CP&L

Carolina Power & Light Company
Harris Nuclear Plant
PO Box 165
New Hill NC 27562

SERIAL: HNP-01-055
10CFR50.90

MAR 2 2 2001

United States Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, DC 20555

SHEARON HARRIS NUCLEAR POWER PLANT
DOCKET NO. 50-400/LICENSE NO. NPF-63
REACTOR VESSEL INTEGRITY DATABASE UPDATE SUPPLEMENTAL

Dear Sir or Madam:

On October 12, 2000, Harris Nuclear Plant (HNP) submitted a letter to the NRC with information concerning the Reactor Vessel Material Surveillance Report and Reactor Vessel Integrity Database update. The letter referenced a calculation (FTI 32-5004664-00) as part of the information provided. HNP is providing this calculation to aid the NRC staff in reviewing the Reactor Vessel Integrity Database update.

Enclosure 1 provides a copy of the calculation for your review

Please refer any questions regarding this matter to Mr. E. A. McCartney at (919) 362-2661.

Sincerely,

Eric McCartney for RJ Field

Richard J. Field

MSE/mse

Enclosures:
1. FTI 32-5004664-00

c: Mr. J. B. Brady, NRC Sr. Resident Inspector
Mr. R. J. Laufer, NRC Project Manager
Mr. L. A. Reyes, NRC Regional Administrator

A008

ENCLOSURE 1 TO SERIAL: HNP-01-055

SHEARON HARRIS NUCLEAR POWER PLANT
DOCKET NO. 50-400/LICENSE NO. NPF-63
REACTOR VESSEL INTEGRITY DATABASE UPDATE SUPPLEMENTAL
CALCULATION FTI 32-5004664-00

20697-3 (12/95)

FRAMATOME TECHNOLOGIES

CALCULATION SUMMARY SHEET (CSS)

Document Identifier 32 - 5004664 - 00

Title PRESSURIZED THERMAL SHOCK REFERENCE TEMPERATURES FOR HNP

PREPARED BY:		REVIEWED BY:	
NAME	M. J. DEVAN	NAME	W. A. PAVINICH
SIGNATURE	M J Devan	SIGNATURE	W A Pavinich
TITLE	SUPERVISORY ENG DATE 10/7/99	TITLE	ADVISORY ENGR DATE 10/12/99
COST CENTER	41020 REF. PAGE(S) ~~19~~ 20 mjd	TM STATEMENT: REVIEWER INDEPENDENCE	K. E. Ro.

PURPOSE AND SUMMARY OF RESULTS:

The projected pressurized thermal shock (PTS) reference temperature (RT_{PTS}) values at 36 effective full power years (36 EFPY) for the Shearon Harris (HNP) reactor vessel beltline materials were calculated in accordance with 10 CFR 50.61, "Fracture Toughness Requirements for Protection Against Pressurized Thermal Shock Events." The controlling beltline material for the HNP reactor vessel with respect to PTS is the intermediate shell plate, heat no. B4197-2 with a RT_{PTS} value of 196.1°F. The screening crtierion for this material is 270°F.

THE FOLLOWING COMPUTER CODES HAVE BEEN USED IN THIS DOCUMENT:

CODE/VERSION/REV	CODE/VERSION/REV

THE DOCUMENT CONTAINS ASSUMPTIONS THAT MUST BE VERIFIED PRIOR TO USE ON SAFETY-RELATED WORK

☐ YES ☒ NO

RECORD OF REVISIONS

Revision	Description
00	Original Release

TABLE OF CONTENTS

1.0 Introduction

The purpose of this analysis is to determine the reactor vessel pressurized thermal shock reference temperatures (RT_{PTS}) applicable to 36 effective full power years (36 EFPY) for the Carolina Power and Light Company (CP&L) Shearon Harris Nuclear Power Plant (HNP).

2.0 Summary of Results

The RT_{PTS} values applicable to 36 EFPY for the HNP reactor vessel beltline materials are listed in Table 1. These values were calculated in accordance with the requirements specified in Code of Federal Regulations, Title 10, Part 50.61 (10 CFR 50.61).[1] The controlling beltline material for the HNP reactor vessel is the intermediate shell plate heat number B4197-2 with a predicted RT_{PTS} value of 196.1°F. Screening criterion for this material is 270°F.

3.0 Assumptions

No major assumptions are contained in this calculation.

4.0 Reactor Vessel Fluence

The extrapolated end-of-license (36 EFPY) fluences for the HNP reactor vessel beltline materials are listed in Table 2.[2] These values are at the clad-base metal interface on the inside surface of the vessel at the location where the material in question receives the highest fluence.

