NUCLEAR POWER BUSINESS UNIT

# CALCULATION DOCUMENT FORM

| Calculation Number: | Title of Calculation: |
|---|---|
| 98-0132, Revision 0 | Evaluation of 23.6 EFPY P-T Limit and LTOP Applicability Date and Pressurized Thermal Shock at 32 EFPY |

☐ Original Calculation

☒ Supersedes Calculation # N-92-066, Rev. 0
# N-92-067, Rev. 0

☐ Revised Calculation. Revision # ________

☒ QA-Scope

☐ Non - QA-Scope

Governing Calculation: N/A

Title: N/A

Associated Modification or Procedure: N/A

Title: N/A

This Calculation has been reviewed in accordance with NP 7.2.4. The review was accomplished by one or a combination of the following (as checked):

___ A review of a representative sample of repetitive calculations.

✓ A detailed review of the original calculation.

___ A review of the calculation against a similar calculation previously performed.

___ A review by an alternate, simplified, or approximate method of calculation.

**Page Inventory:**

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Page 5 - 17 Calculation

Attachments:

Framatome Technologies, Inc. letter FTI-98-2563, "Reevaluation of Weld Wire Heat 61782," August 26, 1998: Pages 18 through 25

| | | |
|---|---|---|
| **Prepared By:** Thomas D. Spry | Thomas D Spry<br>Signature | Date: 9/15/98 |
| **Reviewed By:** James R. Pfefferle | James R. Pfefferle<br>Signature | Date: 9/15/98 |
| **Approved By:** Victoria A. Walther | VAWalther<br>Signature | Date: 9/23/98 |

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## Calculation Checklist (Optional for Non-QA Scope)

| Item No. | | Attribute Description | N/A | Author | Reviewer | |
|---|---|---|---|---|---|---|
| 1. | **Purpose** | | | | | |
| | a. | Is the purpose clearly stated indicating issue to be resolved or information to be determined? | | ☒ | ☒yes | ☐no |
| 2. | **Methodology and Acceptance Criteria** | | | | | |
| | a. | Has the method/approach been described? | | ☒ | ☒yes | ☐no |
| | b. | Have appropriate acceptance criteria and their sources been identified? | | ☒ | ☒yes | ☐no |
| 3. | **Assumptions** | | | | | |
| | a. | Are the assumptions provided with sufficient rationale to permit verification? | | ☒ | ☒yes | ☐no |
| | b. | Have assumptions associated with pending plant or procedure changes that require verification been identified? | N/A | ☐ | ☐yes N/A | ☐no |
| | c. | Have the requirements to revise governing calculations or verify pending assumptions been documented in a modification or an EWR? | N/A | ☐ | ☐yes N/A | ☐no |
| 5. | **References** | | | | | |
| | a. | Have all the appropriate references, including revisions and/or dates, been identified? | | ☒ | ☒yes | ☐no |
| | b. | Are all references readily available in the PBNP Records System, as public documents, or attached? | | ☒ | ☒yes | ☐no |
| 4. | **Inputs** | | | | | |
| | a. | Have the applicable inputs and sources been identified? | | ☒ | ☒yes | ☐no |
| 6. | **Calculation** | | | | | |
| | a. | Have formulae and inputs been provided consistent with the source document, including engineering units? | | ☒ | ☒yes | ☐no |
| 7. | **Computer-Aided Design Calculations (NP 7.2.4 Attachment A)** | | | | | |
| | a. | Has the computer program been validated per the requirements of Attachment A? | N/A | ☐ | ☐yes N/A | ☐no |
| | b. | Have the program version and revision been identified on the computer run and in the calculation? | N/A | ☐ | ☐yes N/A | ☐no |

