vogtle Unit 1 heatup and cooldown pressure-temperature limit curves have been updated based on the use of the ASME Code Case N-640[10], which allows the use of the K_{Ic} methodology, and the elimination of the reactor vessel flange temperature requirement (Ref, WCAP-16142[11]).

1 INTRODUCTION

Heatup and cooldown limit curves are calculated using the adjusted RT_{NDT} (reference nil-ductility temperature) corresponding to the limiting beltline region material of the reactor vessel. The adjusted RT_{NDT} of the limiting material in the core region of the reactor vessel is determined by using the unirradiated reactor vessel material fracture toughness properties, estimating the radiation-induced ΔRT_{NDT}, and adding a margin. The unirradiated 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 unirradiated RT_{NDT} (IRT_{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, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials"[1]. Regulatory Guide 1.99, Revision 2, is used for the calculation of Adjusted Reference Temperature (ART) values (IRT_{NDT} + ΔRT_{NDT} + margins for uncertainties) at the 1/4T and 3/4T locations, where T is the thickness of the vessel at the beltline region measured from the clad/base metal interface. The most limiting ART values are used in the generation of heatup and cooldown pressure-temperature limit curves for normal operation. As a note, calculated capsule and vessel fluence projections[7] were used in determination of the most limiting ART values. The fluence evaluation in Reference 7 used the ENDF/B-VI scattering cross-section data set. This is consistent with the methods presented in WCAP-14040-A. "Methodology Used to Develop Cold Overpressure Mitigating System Setpoints and RCS Heatup and Cooldown Limit Curves"[8].

The heatup and cooldown curves documented in this report were generated using the most limiting ART values and the NRC approved methodology documented in WCAP-14040-A, Revision 4[8], "Methodology Used to Develop Cold Overpressure Mitigating System Setpoints and RCS Heatup and Cooldown Limit Curves" with one exception of the following. The neutron fluence calculations used Equation 3 of Regulatory Guide 1.190 rather than Equation 4 to perform the flux synthesis. As discussed in Section 1.3.4 of Regulatory Guide 1.190, this approach tends to over predict the maximum flux at the pressure vessel, therefore resulting in slightly conservative calculated results. The reactor vessel flange temperature requirement has also been eliminated. Justification has been provided in WCAP-16142[11].

2 PURPOSE

Southern Nuclear contracted Westinghouse to generate new heatup and cooldown curves for 26 and 36 EFPY using the latest Code Methodologies and the elimination of the flange requirement. The heatup and cooldown curves were generated without margins for instrumentation errors. The curves include a hydrostatic leak test limit curve from 2485 to 2000 psig.

The purpose of this report is to present the calculations and the development of the Southern Nuclear Vogtle Electric Generating Plant Unit 1 heatup and cooldown curves for 26 and 36 EFPY. This report documents the calculated adjusted reference temperature (ART) values following the methods of Regulatory Guide 1.99, Revision 2[1], for all the beltline materials and the development of the heatup and cooldown pressure-temperature limit curves for normal operation.

3 CRITERIA FOR ALLOWABLE PRESSURE-TEMPERATURE RELATIONSHIPS

3.1 Overall Approach

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_{Ic}, for the metal temperature at that time. K_{Ic} is obtained from the reference fracture toughness curve, defined in Code Case N-640, "Alternative Reference Fracture Toughness for Development of PT Limit Curves for Section XI"[3 & 10] of the ASME Appendix G to Section XI. The K_{Ic} curve is given by the following equation:

$$K_{Ic} = 33.2 + 20.734 * e^{[0.02(T - RT_{NDT})]} \quad (1)$$

where,

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

This K_{Ic} curve is based on the lower bound of static critical K_I values measured as a function of temperature on specimens of SA-533 Grade B Class1, SA-508-1, SA-508-2, SA-508-3 steel.

3.2 Methodology for Pressure-Temperature Limit Curve Development

The governing equation for the heatup-cooldown analysis is defined in Appendix G of the ASME Code as follows:

$$C * K_{Im} + K_{It} < K_{Ic} \quad (2)$$

where,

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

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

K_{Ic} = 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

For membrane tension, the corresponding K_I for the postulated defect is:

$$K_{Im} = M_m \times (pR_i / t) \qquad (3)$$

where, M_m for an inside surface flaw is given by:

M_m = 1.85 for $\sqrt{t} < 2$,
M_m = $0.926\sqrt{t}$ for $2 \leq \sqrt{t} \leq 3.464$,
M_m = 3.21 for $\sqrt{t} > 3.464$

Similarly, M_m for an outside surface flaw is given by:

M_m = 1.77 for $\sqrt{t} < 2$,
M_m = $0.893\sqrt{t}$ for $2 \leq \sqrt{t} \leq 3.464$,
M_m = 3.09 for $\sqrt{t} > 3.464$

and p = internal pressure, Ri = vessel inner radius, and t = vessel wall thickness.

For bending stress, the corresponding K_I for the postulated defect is:

K_{Ib} = M_b * Maximum Stress, where M_b is two-thirds of M_m

The maximum K_I produced by radial thermal gradient for the postulated inside surface defect of G-2120 is $K_{It} = 0.953 \times 10^{-3} \times CR \times t^{2.5}$, where CR is the cooldown rate in °F/hr., or for a postulated outside surface defect, $K_{It} = 0.753 \times 10^{-3} \times HU \times t^{2.5}$, where HU is the heatup rate in °F/hr.

The through-wall temperature difference associated with the maximum thermal K_I can be determined from Fig. G-2214-1. The temperature at any radial distance from the vessel surface can be determined from Fig. G-2214-2 for the maximum thermal K_I.

(a) The maximum thermal K_I relationship and the temperature relationship in Fig. G-2214-1 are applicable only for the conditions given in G-2214.3(a)(1) and (2).

(b) Alternatively, the K_I for radial thermal gradient can be calculated for any thermal stress distribution and at any specified time during cooldown for a ¼-thickness inside surface defect using the relationship:

$$K_{It} = (1.0359C_0 + 0.6322C_1 + 0.4753C_2 + 0.3855C_3) * \sqrt{\pi a} \qquad (4)$$

or similarly, K_{IT} during heatup for a ¼-thickness outside surface defect using the relationship:

$$K_{It} = (1.043C_0 + 0.630C_1 + 0.481C_2 + 0.401C_3) * \sqrt{\pi a} \quad (5)$$

where the coefficients C_0, C_1, C_2 and C_3 are determined from the thermal stress distribution at any specified time during the heatup or cooldown using the form:

$$\sigma(x) = C_0 + C_1(x/a) + C_2(x/a)^2 + C_3(x/a)^3 \quad (6)$$

and x is a variable that represents the radial distance from the appropriate (i.e., inside or outside) surface to any point on the crack front and a is the maximum crack depth.

Note, that equations 3, 4 and 5 were implemented in the OPERLIM computer code, which is the program used to generate the pressure-temperature (P-T) limit curves. No other changes were made to the OPERLIM computer code with regard to P-T calculation methodology. Therefore, the P-T curve methodology is unchanged from that described in WCAP-14040, "Methodology used to Develop Cold Overpressure Mitigating System Setpoints and RCS Heatup and Cooldown Limit Curves"[8] Section 2.6 (equations 2.6.2-4 and 2.6.3-1) with the exceptions just described above.

At any time during the heatup or cooldown transient, K_{Ic} is determined by the metal temperature at the tip of a postulated flaw at the 1/4T and 3/4T location, 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 1/4T vessel location is at a higher temperature than the fluid adjacent to the vessel inner diameter. This condition, of course, is not true for the steady-state situation. It follows that, at any given reactor coolant temperature, the ΔT (temperature) developed during cooldown results in a higher value of K_{Ic} at the 1/4T location for finite cooldown rates than for steady-state operation. Furthermore, if conditions exist so that the increase in K_{Ic} 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 1/4T 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 1/4T defect at the inside of the wall. The heatup results in compressive stresses at the inside surface that alleviate the tensile stresses produced by internal pressure. The metal temperature at the crack tip lags the coolant temperature; therefore, the K_{Ic} for the 1/4T crack during heatup is lower than the K_{Ic} for the 1/4T 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_{Ic} values 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 1/4T 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 1/4T flaw located at the 1/4T location from the outside surface 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.

3.3 Closure Head/Vessel Flange Requirements

10 CFR Part 50, Appendix G 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 unirradiated RT_{NDT} by at least 120°F for normal operation when the pressure exceeds 20 percent of the preservice hydrostatic test pressure (3106 psi), which is 621 psig for the Vogtle Electric Generating Plant Unit 1. However, per WCAP-16142, "Reactor Vessel Closure Head/Vessel Flange Requirements Evaluation for Vogtle Units 1 and 2"[11], this requirement is no longer necessary when using the

methodology of Code Case N-640[10]. Hence, the Vogtle Electric Generating Plant Unit 1 heatup and cooldown limit curves will be generated without flange requirements included.