Table 1. Shearon Harris Pressurized Thermal Shock Reference Temperature Applicable To 36 EFPY

Material Description				Chemical Composition									
Reactor Vessel Beltline Region Matl.	Matl. Ident.	Heat Number	Type	Cu wt%	Ni wt%	Chem. Factor	Initial RT_{NDT}, F	36 EFPY Fluence at Clad-Base Metal Interface, n/cm^2	Fluence Factor	ΔRT_{PTS}, F	Margin, F	RT_{PTS}, F	Screening Criteria
RT_{PTS} Calculation Per 10 CFR 50.61 Using Tables													
Intermediate Shell (IS) Plate	A9153-1	A9153-1	SA-533 Gr. B1	0.09	0.46	58.0	60	4.55E+19	1.383	80.2	34.0	174.2	270
Intermediate Shell (IS) Plate	B4197-2	B4197-2	SA-533 Gr. B1	0.09	0.50	58.0	91	4.55E+19	1.383	80.2	34.0	205.2	270
Lower Shell (LS) Plate	C9924-1	C9924-1	SA-533 Gr. B1	0.08	0.47	51.0	54	4.44E+19	1.378	70.3	34.0	158.3	270
Lower Shell (LS) Plate	C9924-2	C9924-2	SA-533 Gr. B1	0.08	0.47	51.0	57	4.44E+19	1.378	70.3	34.0	161.3	270
IS Longit. Welds (Both 100%)	BC/BD	4P4784	Linde 124	0.05	0.91	68.0	-20	1.66E+19	1.140	77.5	56.0	113.5	270
IS to LS Circ. Weld (100%)	AB	5P6771	Linde 124	0.03	0.94	41.0	-20	4.36E+19	1.375	56.4	56.0	92.4	300
LS Longit. Welds (Both 100%)	BA/BB	4P4784	Linde 124	0.05	0.91	68.0	-20	1.62E+19	1.133	77.0	56.0	113.0	270
RT_{PTS} Calculation Per 10 CFR 50.61 Using Surveillance Data													
Intermediate Shell (IS) Plate	B4197-2	B4197-2	SA-533 Gr. B1	0.09	0.50	51.4	91	4.55E+19	1.383	71.1	34.0*	[196.1]	270
IS to LS Circ. Weld (100%)	AB	5P6771	Linde 124	0.03	0.94	49.1	-20	4.36E+19	1.375	67.5	28.0	75.5	300

* - Since two of the six surveillance data points are not credible, a full margin value is used to calculate the RT_{PTS} value.

[ ] – Limiting reactor vessel beltline region material in accordance with 10 CFR 50.61.

Table 2. Fluence (E > 1.0 MeV) Values at 36 EFPY for the Shearon Harris Reactor Vessel Beltline Materials

Beltline Materials	Material Ident.	36 EFPY Fluence, n/cm² at the Clad/Base Metal Interface on the Inside Surface
Intermediate Shell (IS) Plate (Ht. No. A9153-1)	A9153-1	4.55E+19
Intermediate Shell (IS) Plate (Ht. No. B4197-2)	B4197-2	4.55E+19
Lower Shell (LS) Plate (Ht. No. C9924-1)	C9924-1	4.44E+19
Lower Shell (LS) Plate (Ht. No. C9924-2)	C9924-2	4.44E+19
IS Longit. Welds (100%) (Wire Ht. 4P4784 / Flux Lot 3930)	BC & BD	1.66E+19
IS to LS Circ. Weld (100%) (Wire Ht. 5P6771 / Flux Lot 0342)	AB	4.36E+19
LS Longit. Welds (100%) (Wire Ht. 4P4784 / Flux Lot 3930)	BA & BB	1.62E+19

5.0 Pressurized Thermal Shock Reference Temperature Calculation Where No Surveillance Data Is Available

The following information is required for determination of the pressurized thermal shock reference temperature in accordance with 10 CFR 50.61.