| Item No. | | Attribute Description | N/A | Author | Reviewer | |
|---|---|---|---|---|---|---|
| | c. | Is the input to the computer program adequately documented? | N/A | ☐ | ☐yes N/A | ☐no |
| | d. | If spreadsheet or other simple computer aided tools are used in the calculation, have the formulae been documented in the calculation? | N/A | ☐ | ☐yes N/A | ☐no |
| | e. | Have the attributes been documented in the calculation for any input or output data files supporting the calculation, including file name, date stamp, time stamp (hour and minute only), and file size? | N/A | ☐ | ☐yes N/A | ☐no |
| 8. | **Summary of Results and Conclusions** | | | | | |
| | a. | Do the summary of results and conclusions clearly state the calculation results and respond to the purpose? | | ☒ | ☒yes | ☐no |
| | b. | Do the conclusions address the acceptability/ unacceptability of the results? | | ☒ | ☒yes | ☐no |
| | c. | Has a CR been initiated to identify any unsatisfactory conditions? | | ☒ CR 98-2340 | ☒yes | ☐no |
| | d. | Have all engineering judgments been provided with sufficient rationale? | | ☒ | ☒yes | ☐no |
| 9. | **Administrative** | | | | | |
| | a. | Have calculation format and content as noted in NP 7.2.4 been followed? | | ☒ | ☒yes | ☐no |
| | b. | Have all required attachments been included in the document and numbered appropriately? | | ☒ | ☒yes | ☐no |
| | c. | Has the calculation been prepared neatly and legibly with sufficient contrast to allow satisfactory record copies to be produced? | | ☒ | ☒yes | ☐no |
| | d. | Are the calculation number, preparer's initials, preparation date, and page number provided on each page? | | ☒ | ☒yes | ☐no |
| | e. | Have revisions been clearly identified by revision bars or other appropriate means (for revised calculations only)? | N/A | ☐ | ☐yes N/A | ☐no |
| | f. | If the calculation supersedes a previous calculation, is this noted on the cover sheet? | | ☒ | ☒yes | ☐no |

| Item No. | | Attribute Description | N/A | Author | Reviewer | |
|---|---|---|---|---|---|---|
| | g. | Has the calculation been appropriately identified as QA or Non-QA scope? | | ☒ | ☒yes | ☐no |
| | h. | Has the review method been clearly identified on the cover page? | | | ☒yes | ☐no |
| | i. | Is all information requested by PBF-1620 entered on the form? | | ☒ | ☒yes | ☐no |

## COMMENTS AND RESOLUTION

| Reviewer Comments: | Resolution: |
|---|---|
| No outstanding comments.<br>JEP 9/15/98 | N/A |

CALCULATION SHEET

CALC. NO. 98-0132, Rev 0

TITLE Evaluation of 23.6 EFPY P-T Limit and LTOP Applicability Date and Pressurized Thermal Shock at 32 EFPY

MADE BY T.D. Spry TDS DATE 9/15/98

REV'D. BY J.R. Pfefferle DATE 9/15/98

**Purpose:**

This calculation provides an evaluation of Unit 1 and Unit 2 vessel beltline material adjusted reference temperatures (ARTs) and their inputs, currently used as input to P-T limits (in Calculation #N-94-058, Revision 2, with a stated applicability date of 23.6 EFPY) and LTOP setpoints (in Calculation No. 98-0046, Revision 0, calculated for the fluence projected as of January 1, 2001). The latest available best-estimate chemistry values and all applicable surveillance data for all vessel beltline materials will be utilized. A revised applicability date in terms of effective full power years (EFPY) is provided for the most limiting vessel, Unit 2. This calculation also provides a pressurized thermal shock evaluation for Unit 1 and 2 at 32 EFPY in accordance with 10 CFR 50.61, using the latest available best-estimate chemistry values and all applicable surveillance data for all vessel beltline materials. This calculation was prepared to formally document the assessment of additional weld chemistry data recently obtained from the B&WOG and CEOG, to determine if this data affects previous RPV integrity analyses. JRP 9/2