4 CALCULATION OF ADJUSTED REFERENCE TEMPERATURE

From Regulatory Guide 1.99, Revision 2, the adjusted reference temperature (ART) for each material in the beltline region is given by the following expression:

$$ART = Initial\ RT_{NDT} + \Delta RT_{NDT} + Margin \quad (7)$$

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[6]. 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 is calculated as follows:

$$\Delta RT_{NDT} = CF * f^{(0.28-0.10\log f)} \quad (8)$$

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.

$$f_{(depth\,x)} = f_{surface} * e^{(-0.24x)} \quad (9)$$

where x inches (vessel beltline thickness is 8.625 inches[5]) is the depth into the vessel wall measured from the vessel clad/base metal interface. The resultant fluence is then placed in Equation 8 to calculate the ΔRT_{NDT} at the specific depth.

The Westinghouse Radiation Engineering and Analysis group evaluated the vessel fluence projections[7] and the results are presented in Section 6 of WCAP-15067 . The evaluation used the ENDF/B-VI scattering cross-section data set. This is consistent with the methods presented in WCAP-14040-A, "Methodology Used to Develop Cold Overpressure Mitigating System Setpoints and RCS Heatup and Cooldown Limit Curves"[8]. Tables 4-1 and 4-2, herein, contain the calculated vessel surface fluence values along with the Regulatory Guide 1.99, Revision 2, 1/4T and 3/4T calculated fluences used to calculate the ART values for all beltline materials in the Vogtle Unit 1 reactor vessel. Additionally, the calculated surveillance capsule fluence values are presented in Table 4-3.

TABLE 4-1
Summary of the Peak Pressure Vessel Neutron Fluence Values at 26 EFPY used for the Calculation of ART Values (n/cm^2, E > 1.0 MeV)

Material	Surface*	¼ T	¾ T
Intermediate Shell Plate B8805-1	1.52×10^{19}	0.906×10^{18}	0.322×10^{18}
Intermediate Shell Plate B8805-2	1.52×10^{19}	0.906×10^{18}	0.322×10^{18}
Intermediate Shell Plate B8805-3	1.52×10^{19}	0.906×10^{18}	0.322×10^{18}
Lower Shell Plate B8606-1	1.52×10^{19}	0.906×10^{18}	0.322×10^{18}
Lower Shell Plate B8606-2	1.52×10^{19}	0.906×10^{18}	0.322×10^{18}
Lower Shell Plate B8606-3	1.52×10^{19}	0.906×10^{18}	0.322×10^{18}
Intermediate Shell Longitudinal Weld Seam 101-124A (0° Azimuth)	0.848×10^{19}	0.505×10^{18}	0.180×10^{18}
Intermediate Shell Longitudinal Weld Seam 101-124B & C (120° & 240°Azimuth)	1.52×10^{19}	0.906×10^{18}	0.322×10^{18}
Intermediate to Lower Shell Circumferential Weld Seam 101-171	1.52×10^{19}	0.906×10^{18}	0.322×10^{18}
Lower Shell Longitudinal Weld Seams 101-142A & C (60° & 300° Azimuth)	1.52×10^{19}	0.906×10^{18}	0.322×10^{18}
Lower Shell Longitudinal Weld Seam 101-142B (180° Azimuth)	0.848×10^{19}	0.505×10^{18}	0.180×10^{18}

* Surface fluence values are calculated.

TABLE 4-2
Summary of the Peak Pressure Vessel Neutron Fluence Values
at 36 EFPY used for the Calculation of ART Values (n/cm^2, E > 1.0 MeV)

Material	Surface*	¼ T	¾ T
Intermediate Shell Plate B8805-1	2.09×10^{19}	1.25×10^{19}	0.442×10^{18}
Intermediate Shell Plate B8805-2	2.09×10^{19}	1.25×10^{19}	0.442×10^{18}
Intermediate Shell Plate B8805-3	2.09×10^{19}	1.25×10^{19}	0.442×10^{18}
Lower Shell Plate B8606-1	2.09×10^{19}	1.25×10^{19}	0.442×10^{18}
Lower Shell Plate B8606-2	2.09×10^{19}	1.25×10^{19}	0.442×10^{18}
Lower Shell Plate B8606-3	2.09×10^{19}	1.25×10^{19}	0.442×10^{18}
Intermediate Shell Longitudinal Weld Seam 101-124A (0° Azimuth)	1.17×10^{19}	0.697×10^{19}	0.248×10^{18}
Intermediate Shell Longitudinal Weld Seam 101-124B & C (120° & 240° Azimuth)	2.09×10^{19}	1.25×10^{19}	0.442×10^{18}
Intermediate to Lower Shell Circumferential Weld Seam 101-171	2.09×10^{19}	1.25×10^{19}	0.442×10^{18}
Lower Shell Longitudinal Weld Seams 101-142A & C (60° & 300° Azimuth)	2.09×10^{19}	1.25×10^{19}	0.442×10^{18}
Lower Shell Longitudinal Weld Seam 101-142B (180° Azimuth)	1.17×10^{19}	0.697×10^{19}	0.248×10^{18}

* Surface fluence values are calculated.

TABLE 4-3
Calculated Integrated Neutron Exposure of the Vogtle Unit 1
Surveillance Capsules Tested to Date

Capsule	Fluence
U	3.691×10^{18} n/cm^2, (E > 1.0 MeV)
Y	1.276×10^{19} n/cm^2, (E > 1.0 MeV)
V	2.178×10^{19} n/cm^2, (E > 1.0 MeV)

Margin is calculated as, $M = 2\sqrt{\sigma_I^2 + \sigma_\Delta^2}$. The standard deviation for the initial RT_{NDT} margin term, σ_i, is 0°F when the initial RT_{NDT} is a measured value, and 17°F when a generic value is used. The standard deviation for the ΔRT_{NDT} margin term, σ_Δ, is 17°F for plates when surveillance capsule data is not used and 8.5°F for plates when surveillance capsule data is used. For welds, σ_Δ is 28°F when surveillance capsule data is not used and 14°F when surveillance capsule data is used. In addition, σ_Δ need not exceed one-half the mean value of ΔRT_{NDT}.

Contained in Table 4-4 is a summary of the Measured 30 ft-lb transition temperature shifts of the beltline materials[7]. These measured shift values were obtained using CVGRAPH, Version 4.1[4], which is a hyperbolic tangent curve-fitting program.

TABLE 4-4
Measured 30 ft-lb Transition Temperature Shifts of the Beltline Materials Contained in the Surveillance Program

Material	Capsule	Measured 30 ft-lb Transition Temperature Shift[a]
Intermediate Shell Plate B8805-3 (Longitudinal Orientation)	U	13.6°F
	Y	31.9°F
	V	42.7°F
Intermediate Shell Plate B8805-3 (Transverse Orientation)	U	0.0°F[b]
	Y	15.2°F
	V	33.8°F
Surveillance Program Weld Metal	U	25.0°F
	Y	7.7°F
	V	0.0°F[b]
Heat Affected Zone	U	0.0°F[b]
	Y	20.8°F
	V	42.1°F

Notes:

(a) Calculated using measured Charpy data and plotted using CVGRAPH[4]

(b) Actual values for ΔRT_{NDT} are -9.13 (Plate), -1.3 (Weld), -19.35 (HAZ Capsule U). This physically should not occur; therefore for conservatism a value of zero will be used.

Table 4-5 contains a summary of the weight percent of copper, the weight percent of nickel and the initial RT_{NDT} of the beltline materials and vessel flanges. The weight percent values of Cu and Ni given in Table 4-5 were used to generate the calculated chemistry factor (CF) values based on Tables 1 and 2 of Regulatory Guide 1.99, Revision 2, and presented in Table 4-7. Table 4-6 provides the calculation of the CF values based on surveillance capsule data, Regulatory Guide 1.99, Revision 2, Position 2.1, which are also summarized in Table 4-7.

TABLE 4-5

Reactor Vessel Beltline Material Unirradiated Toughness Properties[5 & 9]

Material Description	Cu (%)	Ni(%)	Initial RT_{NDT}[a]
Closure Head Flange B8801-1	- -	0.70	20°F
Vessel Flange B8802-1	- -	0.71	0°F
Intermediate Shell Plate B8805-1	0.083	0.597	0°F
Intermediate Shell Plate B8805-2	0.083	0.61	20°F
Intermediate Shell Plate B8805-3	0.062	0.598	30°F
Lower Shell Plate B8606-1	0.053	0.593	20°F
Lower Shell Plate B8606-2	0.057	0.60	20°F
Lower Shell Plate B8606-3	0.067	0.623	10°F
Intermediate Shell Longitudinal Welds, 101-124A, B & C[b]	0.042[c]	0.102	-80°F
Lower Shell Longitudinal Welds, 101-142A, B & C[b]	0.042[c]	0.102	-80°F
Circumferential Weld 101-171[b]	0.042[c]	0.102	-80°F
Surveillance Program Weld Metal	0.040	0.102	- -

Notes:

(a) The initial RT_{NDT} values for the plates and welds are based on measured data.

(b) All welds, including the surveillance weld, were fabricated with weld wire heat number 83653, Linde 0091 Flux, Lot No. 3536. Per Regulatory Guide 1.99, Revision 2, "weight percent copper " and "weight percent nickel" are the best-estimate values for the material, which will normally be the mean of the measured values for a plate or forging or for weld samples made with the weld wire heat number that matches the critical vessel weld."