5.1 Initial RT_{NDT}

The initial RT_{NDT} is the reference temperature for the reactor vessel beltline material in the unirradiated condition, evaluated in accordance with Paragraph NB-2331 of Section III of the ASME Boiler and Pressure Vessel Code.[3] Table 3 lists the initial RT_{NDT} values for the HNP reactor vessel beltline materials.[4]

Table 3. Initial RT_{NDT} Values for the Shearon Harris Reactor Vessel Beltline Materials

Beltline Materials	Material Ident.	Initial RT_{NDT}, F
Intermediate Shell (IS) Plate (Ht. No. A9153-1)	A9153-1	60
Intermediate Shell (IS) Plate (Ht. No. B4197-2)	B4197-2	91
Lower Shell (LS) Plate (Ht. No. C9924-1)	C9924-1	54
Lower Shell (LS) Plate (Ht. No. C9924-2)	C9924-2	57
IS Longit. Welds (100%) (Wire Ht. 4P4784 / Flux Lot 3930)	BC & BD	-20
IS to LS Circ. Weld (100%) (Wire Ht. 5P6771 / Flux Lot 0342)	AB	-20
LS Longit. Welds (100%) (Wire Ht. 4P4784 / Flux Lot 3930)	BA & BB	-20

5.2 ΔRT_{NDT}

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

$$\Delta RT_{NDT} = (CF) * (ff) \qquad (1)$$

where CF = Chemistry Factor
ff = fluence factor

5.2.1 Chemistry Factor

The chemistry factor (CF) is determined from the copper and nickel content for each reactor vessel beltline region material. Using the copper and nickel contents for the HNP reactor vessel beltline materials,[4],[5] the CF is determined from Table 1 (for weld metals) and Table 2 (for base metals) in 10 CFR 50.61. Linear interpolation is permitted. When determining the CF, the "weight percent copper" and "weight percent nickel" are best estimate values for the material, which will normally be the mean of the measured values for the material.

Using Tables 1 and 2 in 10 CFR 50.61, the CF values for the HNP reactor vessel beltline materials are listed in Table 4.

Table 4. 10 CFR 50.61 Chemistry Factors for the Shearon Harris Reactor Vessel Beltline Materials

Beltline Materials	Material Ident.	Cu wt%	Ni wt%	Chemistry Factor
Intermediate Shell (IS) Plate (Ht. No. A9153-1)	A9153-1	0.09	0.46	58.0
Intermediate Shell (IS) Plate (Ht. No. B4197-2)	B4197-2	0.09	0.50	58.0
Lower Shell (LS) Plate (Ht. No. C9924-1)	C9924-1	0.08	0.47	51.0
Lower Shell (LS) Plate (Ht. No. C9924-2)	C9924-2	0.08	0.47	51.0
IS Longit. Welds (100%) (Wire Ht. 4P4784 / Flux Lot 3930)	BC & BD	0.05	0.91	68.0
IS to LS Circ. Weld (100%) (Wire Ht. 5P6771 / Flux Lot 0342)	AB	0.03	0.94	41.0
LS Longit. Welds (100%) (Wire Ht. 4P4784 / Flux Lot 3930)	BA & BB	0.05	0.91	68.0

5.2.2 Fluence Factor

In accordance with 10 CFR 50.61, the fluence factor (ff) is determined as follows:

$$ff = f^{(0.28 - 0.10 \log f)} \tag{2}$$

Table 5 lists the fluence factors for the HNP reactor vessel beltline materials at 36 EFPY.

Table 5. Fluence Factors Through 36 EFPY for the Shearon Harris Reactor Vessel Beltline Materials

Beltline Materials	Material Ident.	Fluence, n/cm^2 (x 10^{19})	Fluence Factor
Intermediate Shell (IS) Plate (Ht. No. A9153-1)	A9153-1	4.55	1.383
Intermediate Shell (IS) Plate (Ht. No. B4197-2)	B4197-2	4.55	1.383
Lower Shell (LS) Plate (Ht. No. C9924-1)	C9924-1	4.44	1.378
Lower Shell (LS) Plate (Ht. No. C9924-2)	C9924-2	4.44	1.378
IS Longit. Welds (100%) (Wire Ht. 4P4784 / Flux Lot 3930)	BC & BD	1.66	1.140
IS to LS Circ. Weld (100%) (Wire Ht. 5P6771 / Flux Lot 0342)	AB	4.36	1.375
LS Longit. Welds (100%) (Wire Ht. 4P4784 / Flux Lot 3930)	BA & BB	1.62	1.133

5.2.3 ΔRT_{NDT} Calculation

The ΔRT_{NDT} values for the HNP reactor vessel beltline materials are calculated by multiplying the chemistry factors and fluence factors. The 36 EFPY ΔRT_{NDT} values for the HNP reactor vessel beltline materials are presented in Table 6.