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**References:**


1. Instruction Manual 132-Inch I.D. Reactor Pressure Vessel, Babcock & Wilcox, September 1969.
2. Instruction Manual, Reactor Vessel, Point Beach Nuclear Plant No. 2, Combustion Engineering, CE Book #4869, October 1970.
3. NRC Regulatory Guide 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials," May 1988.
4. 10 CFR 50.61, "Fracture toughness requirements for protection against pressurized thermal shock events."
5. WCAP-12794, "Reactor Cavity Neutron Measurement Program for Point Beach Unit 1," Rev. 3, December 1995.
6. WCAP-12795, "Reactor Cavity Neutron Measurement Program for Point Beach Unit 2," Rev. 3, August 1995.
7. CEOG Report "Best Estimate Copper and Nickel Values in CE Fabricated Reactor Vessel Welds," CE NPSD-1039, Revision 2, Final Report, June 1997.
8. BAW-2325, "Response to Request for Additional Information (RAI) Regarding Reactor Pressure Vessel Integrity," May 1998.
9. Framatome Technologies, Inc. Letter FTI-98-2563, "Reevaluation of Weld Wire Heat 61782," August 26, 1998 (see attachment).
10. ASTM E 29-93a, "Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications."
11. WEPCO Letter NPL 98-0159, "Monthly Operating Reports," March 6, 1998.
12. Point Beach Nuclear Plant Unit Nos. 1 and 2 Final Safety Analysis Report.
13. WEPCO Calculation No. N-94-058, Revision 2, "Reactor Coolant System Calculations - Effective Through January 2001," 1/23/96.
14. WEPCO Calculation No. 98-0046, Revision 0, "Determination of PBNP LTOP Setpoint Using ASME Code Case N-514 (applicable through appx. Jan. 2001)," 4/27/98.


**Methods & Acceptance Criteria:**

The methodology of this calculation follows the steps listed below:

P-T and LTOP Limits

I. Using References 5 and 6, determine the projected fluence for the limiting reactor vessel materials at the reactor vessel inside surface (clad-base metal interface) at 23.6 EFPY. See Tables 1 and 2 for a description of the methodology used.

II. Determine the corresponding reactor vessel fluence and fluence factors at the one-fourth thickness (1/4T) and three-fourths thickness (3/4T) location from the clad-base metal interface. See Tables 1 and 2 for a description of the methodology used.

III. Determine the chemistry factor, initial properties, and margin term for the PBNP reactor vessel beltline materials using the latest available best-estimate chemistry values and all applicable surveillance data for all vessel beltline materials.

IV. Determine the projected adjusted reference temperature at the 1/4T and 3/4T location for the reactor vessel beltline materials at 23.6 EFPY. See Tables 3 through 6 for a description of the methodology used.

V. Compare the projected ARTs at the 1/4T and 3/4T location for the reactor vessel beltline materials to the values used for the calculation of current licensing basis P-T limits. If the projected ART values at a given thickness are less than the values used for the calculation of current P-T limits, current P-T limits are conservative. If the projected ART values at a given thickness are greater than the values used for the calculation of current licensing basis P-T limits, determine the applicability date using the latest available best-estimate chemistry values and all applicable surveillance data for the most limiting vessel beltline material. See Tables 4 and 6 for a description of the methodology used.

VI. Compare newly determined applicability dates against the EFPY projected to occur through January 1, 2001. If the newly determined applicability date is beyond the projected value on January 1, 2001, current licensing basis P-T limits, LTOP pressure setpoints, and Tenable temperature are acceptable through that date.

PTS Evaluation

VII. Using References 5 and 6, determine projected fluence for the limiting reactor vessel materials at the reactor vessel inside surface (clad-base metal interface) at 32 EFPY.

VIII. Determine the corresponding reactor vessel fluence factors at the clad-base metal interface. See Tables 7 and 8 for a description of the methodology used.

IX. Using the chemistry factor, initial properties, and margin term for the PBNP reactor vessel beltline materials identified in Step III (above), determine the projected $RT_{PTS}$ value at the reactor vessel inside surface at 32 EFPY. See Tables 7 and 8 for a description of the methodology used.