(c) The copper weight percent of 0.042 was obtained using all available data for that heat of weld wire per reference 9. This value is more conservative than that documented (0.039) in Vogtle Electric Generating Plant's "Pressure and Temperature Limits Report".

TABLE 4-6
Calculation of Chemistry Factors using Vogtle Unit 1 Surveillance Capsule Data

Material	Capsule	Capsule f[a]	FF[b]	ΔRT_{NDT}[c]	FF*ΔRT_{NDT}	FF^2
Intermediate Shell	U	0.3691	0.725	13.6	9.9	0.526
Plate B8805-3	Y	1.276	1.068	31.9	34.1	1.141
(Longitudinal)	V	2.178	1.211	42.7	51.7	1.467
Intermediate Shell	U	0.3691	0.725	0[e]	0.0	0.526
Plate B8805-3	Y	1.276	1.068	15.2	16.2	1.141
(Transverse)	V	2.178	1.211	33.8	40.9	1.467
				SUM	152.8	6.268
	$CF_{B8805-3} = \Sigma(FF * RT_{NDT}) \div \Sigma(FF^2) = (152.8) \div (6.268) = 24.4°F$					
Surveillance Weld	U	0.3691	0.725	25.5 (25.0) [d]	18.5	0.526
Metal	Y	1.276	1.068	7.9 (7.7) [d]	8.4	1.141
	V	2.178	1.211	0[e]	0.0	1.467
				SUM	26.9	3.134
	$CF_{Weld} = \Sigma(FF * RT_{NDT}) \div \Sigma(FF^2) = (26.9) \div (3.134) = 8.6°F$					

Notes:

(a) f = Calculated fluence from capsule V dosimetry analysis results[7], (x 10^{19} n/cm^2, E > 1.0 MeV).

(b) FF = fluence factor = $f^{(0.28 - 0.1*\log f)}$

(c) ΔRT_{NDT} values are the measured 30 ft-lb shift values.

(d) The surveillance weld metal ΔRT_{NDT} values have been adjusted by a ratio factor of 1.02.

(e) Actual values for ΔRT_{NDT} are -9.58 (Plate) and -1.34 (Weld). This physically should not occur; therefore for conservatism a value of zero will be used for this calculation.

TABLE 4-7
Summary of the Vogtle Unit 1 Reactor Vessel Beltline Material Chemistry Factors
Based on Regulatory Guide 1.99, Revision 2, Position 1.1 and Position 2.1

Material	Chemistry Factor	
	Position 1.1[a]	Position 2.1[a]
Intermediate Shell Plate B8805-1	53.1°F	---
Intermediate Shell Plate B8805-2	53.1°F	---
Intermediate Shell Plate B8805-3	38.4°F	24.4°F
Lower Shell Plate B8606-1	32.8°F	---
Lower Shell Plate B8606-2	35.2°F	---
Lower Shell Plate B8606-3	41.9°F	---
Intermediate Shell Longitudinal Welds, 101-124A, B & C[b]	34.5°F	8.6°F
Lower Shell Longitudinal Welds, 101-442A, B & C[b]	34.5°F	8.6°F
Circumferential Weld 101-171[b]	34.5°F	8.6°F
Surveillance Program Weld Metal[b]	33.7°F	---

Notes:
(a) Regulatory Guide 1.99, Revision 2, Position 1.1 or Position 2.1 methodology.
(b) All welds, including the surveillance weld, were fabricated with weld wire heat numbers 83653, Linde 0091 Flux, Lot No. 3536.

Contained in Tables 4-8 and 4-9 are summaries of the fluence factors (FF) used in the calculation of adjusted reference temperatures for the Vogtle Electric Generating Plant Unit 1 reactor vessel beltline materials for 26 EFPY and 36 EFPY.

TABLE 4-8
Summary of the Calculated Fluence Factors used for the Generation of the 26 EFPY Heatup and Cooldown Curves

Material	¼ T f (n/cm^2, E > 1.0 MeV)	¼ T FF[(a)]	¾ T f (n/cm^2, E >1.0 MeV)	¾ T FF[(b)]
Intermediate Shell Plate B8805-1	0.906×10^{19}	0.972	0.322×10^{19}	0.689
Intermediate Shell Plate B8805-2	0.906×10^{19}	0.972	0.322×10^{19}	0.689
Intermediate Shell Plate B8805-3	0.906×10^{19}	0.972	0.322×10^{19}	0.689
Lower Shell Plate B8606-1	0.906×10^{19}	0.972	0.322×10^{19}	0.689
Lower Shell Plate B8606-2	0.906×10^{19}	0.972	0.322×10^{19}	0.689
Lower Shell Plate B8606-3	0.906×10^{19}	0.972	0.322×10^{19}	0.689
Intermediate Shell Longitudinal Weld Seam 101-124A (0° Azimuth)	0.505×10^{19}	0.809	0.180×10^{19}	0.545
Intermediate Shell Longitudinal Weld Seams 101-124B & C (120° & 240° Azimuth)	0.906×10^{19}	0.972	0.322×10^{19}	0.689
Intermediate to Lower Shell Circumferential Weld Seam 101-171	0.906×10^{19}	0.972	0.322×10^{19}	0.689
Lower Shell Longitudinal Weld Seams 101-142A & C (60° & 300° Azimuth)	0.906×10^{19}	0.972	0.322×10^{19}	0.689
Lower Shell Longitudinal Weld Seam 101-142B (180° Azimuth)	0.505×10^{19}	0.809	0.180×10^{19}	0.545

Notes:
(a) Fluence Factor at the 1/4T vessel thickness location.
(b) Fluence Factor at the 3/4T vessel thickness location.

TABLE 4-9
Summary of the Calculated Fluence Factors used for the Generation of the 36 EFPY Heatup and Cooldown Curves

Material	¼ T f (n/cm², E > 1.0 MeV)	¼ T FF[a]	¾ T f (n/cm², E > 1.0 MeV)	¾ T FF[b]
Intermediate Shell Plate B8805-1	1.25×10^{19}	1.06	0.442×10^{19}	0.773
Intermediate Shell Plate B8805-2	1.25×10^{19}	1.06	0.442×10^{19}	0.773
Intermediate Shell Plate B8805-3	1.25×10^{19}	1.06	0.442×10^{19}	0.773
Lower Shell Plate B8606-1	1.25×10^{19}	1.06	0.442×10^{19}	0.773
Lower Shell Plate B8606-2	1.25×10^{19}	1.06	0.442×10^{19}	0.773
Lower Shell Plate B8606-3	1.25×10^{19}	1.06	0.442×10^{19}	0.773
Intermediate Shell Longitudinal Weld Seam 101-124A (0° Azimuth)	0.697×10^{19}	0.899	0.248×10^{19}	0.622
Intermediate Shell Longitudinal Weld Seams 101-124B & C (120° & 240° Azimuth)	1.25×10^{19}	1.06	0.442×10^{19}	0.773
Intermediate to Lower Shell Circumferential Weld Seam 101-171	1.25×10^{19}	1.06	0.442×10^{19}	0.773
Lower Shell Longitudinal Weld Seams 101-142A & C (60° & 300° Azimuth)	1.25×10^{19}	1.06	0.442×10^{19}	0.773
Lower Shell Longitudinal Weld Seam 101-142B (180° Azimuth)	0.697×10^{19}	0.899	0.248×10^{19}	0.622

Notes:

(a) Fluence Factor at the 1/4T vessel thickness location.

(b) Fluence Factor at the 3/4T vessel thickness location.

Contained in Tables 4-10 through 4-13 are the calculations of the ART values used for the generation of the 26 EFPY and 36 EFPY heatup and cooldown curves.

TABLE 4-10
Calculation of the ART Values for the 1/4T Location @ 26 EFPY

Material	RG 1.99 R2 Method	CF (°F)	FF	IRT_{NDT}[(a)]	ΔRT_{NDT}[(c)]	Margin	ART[(b)]
Intermediate Shell Plate B8805-1	Position 1.1	53.1	0.972	0	51.6	34	86
Intermediate Shell Plate B8805-2	Position 1.1	53.1	0.972	20	51.6	34	106
Intermediate Shell Plate B8805-3	Position 1.1	38.4	0.972	30	37.3	34	101
	Position 2.1	24.4	0.972	30	23.7	17	71
Lower Shell Plate B8606-1	Position 1.1	32.8	0.972	20	31.9	31.9	84
Lower Shell Plate B8606-2	Position 1.1	35.2	0.972	20	34.2	34	88
Lower Shell Plate B8606-3	Position 1.1	41.9	0.972	10	40.7	34	85
Inter. Shell Longitudinal Weld Seam 101-124A(0° Azimuth)	Position 1.1	34.5	0.809	-80	27.9	27.9	-24
	Position 2.1	8.6	0.809	-80	7.0	7.0	-66
Inter. Shell Long. Weld Seams 101-124B,C (120°, 240° Azimuth)	Position 1.1	34.5	0.972	-80	33.5	33.5	-13
	Position 2.1	8.6	0.972	-80	8.4	8.4	-63
Intermediate to Lower Shell Girth Weld Seam 101-171	Position 1.1	34.5	0.972	-80	33.5	33.5	-13
	Position 2.1	8.6	0.972	-80	8.4	8.4	-63
Lower Shell Long. Weld Seams 101-142A,C (60°, 300° Azimuth)	Position 1.1	34.5	0.972	-80	33.5	33.5	-13
	Position 2.1	8.6	0.972	-80	8.4	8.4	-63
Lower Shell Long. Weld Seam 101-142B (180° Azimuth)	Position 1.1	34.5	0.809	-80	27.9	27.9	-24
	Position 2.1	8.6	0.809	-80	7.0	7.0	-66

Notes:

(a) Initial RT_{NDT} values are measured values (see Table 4-5).