Table 6. ΔRT_{NDT} Values for the Shearon Harris Reactor Vessel Beltline Materials

Beltline Materials	Material Ident.	Chemistry Factor	Fluence Factor	ΔRT_{NDT}, F
Intermediate Shell (IS) Plate (Ht. No. A9153-1)	A9153-1	58.0	1.383	80.2
Intermediate Shell (IS) Plate (Ht. No. B4197-2)	B4197-2	58.0	1.383	80.2
Lower Shell (LS) Plate (Ht. No. C9924-1)	C9924-1	51.0	1.378	70.3
Lower Shell (LS) Plate (Ht. No. C9924-2)	C9924-2	51.0	1.378	70.3
IS Longit. Welds (100%) (Wire Ht. 4P4784 / Flux Lot 3930)	BC & BD	68.0	1.140	77.5
IS to LS Circ. Weld (100%) (Wire Ht. 5P6771 / Flux Lot 0342)	AB	41.0	1.375	56.4
LS Longit. Welds (100%) (Wire Ht. 4P4784 / Flux Lot 3930)	BA & BB	68.0	1.133	77.0

5.3 Margin

The "margin" is the quantity that is added to obtain conservative, upper-bound values of the adjusted reference temperature. The margin is determined by the following expression:

$$Margin = 2\sqrt{\sigma_I^2 + \sigma_\Delta^2} \qquad (3)$$

where σ_I = standard deviation for the initial RT_{NDT}
σ_Δ = standard deviation for ΔRT_{NDT}

If a measured value of initial RT_{NDT} for the material in question is available, σ_I is to be estimated from the precision of the test method. If generic mean values are used, σ_I is the standard deviation obtained from the set of data used to establish the mean.

The standard deviation for ΔRT_{NDT}, σ_Δ, is 28°F for welds and 17°F for base metals, except that σ_Δ need not exceed 0.50 times the mean value of ΔRT_{NDT}.

Table 7 list the margin values calculated for the HNP reactor vessel beltline materials through 36 EFPY.

Table 7. Margin Values for the Shearon Harris Reactor Vessel Beltline Materials

Beltline Material	Material Ident.	σ_I	σ_Δ	ΔRT_{NDT} / 2	Margin
Intermediate Shell (IS) Plate (Ht. No. A9153-1)	A9153-1	0	17.0*	40.1	34.0
Intermediate Shell (IS) Plate (Ht. No. B4197-2)	B4197-2	0	17.0*	40.1	34.0
Lower Shell (LS) Plate (Ht. No. C9924-1)	C9924-1	0	17.0*	35.15	34.0
Lower Shell (LS) Plate (Ht. No. C9924-2)	C9924-2	0	17.0*	35.15	34.0
IS Longit. Welds (100%) (Wire Ht. 4P4784 / Flux Lot 3930)	BC & BD	0	28.0*	38.75	56.0
IS to LS Circ. Weld (100%) (Wire Ht. 5P6771 / Flux Lot 0342)	AB	0	28.0*	28.2	56.0
LS Longit. Welds (100%) (Wire Ht. 4P4784 / Flux Lot 3930)	BA & BB	0	28.0*	38.5	56.0

* - Used to calculate margin term.

5.4 Calculation of Pressurized Thermal Shock Reference Temperature (RT_{PTS})

The RT_{PTS} is given by the following expression:

$$RT_{PTS} = Initial\ RT_{NDT} + \Delta RT_{NDT} + Margin \quad (4)$$

Table 8 lists the RT_{PTS} calculated for the HNP reactor vessel beltline materials through 36 EFPY.

Table 8. Pressurized Thermal Shock Reference Temperatures for the Shearon Harris Reactor Vessel Beltline Materials

Beltline Materials	Material Ident.	Initial RT_{NDT}, F	ΔRT_{NDT}, F	Margin, F	RT_{PTS}, F
Intermediate Shell (IS) Plate (Ht. No. A9153-1)	A9153-1	60	80.2	34.0	174.2
Intermediate Shell (IS) Plate (Ht. No. B4197-2)	B4197-2	91	80.2	34.0	205.2
Lower Shell (LS) Plate (Ht. No. C9924-1)	C9924-1	54	70.3	34.0	158.3
Lower Shell (LS) Plate (Ht. No. C9924-2)	C9924-2	57	70.3	34.0	161.3
IS Longit. Welds (100%) (Wire Ht. 4P4784 / Flux Lot 3930)	BC & BD	-20	77.5	56.0	113.5
IS to LS Circ. Weld (100%) (Wire Ht. 5P6771 / Flux Lot 0342)	AB	-20	56.4	56.0	92.4
LS Longit. Welds (100%) (Wire Ht. 4P4784 / Flux Lot 3930)	BA & BB	-20	77.0	56.0	113.0