X. Compare the projected $RT_{PTS}$ value to the PTS Screening Criteria of 10 CFR 50.61. If the projected $RT_{PTS}$ value is less than the screening criteria, no submittal to NRC pursuant to 10 CFR 50.61 is required.

**Assumptions:**

1. A capacity factor of 80% is assumed for future plant operation. This is a standard industry value for reactor vessel evaluations and will be verified against future plant performance.
2. Changes in core design will not increase vessel inner-surface fluence beyond the values provided at specific vessel altitude and azimuth locations in WCAPs 12794, Rev. 3 and 12795, Rev. 3.
3. Reactor vessel thickness is based on the distance from the clad-base metal interface to the outside diameter.

**Inputs:**

Specified in Tables 1 through 8.

**Calculations:**

I. **Fluence, Adjusted Reference Temperature (ART), and Pressurized Thermal Shock (PTS) Evaluations (Tables 1 through 8)**

# Table 1. Point Beach Unit 1 RPV Beltline 23.6 EFPY Fluence Values

Based on WCAP-12794, "Reactor Cavity Neutron Measurement Program For Wisconsin Electric Power Company Point Beach Unit 1," Rev. 3, December 1995. Note that the estimated fluence at a specific point in time is not linearly interpolated between zero and the estimated fluence at 32 EFPY, due to changes in core design at certain points in the operating history of the unit. As intermediate input to further calculations, these values are not rounded in accordance with ASTM E29.

| | |
|---|---|
| Vessel Manufacturer: | Babcock & Wilcox |
| Plate and Weld Thickness (without cladding): | 6.5", without clad *(D)* |

| Component Description | Heat or Heat/Lot | 32 EFPY Inside Surface Fluence (E19 n/cm$^2$) | 23.6 EFPY Inside Surface Fluence (E19 n/cm$^2$) *(A)* | 23.6 EFPY 1/4T Fluence (E19 n/cm$^2$) *(B)* | 23.6 EFPY 1/4T Fluence Factor *(C)* | 23.6 EFPY 3/4T Fluence (E19 n/cm$^2$) *(B)* | 23.6 EFPY 3/4T Fluence Factor *(C)* |
|---|---|---|---|---|---|---|---|
| Nozzle Belt Forging | 122P237 | 0.547 | 0.4166 | 0.2821 | 0.6545 | 0.1293 | 0.4702 |
| Intermediate Shell Plate | A9811-1 | 2.91 | 2.22 | 1.503 | 1.113 | 0.689 | 0.8955 |
| Lower Shell Plate | C1423-1 | 2.46 | 1.971 | 1.335 | 1.08 | 0.6117 | 0.8623 |
| Nozzle Belt to Intermed. Shell Circ Weld (100%) | 8T1762 (SA-1426) | 0.547 | 0.4166 | 0.2821 | 0.6545 | 0.1293 | 0.4702 |
| Intermediate Shell Long Seam (ID 27%) | 1P0815 (SA-812) | 1.87 | 1.425 | 0.9648 | 0.99 | N/A | N/A |
| Intermediate Shell Long Seam (OD 73%) | 1P0661 (SA-775) | 1.87 | 1.425 | N/A | N/A | 0.4423 | 0.7731 |
| Intermed. to Lower Shell Circ. Weld (100%) | 71249 (SA-1101) | 2.46 | 1.971 | 1.335 | 1.08 | 0.6117 | 0.8623 |
| Lower Shell Long Seam (100%) | 61782 (SA-847) | 1.66 | 1.309 | 0.8863 | 0.9662 | 0.4063 | 0.7502 |

Footnotes:

*(A)* Interpolation of neutron exposure (in units of E19 n/cm$^2$, E>1 MeV) to a particular value of effective full power years (EFPY) is performed based on WCAP-12794, Revision 3. For example, for the nozzle belt forging, heat no. 122P237,

$$\text{fluence} = 0.339 + \left(\frac{0.547 - 0.339}{32\ \text{EFPY} - 18.6\ \text{EFPY}}\right) \times (23.6\ \text{EFPY} - 18.6\ \text{EFPY}) = 0.4166\ \text{E19 n/cm}^2$$