(b) ART = Initial RT_{NDT} + ΔRT_{NDT} + Margin (°F); (Rounded per ASTM E29, using the "Rounding Method")

(c) ΔRT_{NDT} = CF * FF

TABLE 4-11
Calculation of the ART Values for the 3/4T Location @ 26 EFPY

Material	RG 1.99 R2 Method	CF (°F)	FF	IRT_{NDT}[(a)]	ΔRT_{NDT}[(c)]	Margin	ART[(b)]
Intermediate Shell Plate B8805-1	Position 1.1	53.1	0.689	0	36.6	34	71
Intermediate Shell Plate B8805-2	Position 1.1	53.1	0.689	20	36.6	34	91
Intermediate Shell Plate B8805-3	Position 1.1	38.4	0.689	30	26.5	26.5	83
	Position 2.1	24.4	0.689	30	16.8	16.8	64
Lower Shell Plate B8606-1	Position 1.1	32.8	0.689	20	22.6	22.6	65
Lower Shell Plate B8606-2	Position 1.1	35.2	0.689	20	24.3	24.3	69
Lower Shell Plate B8606-3	Position 1.1	41.9	0.689	10	28.9	28.9	68
Inter. Shell Longitudinal Weld Seam 101-124A(0° Azimuth)	Position 1.1	34.5	0.545	-80	18.8	18.8	-42
	Position 2.1	8.6	0.545	-80	4.7	4.7	-71
Inter. Shell Long. Weld Seams 101-124B,C (120°, 240° Azimuth)	Position 1.1	34.5	0.689	-80	23.8	23.8	-32
	Position 2.1	8.6	0.689	-80	5.9	5.9	-68
Intermediate to Lower Shell Girth Weld Seam 101-171	Position 1.1	34.5	0.689	-80	23.8	23.8	-32
	Position 2.1	8.6	0.689	-80	5.9	5.9	-68
Lower Shell Long. Weld Seams 101-142A,C (60°, 300° Azimuth)	Position 1.1	34.5	0.689	-80	23.8	23.8	-32
	Position 2.1	8.6	0.689	-80	5.9	5.9	-68
Lower Shell Long. Weld Seam 101-142B (180° Azimuth)	Position 1.1	34.5	0.545	-80	18.8	18.8	-42
	Position 2.1	8.6	0.545	-80	4.7	4.7	-71

Notes:
(a) Initial RT_{NDT} values are measured values (see Table 4-5).
(b) ART = Initial RT_{NDT} + ΔRT_{NDT} + Margin (°F); (Rounded per ASTM E29, using the "Rounding Method")
(c) ΔRT_{NDT} = CF * FF

TABLE 4-12

Calculation of the ART Values for the 1/4T Location @ 36 EFPY

Material	RG 1.99 R2 Method	CF (°F)	FF	IRT_{NDT} (a)	ΔRT_{NDT} (c)	Margin	ART (b)
Intermediate Shell Plate B8805-1	Position 1.1	53.1	1.06	0	56.3	34	90
Intermediate Shell Plate B8805-2	Position 1.1	53.1	1.06	20	56.3	34	110
Intermediate Shell Plate B8805-3	Position 1.1	38.4	1.06	30	40.7	34	105
	Position 2.1	24.4	1.06	30	26.0	17	73
Lower Shell Plate B8606-1	Position 1.1	32.8	1.06	20	34.8	34	89
Lower Shell Plate B8606-2	Position 1.1	35.2	1.06	20	37.3	34	91
Lower Shell Plate B8606-3	Position 1.1	41.9	1.06	10	44.4	34	88
Inter. Shell Longitudinal Weld Seam 101-124A(0° Azimuth)	Position 1.1	34.5	0.899	-80	31.0	31	-18
	Position 2.1	8.6	0.899	-80	7.7	7.7	-65
Inter. Shell Long. Weld Seams 101-124B,C (120°, 240° Azimuth)	Position 1.1	34.5	1.06	-80	36.6	36.6	-7
	Position 2.1	8.6	1.06	-80	9.1	9.1	-62
Intermediate to Lower Shell Girth Weld Seam 101-171	Position 1.1	34.5	1.06	-80	36.6	36.6	-7
	Position 2.1	8.6	1.06	-80	9.1	9.1	-62
Lower Shell Long. Weld Seams 101-142A,C (60°, 300° Azimuth)	Position 1.1	34.5	1.06	-80	36.6	36.6	-7
	Position 2.1	8.6	1.06	-80	9.1	9.1	-62
Lower Shell Long. Weld Seam 101-142B (180° Azimuth)	Position 1.1	34.5	0.899	-80	31.0	31	-18
	Position 2.1	8.6	0.899	-80	7.7	7.7	-65

Notes:

(a) Initial RT_{NDT} values are measured values (see Table 4-5).

(b) ART = Initial RT_{NDT} + ΔRT_{NDT} + Margin (°F) ; (Rounded per ASTM E29, using the "Rounding Method")

(c) ΔRT_{NDT} = CF * FF

TABLE 4-13

Calculation of the ART Values for the 3/4T Location @ 36 EFPY

Material	RG 1.99 R2 Method	CF (°F)	FF	IRT_{NDT}[a]	ΔRT_{NDT}[c]	Margin	ART[b]
Intermediate Shell Plate B8805-1	Position 1.1	53.1	0.773	0	41.0	34	75
Intermediate Shell Plate B8805-2	Position 1.1	53.1	0.773	20	41.0	34	95
Intermediate Shell Plate B8805-3	Position 1.1	38.4	0.773	30	29.7	29.7	89
	Position 2.1	24.4	0.773	30	18.9	17	66
Lower Shell Plate B8606-1	Position 1.1	32.8	0.773	20	25.4	25.4	71
Lower Shell Plate B8606-2	Position 1.1	35.2	0.773	20	27.2	27.2	74
Lower Shell Plate B8606-3	Position 1.1	41.9	0.773	10	32.4	32.4	75
Inter. Shell Longitudinal Weld Seam 101-124A(0° Azimuth)	Position 1.1	34.5	0.622	-80	21.5	21.5	-37
	Position 2.1	8.6	0.622	-80	5.3	5.3	-69
Inter. Shell Long. Weld Seams 101-124B,C (120°, 240° Azimuth)	Position 1.1	34.5	0.773	-80	26.7	26.7	-27
	Position 2.1	8.6	0.773	-80	6.6	6.6	-67
Intermediate to Lower Shell Girth Weld Seam 101-171	Position 1.1	34.5	0.773	-80	26.7	26.7	-27
	Position 2.1	8.6	0.773	-80	6.6	6.6	-67
Lower Shell Long. Weld Seams 101-142A,C (60°, 300° Azimuth)	Position 1.1	34.5	0.773	-80	26.7	26.7	-27
	Position 2.1	8.6	0.773	-80	6.6	6.6	-67
Lower Shell Long. Weld Seam 101-142B (180° Azimuth)	Position 1.1	34.5	0.622	-80	21.5	21.5	-37
	Position 2.1	8.6	0.622	-80	5.3	5.3	-69

Notes:

(a) Initial RT_{NDT} values are measured values (see Table 4-5).

(b) ART = Initial RT_{NDT} + ΔRT_{NDT} + Margin (°F) ; (Rounded per ASTM E29, using the "Rounding Method")

(c) ΔRT_{NDT} = CF * FF

The intermediate shell plate B8805-2 is the limiting beltline material for all heatup and cooldown curves to be generated. Contained in Table 4-14 is a summary of the limiting ARTs to be used in the generation of the Vogtle Electric Generating Plant Unit 1 reactor vessel heatup and cooldown curves.

TABLE 4-14
Summary of the Limiting ART Values Used in the
Generation of the Vogtle Unit 1 Heatup/Cooldown Curves

EFPY	1/4T Limiting ART	3/4T Limiting ART
26	106°F	91°F
36	110°F	95°F

5 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 for the pressure and temperature in the reactor vessel beltline region using the methods discussed in Section 3 and 4 of this report. This approved methodology is also presented in WCAP-14040-A[8].

Figures 5-1 and 5-3 present the heatup curves with no margins for possible instrumentation errors for heatup rates of 60 and 100°F/hr. These curves are applicable for 26 EFPY and 36 EFPY respectively, for the Vogtle Unit 1 reactor vessel. Additionally, Figures 5-2 and 5-4 present the cooldown curves with no margins for possible instrumentation errors for cooldown rates of 0, 20, 40, 60, and 100°F/hr. These curves are also applicable for 26 EFPY and 36 EFPY, respectively, for the Vogtle Electric Generating Plant Unit 1 reactor vessel. Allowable combinations of temperature and pressure for specific temperature change rates are below and to the right of the limit lines shown in Figures 5-1 through 5-4. This is in addition to other criteria which must be met before the reactor is made critical, as discussed in the following paragraphs.