6.0 Pressurized Thermal Shock Reference Temperature Calculation Where Surveillance Data is Available

When two or more credible surveillance data sets are available, these data may be used to determine the RT_{PTS} of the reactor vessel beltline materials as follows:

First, if there is clear evidence that the copper or nickel content of the surveillance weld differs from that of the reactor vessel weld, the measured values of ΔRT_{NDT} should be adjusted by multiplying the values by the ratio of the chemistry factor for the reactor vessel weld to that for the surveillance weld. Second, using the ΔRT_{NDT} and its corresponding fluence, the chemistry factor may be calculated by multiplying each adjusted ΔRT_{NDT} by the corresponding fluence factor, summing the products, and dividing by the sum of the squares of the fluence factors:

$$CF = \frac{\sum \Delta RT_{NDT} * ff}{\sum ff^2} \qquad (5)$$

The HNP plant specific reactor vessel surveillance program (RVSP) provides data for predicting the reference temperature shift for the base metal plate heat number B4197-2 and weld metal AB (wire heat 5P6771 / flux lot 0342). To date, surveillance data for three capsules (Capsules U, V, and X) are available for HNP.[6],[7],[8]

6.1 Surveillance Data Credibility

Results from plant specific surveillance programs may be integrated into the RT_{PTS} estimate if the surveillance data have been deemed credible as judged by the following criteria:

Criterion 1. The materials in the surveillance capsules must be those which are the controlling materials with regard to radiation embrittlement.

Surveillance data available include the following materials:

Base Metal Heat No. B4197-2
Weld Wire Heat No. 5P6771 / Flux Lot No. 0342

All these heats of material lie within the reactor vessel beltline region of the HNP reactor vessel as defined in 10 CFR 50, Appendix G.[9] Therefore, these materials could be controlling with regard to radiation embrittlement.

Criterion 2. Scatter in the plots of Charpy energy versus temperature for the irradiated and unirradiated conditions must be small enough to permit the determination of the 30 ft-lb temperature unambiguously.

The available Charpy V-notch data for these surveillance data permit the determination of the 30 ft-lb temperatures and are presented in their respective RVSP reports.

Criterion 3. Where there are two or more sets of surveillance data from one reactor, the scatter of ΔRT_{NDT} values must be less than 28°F for welds and 17°F for base metal. Even if the fluence range is large (two or more orders of magnitude), the scatter may not exceed twice those values.

The scatter of the measured ΔRT_{NDT} values for the available surveillance data are presented in Table 9. The scatter of the measured ΔRT_{NDT} values is greater than 17°F for the base metal, and the scatter of the measured ΔRT_{NDT} values for the surveillance weld metal is not greater than 28°F.

Table 9. Credibility Assessment for Shearon Harris Surveillance Materials

Material	Capsule	Cu wt%	Ni wt%	Chemistry Factor	Fluence ($x10^{19}$) n/cm^2	Fluence Factor	Measured ΔRT_{NDT}[(a)] (°F)	Predicted ΔRT_{NDT} from Best Fit Line[(b)] (°F)	(Measured - Predicted) ΔRT_{NDT} (°F)
Intermediate Shell Plate B4197-2 (LT)	U	0.087	0.51	55.9	0.552	0.834	30	42.9	-12.9
Intermediate Shell Plate B4197-2 (TL)	U	0.087	0.51	55.9	0.552	0.834	38	42.9	-4.9
Intermediate Shell Plate B4197-2 (LT)	V	0.087	0.51	55.9	1.32	1.077	43	55.4	-12.4
Intermediate Shell Plate B4197-2 (TL)	V	0.087	0.51	55.9	1.32	1.077	35	55.4	-20.4
Intermediate Shell Plate B4197-2 (LT)	X	0.087	0.51	55.9	3.25	1.310	94	67.4	26.6
Intermediate Shell Plate B4197-2 (TL)	X	0.087	0.51	55.9	3.25	1.310	79	67.4	11.6
Weld Metal (5P6771 / 0342)	U	0.024	0.96	32.6	0.552	0.834	20	32.6	-12.6
Weld Metal (5P6771 / 0342)	V	0.024	0.96	32.6	1.32	1.077	18	42.1	-24.1
Weld Metal (5P6771 / 0342)	X	0.024	0.96	32.6	3.25	1.310	79	51.2	27.8

(a) Surveillance data have been re-evaluated using a hyperbolic tangent curve-fitting program to achieve consistency in the interpolation of the available surveillance test data.[8]

(b) Predicted ΔRT_{NDT} = ($Slope_{best\ fit}$) * (Fluence Factor) and
$Slope_{best\ fit} = \Sigma(\Delta RT_{NDT} * ff) / \Sigma(ff^2)$ (for the plate, $Slope_{best\ fit}$ = 51.4°F and for the weld metal, $Slope_{best\ fit}$ = 39.1°F)

Criterion 4. The irradiation temperature of the Charpy specimens in the capsule must equal the vessel wall temperature at the cladding/base metal interface within ±25°F.