*(B)* From an inside surface fluence value (not including cladding), fluence is attenuated to a desired thickness using equation (3) of Regulatory Guide 1.99, Revision 2: $f = f_{surf} \times e^{-0.24x}$, where $f_{surf}$ is expressed in units of E19 n/cm$^2$, E > 1MeV, and x is the desired depth in inches into the vessel wall. For example, for the nozzle belt forging, heat no. 122P237, at 23.6 EFPY, at a depth of ¼ of the 6.5" vessel wall (1.625"), $f = 0.4166 \times e^{-0.24(1.625)} = 0.2821$ E19 n/cm$^2$.

*(C)* The dimensionless fluence factor is calculated using the fluence factor formula from equation (2) of Regulatory Guide 1.99, Revision 2: $ff = f^{(0.28 - 0.10 \log f)}$, where f is the fluence in units of E19 n/cm$^2$. For example, the 23.6 EFPY 1/4T fluence factor for nozzle belt forging, heat no. 122P237, $ff = 0.2821^{(0.28 - 0.10 \log 0.2821)} = 0.6545$.

*(D)* Instruction Manual, 132-Inch I.D. Reactor Pressure Vessel, Babcock & Wilcox, September 1969.

## Table 2. Point Beach Unit 2 RPV Beltline 23.6 EFPY Fluence Values

Based on WCAP-12795, "Reactor Cavity Neutron Measurement Program For Wisconsin Electric Power Company Point Beach Unit 2," Rev. 3, August 1995. Note that the estimated fluence at a specific point in time is not linearly interpolated between zero and the estimated fluence at 32 EFPY, due to changes in core design at certain points in the operating history of the unit. As intermediate input to further calculations, these values are not rounded in accordance with ASTM E29.

| | |
|---|---|
| Vessel Manufacturer: | Babcock & Wilcox and Combustion Engineering |
| Plate and Weld Thickness (without cladding): | 6.5", without clad *(D)* |

| Component Description | Heat or Heat/Lot | 32 EFPY Inside Surface Fluence (E19 n/cm$^2$) | 23.6 EFPY Inside Surface Fluence (E19 n/cm$^2$) *(A)* | 23.6 EFPY 1/4T Fluence (E19 n/cm$^2$) *(B)* | 23.6 EFPY 1/4T Fluence Factor *(C)* | 23.6 EFPY 3/4T Fluence (E19 n/cm$^2$) *(B)* | 23.6 EFPY 3/4T Fluence Factor *(C)* |
|---|---|---|---|---|---|---|---|
| Nozzle Belt Forging | 123V352 | 0.548 | 0.4244 | 0.2873 | 0.6592 | 0.1317 | 0.4742 |
| Intermediate Shell Forging | 123V500 | 3.01 | 2.322 | 1.572 | 1.125 | 0.7207 | 0.9081 |
| Lower Shell Forging | 122W195 | 2.52 | 2.015 | 1.364 | 1.086 | 0.6254 | 0.8685 |
| Nozzle Belt to Intermed. Shell Circ Weld (100%) | 21935 | 0.548 | 0.4244 | 0.2873 | 0.6592 | 0.1317 | 0.4742 |
| Intermed. to Lower Shell Circ. Weld (100%) | 72442 (SA-1484) | 2.49 | 2.003 | 1.356 | 1.085 | 0.6217 | 0.8668 |

**Footnotes**

*(A)* Interpolation of neutron exposure (in units of E19 n/cm$^2$, E>1 MeV) to a particular value of effective full power years (EFPY) is performed based on WCAP-12795, Revision 3. For example, for the nozzle belt forging, heat no. 123V352,

$$\text{fluence} = 0.345 + \left(\frac{0.548 - 0.345}{32\text{ EFPY} - 18.2\text{ EFPY}}\right) \times (23.6\text{ EFPY} - 18.2\text{ EFPY}) = 0.4244\text{E19 n/cm}^2$$