The reactor must not be made critical until pressure-temperature combinations are to the right of the criticality limit line shown in Figures 5-1 and 5-3 (for the specific heatup rate being utilized). The straight-line portion of the criticality limit is at the minimum permissible temperature for the 2485 psig inservice hydrostatic test as required by Appendix G to 10 CFR Part 50. The governing equation for the hydrostatic test is defined in Appendix G to Section XI of the ASME Code[3] as follows:

$$1.5K_{Im} < K_{Ic} \qquad (10)$$

where,

K_{Im} is the stress intensity factor covered by membrane (pressure) stress,
$K_{Ic} = 33.2 + 20.734e^{[0.02\,(T - RT_{NDT})]}$,

T is the minimum permissible metal temperature, and
RT_{NDT} is the metal reference nil-ductility temperature

The criticality limit curve specifies pressure-temperature limits for core operation to provide additional margin during actual power production as specified in Reference 2. 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 permissible temperature in the corresponding pressure-temperature curve for heatup and cooldown calculated as described in Section 3 of this report. The vertical line drawn from these points on the pressure-temperature curve, intersecting a curve 40°F higher than the pressure-temperature limit curve, constitutes the limit for core operation for the reactor vessel.

Figures 5-1 through 5-4 define all of the above limits for ensuring prevention of nonductile failure for the Vogtle Electric Generating Plant Unit 1 reactor vessel. The data points for the heatup and cooldown pressure-temperature limit curves shown in Figures 5-1 through 5-4 are presented in Tables 5-1 through 5-4, respectively.

MATERIAL PROPERTY BASIS

LIMITING MATERIAL: INTERMEDIATE SHELL PLATE B8805-2
LIMITING ART VALUES AT 26 EFPY: 1/4T, 106°F
3/4T, 91°F

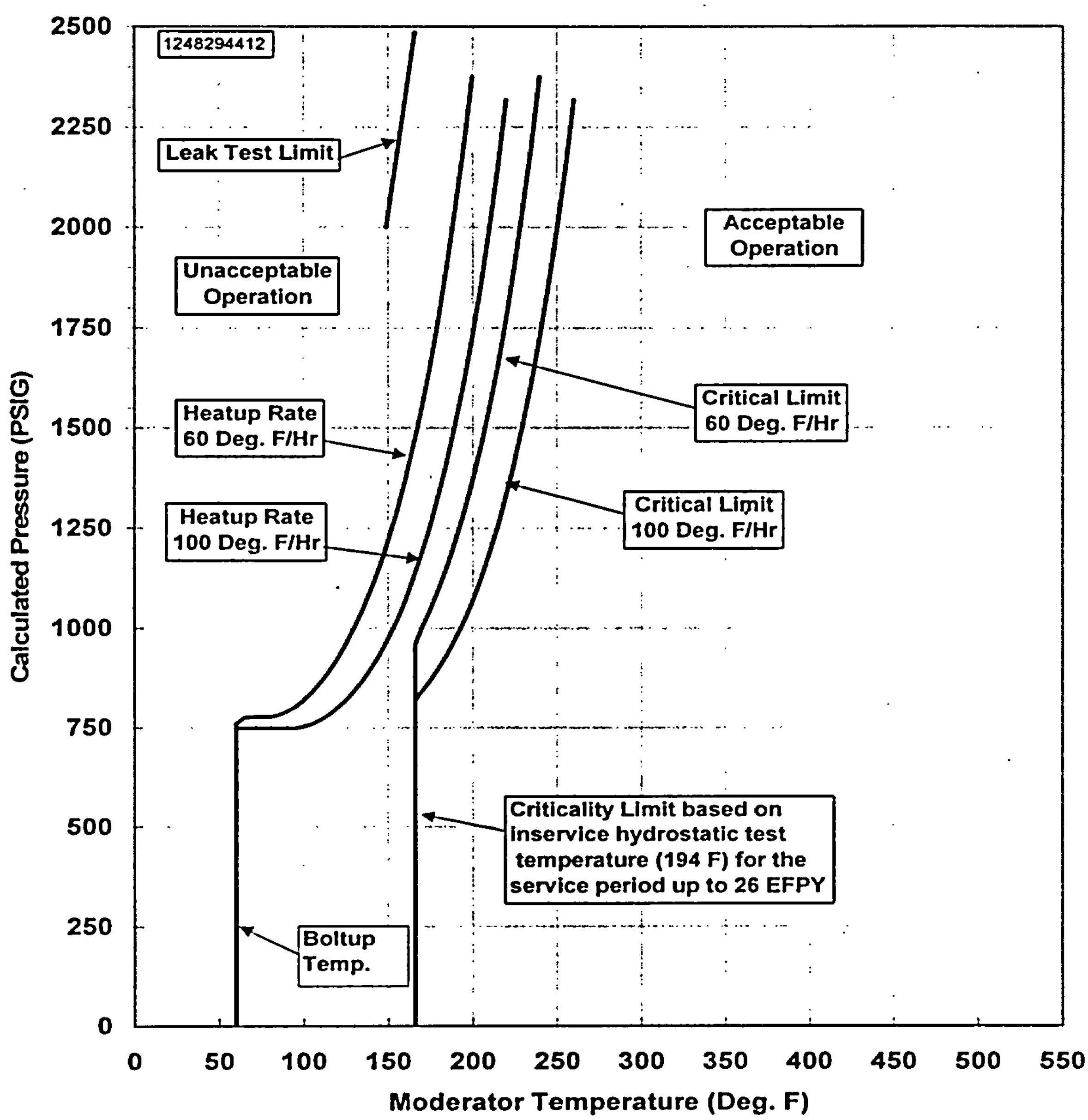

FIGURE 5-1 Vogtle Unit 1 Reactor Coolant System Heatup Limitations (Heatup Rates of 60 and 100°F/hr) Applicable to 26 EFPY (Without Margins of for Instrumentation Errors)

MATERIAL PROPERTY BASIS

LIMITING MATERIAL: INTERMEDIATE SHELL PLATE B8805-2
LIMITING ART VALUES AT 26 EFPY: 1/4T, 106°F
3/4T, 91°F

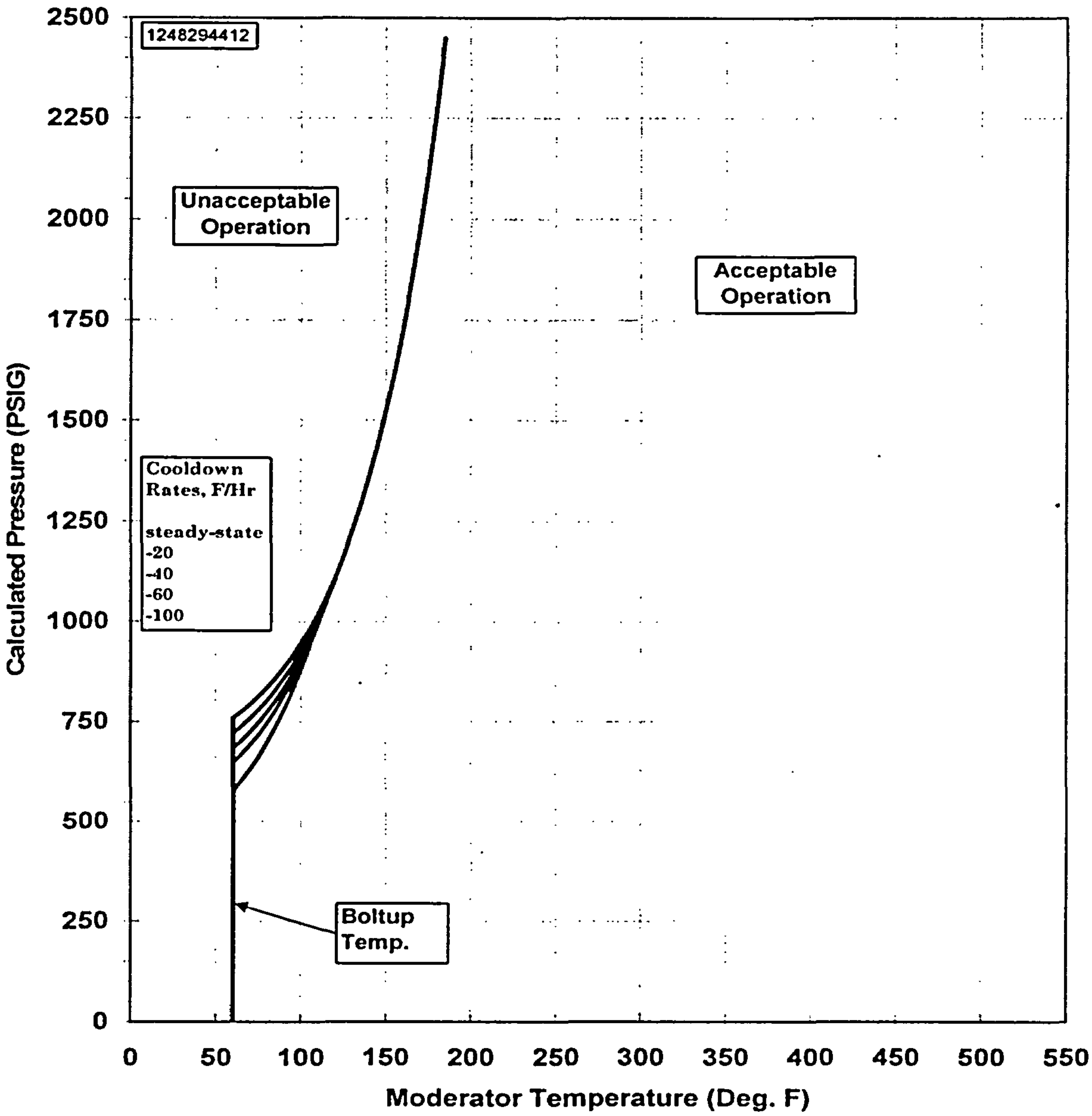

FIGURE 5-2 Vogtle Unit 1 Reactor Coolant System Cooldown Limitations (Cooldown Rates of 0, 20, 40, 60 and 100°F/hr) Applicable to 26 EFPY (Without Margins for Instrumentation Errors)