The HNP capsules are positioned inside the reactor vessel between the neutron shielding pads and the vessel wall. Therefore, the irradiation temperature of the HNP capsule specimens is considered to be within 25°F of the reactor vessel inside surface cold-leg temperature.

Criterion 5. The surveillance data for the correlation monitor material in the capsule must fall within the scatter band of the data base for that material.

The HNP plant-specific RVSP program does not include a correlation monitor plate material. Therefore, this criterion is not applicable with respect to HNP surveillance data analysis.

Based on the above evaluation of the five criteria for assessing credibility that is called out in 10 CFR 50.61, the HNP surveillance base metal data is not credible, and the HNP surveillance weld metal data is credible.

6.2 Calculation of Chemistry Factor for Base Metal Heat No. B4197-2

Using the available HNP surveillance data, the chemistry factor for the base metal plate heat no. B4197-2 is calculated as follows:

1. No temperature adjustments are necessary since the capsule irradiation temperature, $T_{Capsule}$, equals the vessel irradiation temperature, T_{Plant} (i.e., the capsules were irradiated in the plant being assessed).

2. No chemical composition adjustments are necessary since the material is base metal (ratio procedure applies to welds only).

3. Determine the best-fit line relating the measured ΔRT_{NDT} to the capsule fluence factor (Table 10). The slope of this best-fit line is the surveillance data chemistry factor ($CF_{Surv.\ Data}$) which is calculated to be 51.4°F.

Table 10. Calculation of Base Metal Heat No. B4197-2 Chemistry Factor Using Shearon Harris Surveillance Data

Material	Capsule	Fluence ($\times 10^{19}$) n/cm^2	Fluence Factor (ff)	Measured ΔRT_{NDT} (°F)	Measured ΔRT_{NDT} * ff	ff^2
Intermediate Shell Plate B4197-2 (LT)	U	0.552	0.834	30	25.0	0.696
Intermediate Shell Plate B4197-2 (TL)	U	0.552	0.834	38	31.7	0.696
Intermediate Shell Plate B4197-2 (LT)	V	1.32	1.077	43	46.3	1.160
Intermediate Shell Plate B4197-2 (TL)	V	1.32	1.077	35	37.7	1.160
Intermediate Shell Plate B4197-2 (LT)	X	3.25	1.310	94	123.1	1.716
Intermediate Shell Plate B4197-2 (TL)	X	3.25	1.310	79	103.5	1.716
	CF = $\Sigma(\Delta RT_{NDT}$ * ff) / Σ(ff^2) = 51.4					

6.3 Calculation of Chemistry Factor for Weld Wire Heat 5P6771

Using the available HNP surveillance data, the chemistry factor for the weld metal (wire heat 5P6771 / flux lot 0342) is calculated as follows:

1. No temperature adjustments are necessary since the capsule irradiation temperature, $T_{Capsule}$, equals the vessel irradiation temperature, T_{Plant} (i.e., the capsules were irradiated in the plant being assessed).

2. Adjust the measured ΔRT_{NDT} values for chemical composition differences between the surveillance weld metal chemistry and the reactor vessel beltline weld metal chemistry as follows:

$$\textit{Ratio Adjusted } \Delta RT_{NDT} = \left[\frac{CF_{Table, Vessel Chem.}}{CF_{Table, Surv. Chem.}} \right] * \textit{Measured } \Delta RT_{NDT}$$

The available copper and nickel chemistry data for weld metal heat 5P6771 are listed below.[5]

Data Source (Weld heat 5P6771)	Copper (% Weight)	Nickel (% Weight)
CB&I Fabrication Record Test CN-161 [Single Wire]	0.03	0.88
CB&I Fabrication Record Test CN-161 [Tandem Wire]	0.04	0.95
WCAP-10502 [HNP Surveillance Report-Unirradiated]	0.023	0.87
BAW-2083 [HNP Surveillance Report-Irradiated]	0.026	0.94
BAW-2083 [HNP Surveillance Report-Irradiated]	0.019	1.07
BAW-2083 [HNP Surveillance Report-Irradiated]	0.029	0.95

The copper and nickel chemical contents for the surveillance weld metal are based on the mean of four reported copper and nickel contents. These chemical contents are based on measurements performed as part of the development of the reactor surveillance program and on measurements on broken irradiated surveillance Charpy specimens (Cu = 0.024 wt% and Ni = 0.96 wt%). The copper and nickel contents for the reactor vessel weld are the mean of all available data points indicating the "best estimate" values (Cu = 0.03 wt% and Ni = 0.94 wt%).