*(B)* From an inside surface fluence value (not including cladding), fluence is attenuated to a desired thickness using equation (3) of Regulatory Guide 1.99, Revision 2: $f = f_{surf} \times e^{-0.24x}$, where $f_{surf}$ is expressed in units of E19 n/cm$^2$, E > 1MeV, and x is the desired depth in inches into the vessel wall. For example, for the nozzle belt forging, heat no. 123V352, at 23.6 EFPY, at a depth of ¼ of the 6.5" vessel wall (1.625"), $f = 0.4244 \times e^{-0.24(1.625)} = 0.2873$ E19 n/cm$^2$.

*(C)* The dimensionless fluence factor is calculated using the fluence factor formula from equation (2) of Regulatory Guide 1.99, Revision 2: $ff = f^{(0.28 - 0.10 \log f)}$, where f is the fluence in units of E19 n/cm$^2$. For example, the 23.6 EFPY 1/4T fluence factor for nozzle belt forging, heat no. 123V352, $ff = 0.2873^{(0.28 - 0.10 \log 0.2873)} = 0.6592$.

*(D)* Instruction Manual, Reactor Vessel, Point Beach Nuclear Plant No. 2, Combustion Engineering, CE Book #4869, October 1970.

## Table 3. Point Beach Unit 1 RPV 1/4T Beltline Material Adjusted Reference Temperatures at 23.6 EFPY

Unless otherwise noted, all ART input data obtained from BAW-2325, "Response to Request for Additional Information (RAI) Regarding Reactor Pressure Vessel Integrity," May 1998, including the most recent best-estimate chemistry values for welds, applying current B&WOG mean-of-the-sources approach. All beltline materials are included for comparison.

| | |
|---|---|
| Vessel Manufacturer: | Babcock & Wilcox |
| Plate and Weld Thickness (without cladding): | 6.5", without clad *(F)* |

| Component Description | Heat or Heat/Lot | Initial $RT_{NDT}$ (°F) | %Cu | %Ni | CF | CF Method | 1/4T 23.6 EFPY Fluence Factor *(A)* | $\Delta RT_{NDT}$ (°F) | $\sigma_I$ | $\sigma_\Delta$ | Margin (°F) | ART (°F) *(E)* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nozzle Belt Forging | 122P237 | +50 | 0.11 | 0.82 | 77 | Table | 0.6545 | 50.4 | 0 | 17 | 34 | 134 |
| Intermediate Shell Plate | A9811-1 | +1 | 0.20 | 0.06 | 88 | Table | 1.113 | 97.94 | 26.9 | 17 | 63.64 | 163 |
| " | " | " | | | 79.3 | Surv. Data *(B)* | " | 88.26 | " | 8.5 | 56.42 | 146 |
| Lower Shell Plate | C1423-1 | +1 | 0.12 | 0.07 | 55.3 | Table | 1.08 | 59.74 | 26.9 | 17 | 63.64 | 124 |
| " | " | " | | | 35.8 | Surv. Data *(B)* | " | 38.67 | " | 8.5 | 56.42 | 96 |
| Nozzle Belt to Intermed. Shell Circ Weld (100%) | 8T1762 (SA-1426) | -5 | 0.19 | 0.57 | 152.4 | Table | 0.6545 | 99.75 | 19.7 | 28 | 68.47 | 163 |
| Intermediate Shell Long Seam (ID 27%) | 1P0815 (SA-812) | -5 | 0.17 | 0.52 | 138.2 | Table | 0.99 | 136.82 | 19.7 | 28 | 68.47 | 200 |
| Intermediate Shell Long Seam (OD 73%) | 1P0661 (SA-775) | -5 | 0.17 | 0.64 | 157.6 | Table | N/A | N/A | 19.7 | N/A | N/A | N/A |
| Intermed. To Lower Shell Circ. Weld (100%) | 71249 (SA-1101) | +10 | 0.23 | 0.59 | 167.6 | Table *(C)* | 1.08 | 181.01 | 0 | 28 | 56 | $\boxed{247\ (G)}$ |
| Lower Shell Long Seam (100%) | 61782 (SA-847) | -5 | 0.23 | 0.52 | 157.4 | Table | 0.9662 | 152.08 | 19.7 | 28 | 68.47 | 216 |
| " | " | " | | | 161.1 | Surv. Data *(D)* | " | 155.65 | " | 14 | 48.34 | 199 |