TABLE 5-1
Vogtle Unit 1 Heatup Data at 26 EFPY
Without Margins for Instrumentation Errors

60°F/hr Heatup		60°F/hr Criticality Limit		100°F/hr Heatup		100°F/hr Critical. Limit		Leak Test Limit	
T	P	T	P	T	P	T	P	T	P
60	0	166	0	60	0	166	0	149	2000
60	759	166	775	60	748	166	748	166	2485
65	775	166	782	65	748	166	748		
70	777	166	777	70	748	166	748		
75	777	166	777	75	748	166	748		
80	777	166	781	80	748	166	748		
85	781	166	790	85	748	166	748		
90	790	166	802	90	748	166	748		
95	802	166	819	95	748	166	752		
100	819	166	839	100	752	166	759		
105	839	166	863	105	759	166	769		
110	863	166	891	110	769	166	782		
115	891	166	923	115	782	166	799		
120	923	166	959	120	799	166	818		
125	959	170	1000	125	818	170	842		
130	1000	175	1046	130	842	175	868		
135	1046	180	1097	135	868	180	899		
140	1097	185	1154	140	899	185	934		
145	1154	190	1218	145	934	190	974		
150	1218	195	1289	150	974	195	1018		
155	1289	200	1367	155	1018	200	1068		
160	1367	205	1453	160	1068	205	1124		
165	1453	210	1549	165	1124	210	1186		
170	1549	215	1655	170	1186	215	1254		
175	1655	220	1772	175	1254	220	1331		
180	1772	225	1901	180	1331	225	1415		
185	1901	230	2044	185	1415	230	1509		
190	2044	235	2201	190	1509	235	1613		
195	2201	240	2375	195	1613	240	1727		
200	2375			200	1727	245	1854		
				205	1854	250	1993		
				210	1993	255	2147		
				215	2147	260	2317		
				220	2317				

TABLE 5-2
Vogtle Unit 1 Cooldown Data at 26 EFPY
Without Margins for Instrumentation Errors

Steady State		20°F/hr		40°F/hr		60°F/hr		100°F/hr	
T	P	T	P	T	P	T	P	T	P
60	0	60	0	60	0	60	0	60	0
60	759	60	721	60	684	60	648	60	578
65	775	65	739	65	703	65	669	65	603
70	792	70	758	70	724	70	692	70	631
75	812	75	779	75	747	75	717	75	662
80	833	80	802	80	773	80	746	80	697
85	857	85	828	85	802	85	777	85	735
90	883	90	857	90	833	90	812	90	778
95	912	95	889	95	868	95	850	95	825
100	944	100	924	100	907	100	893	100	878
105	979	105	963	105	950	105	940	105	936
110	1018	110	1006	110	997	110	993		
115	1062	115	1053	115	1049				
120	1109	120	1106						
125	1162								
130	1221								
135	1285								
140	1356								
145	1435								
150	1522								
155	1618								
160	1725								
165	1842								
170	1972								
175	2116								
180	2274								
185	2449								

MATERIAL PROPERTY BASIS

LIMITING MATERIAL: INTERMEDIATE SHELL PLATE B8805-2
LIMITING ART VALUES AT 36 EFPY: 1/4T, 110°F
3/4T, 95°F

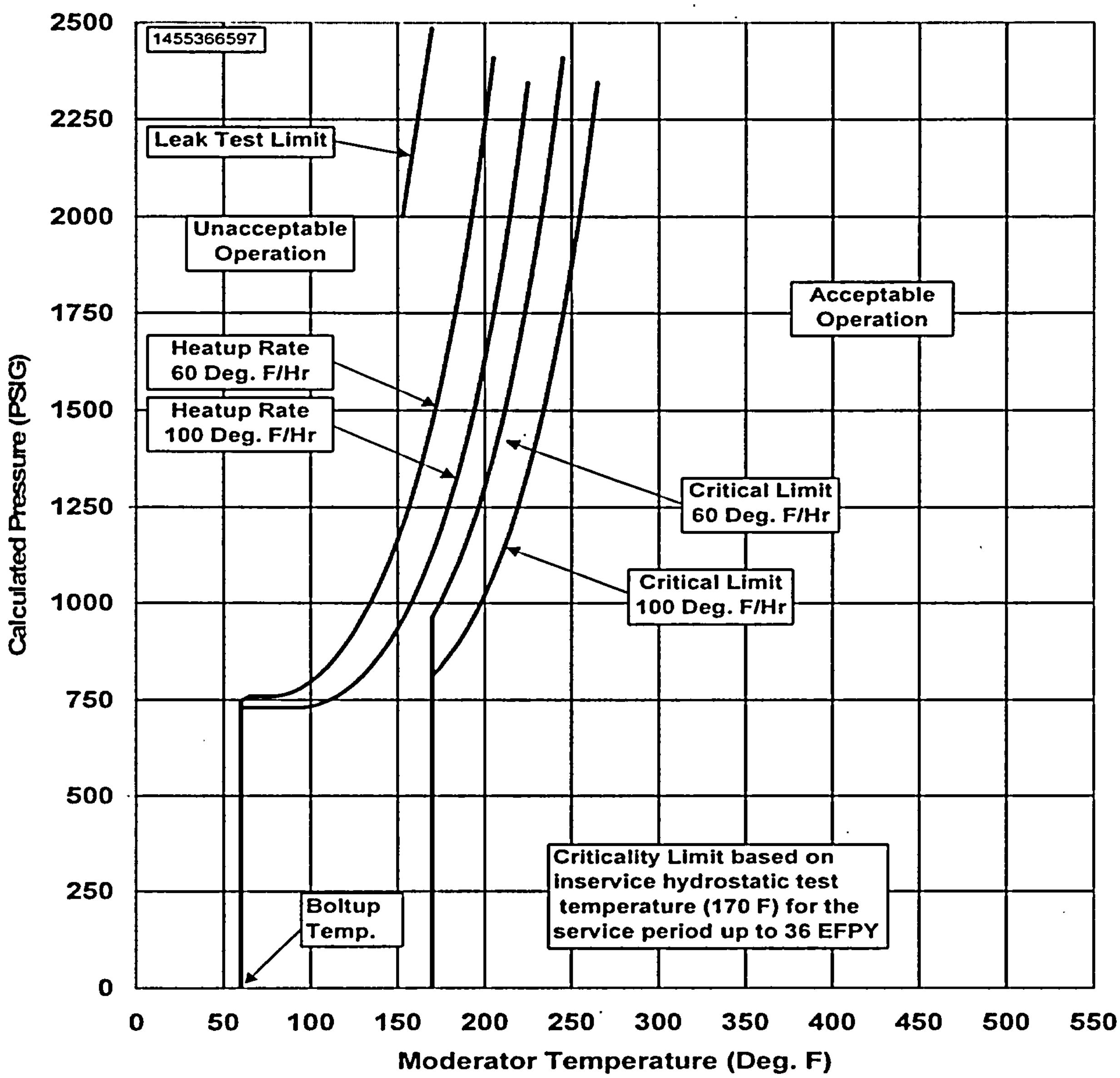

FIGURE 5-3 Vogtle Unit 1 Reactor Coolant System Heatup Limitations (Heatup Rate of 60 and 100°F/hr) Applicable to 36 EFPY (Without Margins of for Instrumentation Errors)