3. Determine the best-fit line relating the ratio adjusted ΔRT_{NDT} to the capsule fluence factor (Table 11). The slope of this best-fit line is the surveillance data chemistry factor ($CF_{Surv. Data}$) which is calculated to be 49.1°F.

Table 11. Calculation of Weld Wire Heat 5P6771 Chemistry Factor Using Shearon Harris Surveillance Data

Material	Capsule	Cu wt%	Ni wt%	Chem. Factor	Fluence ($x 10^{19}$) n/cm^2	Fluence Factor (ff)	Measured ΔRT_{NDT} (°F)	Ratio Adjusted ΔRT_{NDT} (°F)	Ratio Adjusted ΔRT_{NDT} * ff	ff^2
Weld Metal (5P6771 / 0342)	U	0.024	0.96	32.6	0.552	0.834	20	25.2	21.0	0.696
Weld Metal (5P6771 / 0342)	V	0.024	0.96	32.6	1.32	1.077	18	22.6	24.3	1.160
Weld Metal (5P6771 / 0342)	X	0.024	0.96	32.6	3.25	1.310	79	99.4	130.2	1.716
Vessel Weld Metal AB (5P6771 / 0342)		0.03	0.94	41.0						
		CF = Σ(Ratio Adjusted ΔRT_{NDT} * ff) / Σ(ff^2) = 49.1								

6.4 Pressurized Thermal Shock Reference Temperature Calculated Using Surveillance Data

6.4.1 ΔRT_{NDT}

The ΔRT_{NDT} values for the HNP reactor vessel beltline materials where surveillance data is available are calculated in accordance with Equation 1 (Section 5.2). The chemistry factors determined in Sections 6.2 and 6.3 are used in the calculation of the ΔRT_{NDT} values.

The 36 EFPY ΔRT_{NDT} values for the HNP reactor vessel beltline materials where surveillance data is available are presented in Table 12.

Table 12. ΔRT_{NDT} Value for the Shearon Harris Reactor Vessel Beltline Materials With Surveillance Data Available

Beltline Materials	Material Ident.	Chemistry Factor	Fluence Factor	ΔRT_{NDT}, F
Intermediate Shell (IS) Plate (Ht. No. B4197-2)	B4197-2	51.4	1.383	71.1
IS to LS Circ. Weld (100%) (Wire Ht. 5P6771 / Flux Lot 0342)	AB	49.1	1.375	67.5

6.4.2 Margin

Applying the credibility criteria defined in 10 CFR 50.61, for the base metal plate heat no. B4197-2 surveillance data, it is determined that two of the six data points are not credible; however, all the data points are within the 2-sigma limits, 34°F, using 10 CFR 50.61 (see Table 13). Therefore, to bound the scatter of the measured base metal surveillance data about the best-fit line, the σ_Δ value was not reduced as permitted by 10 CFR 50.61, such that a full margin value of 34°F is used to calculate the RT_{PTS} value for the intermediate shell plate, heat no. B4197-2.

Table 13. Code of Federal Regulation, Title 10, Part 50.61, Table Chemistry Factor Conservatism Assessment for HNP Base Metal B4197-2 Surveillance Data

Material	Capsule	Table CF	Fluence (x 10^{19}) n/cm^2	Capsule Fluence Factor (ff)	Measured ΔRT_{NDT} (°F)	Predicted ΔRT_{NDT}[a] (°F)	(Measured - Predicted) ΔRT_{NDT}, (°F)
Intermediate Shell Plate B4197-2 (LT)	U	55.9	0.552	0.834	30	46.6	-16.6
Intermediate Shell Plate B4197-2 (TL)	U	55.9	0.552	0.834	38	46.6	-8.6
Intermediate Shell Plate B4197-2 (LT)	V	55.9	1.32	1.077	43	60.2	-17.2
Intermediate Shell Plate B4197-2 (TL)	V	55.9	1.32	1.077	35	60.2	-25.2
Intermediate Shell Plate B4197-2 (LT)	X	55.9	3.25	1.310	94	73.2	20.8
Intermediate Shell Plate B4197-2 (TL)	X	55.9	3.25	1.310	79	73.2	5.8

[a] Predicted ΔRT_{NDT} = (Table Chem. Factor) * (Capsule Fluence Factor)

In accordance with 10 CFR 50.61, the surveillance data for the weld metal (wire heat 5P6771 / flux lot 0342) is deemed credible. To calculate the margin value for the HNP reactor vessel beltline weld metal with surveillance data available, Equation 3 (Section 5.3) is used, however, the σ_Δ value is reduced by one-half.