Footnotes:

*(A)* See Table 1.

*(B)* Credible Surveillance Data; see BAW-2325 for evaluation..

*(C)* Non-credible surveillance data; see BAW-2325 for evaluation. Table CF conservative because difference between ratio-adjusted measured $\Delta RT_{NDT}$ and predicted $\Delta RT_{NDT}$ based on Table CF is less than $2\sigma$ (56°F).

*(D)* Credible Surveillance Data; see Framatome Technologies, Inc. letter FTI-98-2563, August 26, 1998, "Reevaluation of Weld Wire Heat 61782," utilizing latest time-weighted temperature data for Point Beach Unit 1, which supersedes BAW-2325.

*(E)* Adjusted reference temperature (ART) calculated per Regulatory Guide 1.99, Rev. 2. ART = Initial $RT_{NDT}$ + $\Delta RT_{NDT}$ + Margin, where $\Delta RT_{NDT}$ = Chemistry Factor x Fluence Factor, and Margin = $2(\sigma_I^2 + \sigma_\Delta^2)^{0.5}$, with $\sigma_I$ defined as the standard deviation of the Initial $RT_{NDT}$, and $\sigma_\Delta$ defined as the standard deviation of $\Delta RT_{NDT}$. For example, for nozzle belt forging, heat no. 122P237, ART = 50 +(77 x 0.6545) + 34 = 134°F. Calculated ART values are rounded to the nearest °F in accordance with the rounding-off method of ASTM Practice E29.

*(F)* Instruction Manual, 132-Inch I.D. Reactor Pressure Vessel, Babcock & Wilcox, September 1969.

*(G)* By inspection, for these limiting material properties, the applicability date of 23.6 EFPY for P-T limits in Calculation N-94-058 Revision 2 based on a 1/4T ART of 258.4°F is conservative for Unit 1, since the newly calculated value of 247°F is lower.

# Table 4. Point Beach Unit 2 RPV 1/4T Beltline Material Adjusted Reference Temperatures at 23.6 EFPY

Unless otherwise noted, all ART input data obtained from BAW-2325, "Response to Request for Additional Information (RAI) Regarding Reactor Pressure Vessel Integrity," May 1998, including the most recent best-estimate chemistry values for welds, applying current B&WOG mean-of-the-sources approach. All beltline materials are included for comparison.

| | |
|---|---|
| Vessel Manufacturer: | Babcock & Wilcox and Combustion Engineering |
| Plate and Weld Thickness (without cladding): | 6.5", without clad *(F)* |

| Component Description | Heat or Heat/Lot | Initial $RT_{NDT}$ (°F) | %Cu | %Ni | CF | CF Method | 1/4T 23.6 EFPY Fluence Factor *(A)* | $\Delta RT_{NDT}$ (°F) | $\sigma_I$ | $\sigma_\Delta$ | Margin (°F) | ART (°F) *(E)* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nozzle Belt Forging | 123V352 | +40 | 0.11 | 0.73 | 76 | Table | 0.6592 | 50.1 | 0 | 17 | 34 | 124 |
| Intermediate Shell Forging | 123V500 | +40 | 0.09 | 0.70 | 58 | Table *(B)* | 1.125 | 65.25 | 0 | 17 | 34 | 139 |
| Lower Shell Forging | 122W195 | +40 | 0.05 | 0.72 | 31 | Table | 1.086 | 33.67 | 0 | 17 | 34 | 108 |
| " | " | " | | | 42.8 | Surv. Data *(C)* | " | 46.48 | " | 8.5 | 17 | 103 |
| Nozzle Belt to Intermed. Shell Circ Weld (100%) | 21935 | -56 | 0.18 | 0.70 | 170 | Table *(H)* | 0.6592 | 112.1 | 17 | 28 | 65.51 | 122 |
| Intermed. To Lower Shell Circ. Weld (100%) | 72442 (SA-1484) | -5 | 0.26 | 0.60 | 180 | Table *(D)* | 1.085 | 195.3 | 19.7 | 28 | 68.47 | $\boxed{259\ (G)}$ |