MATERIAL PROPERTY BASIS

LIMITING MATERIAL: INTERMEDIATE SHELL PLATE B8805-2
LIMITING ART VALUES AT 36 EFPY: 1/4T, 110°F
3/4T, 95°F

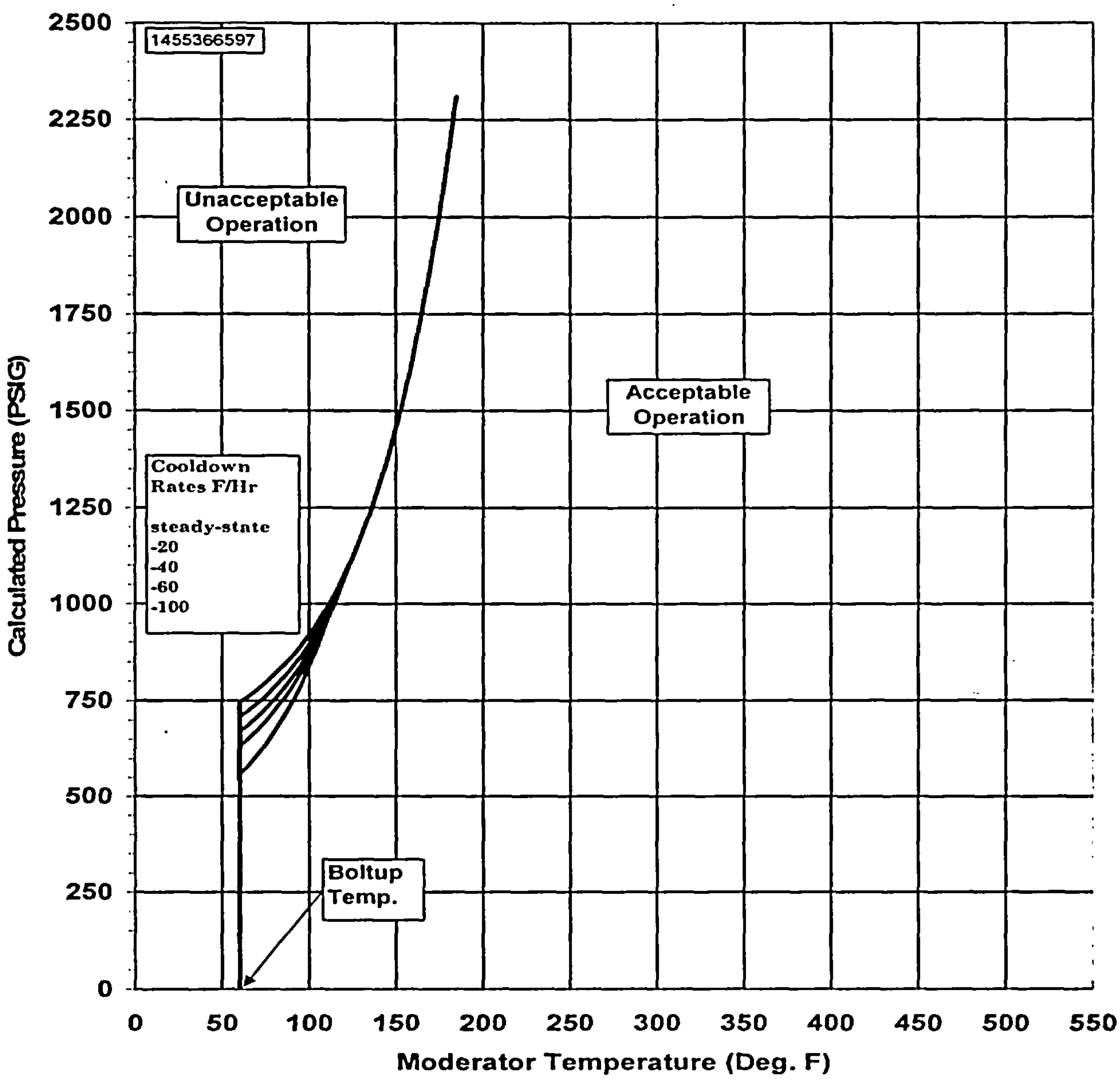

FIGURE 5-4 Vogtle Unit 1 Reactor Coolant System Cooldown Limitations (Cooldown Rates of 0, 20, 40, 60 and 100°F/hr) Applicable to 36 EFPY (Without Margins for Instrumentation Errors)

TABLE 5-3
Vogtle Unit 1 Heatup Data at 36 EFPY
Without Margins for Instrumentation Errors

60°F/hr Heatup		60°F/hr Criticality Limit		100°F/hr Heatup		100°F/hr Critical. Limit		Leak Test Limit	
T	P	T	P	T	P	T	P	T	P
60	0	170	0	60	0	170	0	153	2000
60	747	170	760	60	730	170	730	170	2485
65	760	170	763	65	730	170	733		
70	760	170	770	170	730	170	739		
75	760	170	782	75	730	170	747		
80	760	170	796	80	730	170	759		
85	763	170	815	85	730	170	774		
90	770	170	836	90	730	170	791		
95	782	170	862	95	730	170	812		
100	796	170	891	100	733	175	837		
105	815	170	925	105	739	180	865		
110	836	170	962	110	747	185	897		
115	862	175	1005	115	759	190	933		
120	891	180	1052	120	774	195	974		
125	925	185	1105	125	791	200	1020		
130	962	190	1163	130	812	205	1071		
135	1005	195	1228	135	837	210	1128		
140	1052	200	1300	140	865	215	1191		
145	1105	205	1380	145	897	220	1261		
150	1163	210	1468	150	933	225	1339		
155	1228	215	1566	155	974	230	1426		
160	1300	220	1674	160	1020	235	1521		
165	1380	225	1793	165	1071	240	1627		
170	1468	230	1925	170	1128	245	1743		
175	1566	235	2070	175	1191	250	1872		
180	1674	240	2231	180	1261	255	2014		
185	1793	245	2408	185	1339	260	2171		
190	1925			190	1426	265	2344		
195	2070			195	1521				
200	2231			200	1627				
205	2408			205	1743				
				210	1872				
				215	2014				
				220	2171				
				225	2344				

TABLE 5-4
Vogtle Unit 1 Cooldown Data at 36 EFPY
Without Margins for Instrumentation Errors

Steady State		20°F/hr		40°F/hr		60°F/hr		100°F/hr	
T	P	T	P	T	P	T	P	T	P
60	0	60	0	60	0	60	0	60	0
60	747	60	709	60	670	60	633	60	559
65	762	65	725	65	688	65	652	65	582
70	778	70	742	70	707	70	673	70	608
75	796	75	762	75	728	75	696	75	637
80	816	80	783	80	752	80	722	80	668
85	838	85	807	85	778	85	751	85	704
90	862	90	834	90	807	90	783	90	743
95	889	95	863	95	840	95	819	95	787
100	918	100	895	100	875	100	858	100	835
105	951	105	931	105	915	105	902	105	889
110	987	110	971	110	959	110	950	110	948
115	1027	115	1015	115	1007	115	1004		
120	1071	120	1063	120	1061				
125	1120	125	1117						
130	1173								
135	1233								
140	1299								
145	1371								
150	1452								
155	1541								
160	1639								
165	1747								
170	1867								
175	2000								
180	2146								
185	2308								

6 REFERENCES

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

2 10 CFR Part 50, Appendix G, "Fracture Toughness Requirements", Federal Register, Volume 60, No. 243, dated December 19, 1995.

3 Section XI of the ASME Boiler and Pressure Vessel Code, Appendix G, "Fracture Toughness Criteria for Protection Against Failure.", Dated December 1995.

4 CVGRAPH, Hyperbolic Tangent Curve-Fitting Program, Version 4.1, developed by ATI Consulting, March 1996.

5 WCAP-13931, Rev. 1, "Analysis of Capsule Y from the Georgia Power Company Vogtle Unit 1 Reactor Vessel Radiation Surveillance Program", M.J. Malone, et al., August 1995.

6 1989 Section III, Division 1 of the ASME Boiler and Pressure Vessel Code, Paragraph NB-2331, "Material for Vessels".

7 WCAP-15067, "Analysis of Capsule V from the Georgia Power Vogtle Electric Generating Plant Unit 1 Reactor Vessel Radiation Surveillance Program", T. J. Laubham, et al., September 1998.

8 WCAP-14040-A, Revision 4, "Methodology used to Develop Cold Overpressure Mitigating System Setpoints and RCS Heatup and Cooldown Limit Curves", J. D. Andrachek, et al.

9 CE NPSD-1039, Rev. 2, "Best Estimate Copper and Nickel Values in CE Fabricated Reactor Vessel Welds, Appendix A, CE Reactor Vessel Weld Properties Database, Volume 1," CEOG Task 902, June 1997.

10 ASME Code Case N-640, "Alternative Reference Fracture Toughness for Development of P-T Limit Curves for Section XI, Division 1", February 26, 1999.

11 WCAP-16142, "Reactor Vessel Closure Head/Vessel Flange Requirements Evaluation for Vogtle Units 1 and 2", Revision 1, W. Bamford, et.al., February 2004.