Table 14 lists the margin values calculated for the HNP reactor vessel beltline materials with surveillance data available through 36 EFPY.

Table 14. Margin Values for the Shearon Harris Reactor Vessel Beltline Materials With Surveillance Data Available

Beltline Material	Material Ident.	σ_I	σ_Δ	ΔRT_{NDT} / 2	Margin
Intermediate Shell (IS) Plate (Ht. No. B4197-2)	B4197-2	0.0	17.0*	---	34.0
IS to LS Circ. Weld (100%) (Wire Ht. 5P6771 / Flux Lot 0342)	AB	0.0	14.0*	33.75	28.0

* - Used to calculate margin term.

6.4.3 Calculation of Pressurized Thermal Shock Reference Temperature (RT_{PTS})

The RT_{PTS} values for the HNP reactor vessel beltline materials where surveillance data is available are calculated using Equation 4 (Section 5.4). Table 15 lists the calculated RT_{PTS} values for the HNP reactor vessel beltline materials with surveillance data available through 36 EFPY.

Table 15. Pressurized Thermal Shock Reference Temperatures for the Shearon Harris Reactor Vessel Beltline Materials With Surveillance Data Available

Beltline Materials	Material Ident.	Initial RT_{NDT}, F	ΔRT_{NDT}, F	Margin, F	RT_{PTS}, F
Intermediate Shell (IS) Plate (Ht. No. B4197-2)	B4197-2	91	71.1	34.0	196.1
IS to LS Circ. Weld (100%) (Wire Ht. 5P6771 / Flux Lot 0342)	AB	-20	67.5	28.0	75.5

7.0 References

1. Code of Federal Regulations, Title 10, *"Domestic Licensing of Production and Utilization Facilities,"* Part 50.61, *"Fracture Toughness Requirements for Protection Against Pressurized Thermal Shock,"* Effective Date: August 28, 1996.

2. Framatome Technologies Inc. Document 86-5004161-01, *"HNP PT Fluence Analysis Report Capsule X - Cycles 1 thru 8,"* released October 1999.

3. American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section III, *Nuclear Power Plant Components,* Subsection NB, Class 1 Components.

4. Letter from W. R. Robinson (CP&L) to U.S. Nuclear Regulatory Commission, Attention: Document Control Desk, *"Shearon Harris Nuclear Power Plant Docket No. 50-400/License No. NPF-63 Request for License Amendment RCS Pressure/Temperature Limits,"* Serial: HNP-96-206, dated December 30, 1996 (FTI Document No. 38-1247892-00).

5. Letter from James Scarola (CP&L) to U.S. Nuclear Regulatory Commission, Attention: Document Control Desk, *"Shearon Harris Nuclear Power Plant Docket No. 50-400/License No. NPF-63 Response to Request for Additional Information Regarding Generic Letter 92-01, Revision 1, Supplement 1,"* Serial: HNP-98-129, dated September 16, 1998 (FTI Document No. 38-1247892-00).

6. A. L. Lowe, Jr., et al., *"Analysis of Capsule U Carolina Power & Light Company Shearon Harris Unit No. 1, Reactor Vessel Material Surveillance Program,"* BAW-2083, Babcock & Wilcox, Nuclear Power Division, Lynchburg, Virginia, August 1989.

7. A. L. Lowe, Jr., et al., *"Analysis of Capsule V Carolina Power & Light Company Shearon Harris Unit No. 1, Reactor Vessel Material Surveillance Program,"* BAW-2154, B&W Nuclear Technologies, Inc., Lynchburg, Virginia, March 1992.

8. M. J. DeVan and S. Q. King, *"Analysis of Capsule X Carolina Power & Light Company Shearon Harris Nuclear Power Plant, Reactor Vessel Material Surveillance Program,"* BAW-2355, Framatome Technologies, Inc., Lynchburg, Virginia, October 1999.

9. Code of Federal Regulations, Title 10, Part 50, *"Fracture Toughness Requirements for Light-Water Nuclear Reactors,"* Appendix G, *"Fracture Toughness Requirements,"* Effective Date: January 18, 1996.