APPENDIX A

Thermal Stress Intensity Factors (K_{It})

The following page contain the thermal stress intensity factors (K_{It}) for the maximum heatup and cooldown rates at 26 and 36 EFPY. The vessel radius to the ¼T and ¾T locations are as follows:

- 1/4T Radius = 88.812"
- 3/4T Radius = 93.125"

TABLE A1
K_{It} Values for 100°F/hr Heatup Curve (26 EFPY)

Water Temp. (°F)	Vessel Temperature @ 1/4T Location for 100°F/hr Heatup (°F)	1/4T Thermal Stress Intensity Factor (KSI SQ. RT. IN.)	Vessel Temperature @ 3/4T Location for 100°F/hr Heatup (°F)	3/4T Thermal Stress Intensity Factor (KSI SQ. RT. IN.)
60	55.99	-0.9954	55.04	0.4731
65	58.56	-2.4522	55.29	1.4378
70	61.62	-3.7125	55.96	2.4257
75	64.90	-4.9101	57.10	3.3563
80	68.45	-5.9455	58.65	4.1903
85	72.11	-6.8918	60.59	4.9375
90	75.95	-7.7139	62.86	5.5992
95	79.90	-8.4650	65.44	6.1920
100	83.97	-9.1227	68.28	6.7187
105	88.13	-9.7209	71.36	7.1893
110	92.39	-10.2475	74.64	7.6093
115	96.72	-10.7283	78.10	7.9875
120	101.12	-11.1541	81.71	8.3272
125	105.58	-11.5441	85.47	8.6336
130	110.09	-11.8911	89.36	8.9098
135	114.65	-12.2102	93.35	9.1601
140	119.25	-12.4955	97.44	9.3868
145	123.89	-12.7594	101.61	9.5932
150	128.56	-12.9966	105.86	9.7812
155	133.26	-13.2173	110.18	9.9534
160	137.98	-13.4168	114.56	10.1112
165	142.73	-13.6038	118.98	10.2566
170	147.50	-13.7740	123.46	10.3908
175	152.28	-13.9346	127.97	10.5153
180	157.08	-14.0817	132.52	10.6310
185	161.89	-14.2217	137.10	10.7391
190	166.71	-14.3508	141.71	10.8404
195	171.55	-14.4746	146.35	10.9357
200	176.39	-14.5897	151.01	11.0256

Note: The 100°F/hr Heatup Curve is limited entirely by the 3/4T Location

TABLE A2
K_{It} Values for 100°F/hr Cooldown Curve (26 EFPY)

Water Temp. (°F)	Vessel Temperature @ 1/4T Location for 100°F/hr Cooldown (°F)	100°F/hr Cooldown 1/4T Thermal Stress Intensity Factor (KSI SQ. RT. IN.)
185	211.61	16.7952
180	206.53	16.7262
175	201.44	16.6565
170	196.35	16.5873
165	191.27	16.5176
160	186.18	16.4483
155	181.09	16.3786
150	176.00	16.3093
145	170.92	16.2396
140	165.83	16.1704
135	160.74	16.1008
130	155.65	16.0317
125	150.56	15.9623
120	145.48	15.8933
115	140.39	15.8240
110	135.30	15.7553
105	130.22	15.6862
100	125.13	15.6177
95	120.04	15.5488
90	114.95	15.4805
85	109.87	15.4120
80	104.78	15.3439
75	99.69	15.2756
70	94.61	15.2078
65	89.52	15.1398
60	84.44	15.0715

TABLE A3

K_{It} Values for 100°F/hr Heatup Curve (36 EFPY)

Water Temp. (°F)	Vessel Temperature @ 1/4T Location for 100°F/hr Heatup (°F)	1/4T Thermal Stress Intensity Factor (KSI SQ. RT. IN.)	Vessel Temperature @ 3/4T Location for 100°F/hr Heatup (°F)	3/4T Thermal Stress Intensity Factor (KSI SQ. RT. IN.)
60	55.99	-0.9954	55.04	0.4731
65	58.56	-2.4522	55.29	1.4378
70	61.62	-3.7125	55.96	2.4257
75	64.90	-4.9101	57.10	3.3563
80	68.45	-5.9455	58.65	4.1903
85	72.11	-6.8918	60.59	4.9375
90	75.95	-7.7139	62.86	5.5992
95	79.90	-8.4650	65.44	6.1920
100	83.97	-9.1227	68.28	6.7187
105	88.13	-9.7209	71.36	7.1893
110	92.39	-10.2475	74.64	7.6093
115	96.72	-10.7283	78.10	7.9875
120	101.12	-11.1541	81.71	8.3272
125	105.58	-11.5441	85.47	8.6336
130	110.09	-11.8911	89.36	8.9098
135	114.65	-12.2102	93.35	9.1601
140	119.25	-12.4955	97.44	9.3868
145	123.89	-12.7594	101.61	9.5932
150	128.56	-12.9966	105.86	9.7812
155	133.26	-13.2173	110.18	9.9534
160	137.98	-13.4168	114.56	10.1112
165	142.73	-13.6038	118.98	10.2566
170	147.50	-13.7740	123.46	10.3908
175	152.28	-13.9346	127.97	10.5153
180	157.08	-14.0817	132.52	10.6310
185	161.89	-14.2217	137.10	10.7391
190	166.71	-14.3508	141.71	10.8404
195	171.55	-14.4746	146.35	10.9357
200	176.39	-14.5897	151.01	11.0256
205	181.25	-14.7007	155.68	11.1109

Note: The 100°F/hr Heatup Curve is limited entirely by the 3/4T Location

TABLE A4
K_{It} Values for 100°F/hr Cooldown Curve (36 EFPY)

Water Temp. (°F)	Vessel Temperature @ 1/4T Location for 100°F/hr Cooldown (°F)	100°F/hr Cooldown 1/4T Thermal Stress Intensity Factor (KSI SQ. RT. IN.)
185	211.61	16.7952
180	206.53	16.7262
175	201.44	16.6565
170	196.35	16.5873
165	191.27	16.5176
160	186.18	16.4483
155	181.09	16.3786
150	176.00	16.3093
145	170.92	16.2396
140	165.83	16.1704
135	160.74	16.1008
130	155.65	16.0317
125	150.56	15.9623
120	145.48	15.8933
115	140.39	15.8240
110	135.30	15.7553
105	130.22	15.6862
100	125.13	15.6177
95	120.04	15.5488
90	114.95	15.4805
85	109.87	15.4120
80	104.78	15.3439
75	99.69	15.2756
70	94.61	15.2078
65	89.52	15.1398
60	84.44	15.0715

Enclosure 5

Vogtle Electric Generating Plant Units 1 and 2
Affidavit for Withholding, Proprietary Information Notice, Copyright Notice

Westinghouse

Westinghouse Electric Company
Nuclear Services
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555-0001

Direct tel: (412) 374-5282
Direct fax: (412) 374-4011
e-mail: galem1js@westinghouse.com

Our ref: CAW-03-1736

November 13, 2003

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: WCAP-16142-P, "Reactor Vessel Closure Head/Vessel Flange Requirements Evaluation for Vogtle Units 1 and 2" (Proprietary)

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-03-1736 signed by the owner of the proprietary information, Westinghouse Electric Company LLC. The affidavit, which accompanies this letter, sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of 10 CFR Section 2.790 of the Commission's regulations.

Accordingly, this letter authorizes the utilization of the accompanying affidavit by Southern Nuclear Operating Company.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse affidavit should reference this letter, CAW-03-1736, and should be addressed to J. S. Galembush, Acting Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

J. S. Galembush, Acting Manager
Regulatory Compliance and Plant Licensing

Enclosures

cc: D. Holland
B. Benney
E. Peyton

bcc: J. S. Galembush (ECE 4-7A) 1L
R. Bastien, 1L, 1A (Nivelles, Belgium)
C. Brinkman, 1L, 1A (Westinghouse Electric Co., 12300 Twinbrook Parkway, Suite 330, Rockville, MD 20852)
RCPL Administrative Aide (ECE 4-7A) 1L, 1A (letter and affidavit only)

CAW-03-1736

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared J. S. Galembush, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

J. S. Galembush, Acting Manager
Regulatory Compliance and Plant Licensing

Sworn to and subscribed
before me this 13th day
of November, 2003

Sharon L. Fiori
Notary Public

SHARON L. FIORI
COMMONWEALTH OF PENNSYLVANIA
NOTARY PUBLIC

Notarial Seal
Sharon L. Fiori, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires January 29, 2007
Member, Pennsylvania Association Of Notaries

(1) I am Acting Manager, Regulatory Compliance and Plant Licensing, in Nuclear Services, Westinghouse Electric Company LLC (Westinghouse), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rule making proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.790 of the Commission's regulations and in conjunction with the Westinghouse "Application for Withholding" accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.790 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of

Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information that is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.790, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in WCAP-16142-P, "Reactor Vessel Closure Head/Vessel Flange Requirements Evaluation for Vogtle Units 1 and 2," (Proprietary) dated November, 2003, being transmitted by Southern Nuclear Operating Company letter and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted for use by Westinghouse for Vogtle Units 1 and 2 is expected to be applicable for other licensee submittals in response to certain NRC requirements for justification of the elimination of the flange temperature requirement for the reactor vessel P-T limit curves.

This information is part of that which will enable Westinghouse to:

(a) Support an exemption request to eliminate the flange temperature requirement.

(b) Document the basis for the postulated flaw size, the detail of the stress analyses, and the material properties.

(c) Provide the potential effect of thermal aging of the reactor vessel steel.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of similar information to its customers for purposes of meeting NRC Requirements for Licensing documentation.

(b) Westinghouse can sell support and defense of elimination of the flange temperature requirement.

(c) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar calculations and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.790 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.790(b)(1).

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