Footnotes:

*(A)* See Table 2.

*(B)* Non-credible surveillance data; see BAW-2325 for evaluation. Table CF conservative because difference between measured $\Delta RT_{NDT}$ and predicted $\Delta RT_{NDT}$ based on Table CF is less than 2σ (34°F).

*(C)* Credible surveillance data; see BAW-2325 for evaluation.

*(D)* Non-credible surveillance data; Table CF value based on best-estimate chemistry is higher than best fit calculated using surveillance data, and therefore conservative.

*(E)* Adjusted reference temperature (ART) calculated per Regulatory Guide 1.99, Rev. 2. ART = Initial $RT_{NDT}$ + $\Delta RT_{NDT}$ + Margin, where $\Delta RT_{NDT}$ = Chemistry Factor x Fluence Factor, and Margin = $2(\sigma_I^2 + \sigma_\Delta^2)^{0.5}$, with $\sigma_I$ defined as the standard deviation of the Initial $RT_{NDT}$, and $\sigma_\Delta$ defined as the standard deviation of $\Delta RT_{NDT}$. For example, for nozzle belt forging, heat no. 123V352, ART = 40 +(76 x 0.6592) + 34 = 124°F. Calculated ART values are rounded to the nearest °F in accordance with the rounding-off method of ASTM Practice E29.

*(F)* Instruction Manual, Reactor Vessel, Point Beach Nuclear Plant No. 2, Combustion Engineering, CE Book #4869, October 1970.

*(G)* For these limiting material properties, based on Reg. Guide 1.99 Rev. 2 and Table 2, Footnote (A), the applicability date for P-T limits in Calculation N-94-058, Revision 2, based on a 1/4T ART of 258.4°F would be:

$$258.4°F = \text{Initial } RT_{NDT} + \Delta RT_{NDT} + \text{Margin} = -5 + (180 \times \text{Applicable EFPY 1/4T Fluence Factor}) + 68.47$$

$$\text{Applicable EFPY 1/4T (1.625") Fluence Factor} = 1.0829444 = (1/4T\ f)^{(0.28 - 0.10 \log 1/4T\ f)}$$

$$1/4T\ f = 1.3475 = f_{surf} \times e^{-0.24(1.625)}$$

$$f_{surf} = 1.9902 = 1.69 + \frac{2.49 - 1.69}{32 - 18.2} \times (\text{Applicable EFPY} - 18.2)$$

**Applicable EFPY = 23.4**

*(H)* Table CF value based on best-estimate chemistry data from CEOG Report "Best Estimate Copper and Nickel Values in CE Fabricated Reactor Vessel Welds," CE NPSD-1039, Revision 2, Final Report, June 1997.

## Table 5. Point Beach Unit 1 RPV 3/4T Beltline Material Adjusted Reference Temperatures at 23.6 EFPY

Unless otherwise noted, all ART input data obtained from BAW-2325, "Response to Request for Additional Information (RAI) Regarding Reactor Pressure Vessel Integrity," May 1998, including the most recent best-estimate chemistry values for welds, applying current B&WOG mean-of-the-sources approach. All beltline materials are included for comparison.

| | |
|---|---|
| Vessel Manufacturer: | Babcock & Wilcox |
| Plate and Weld Thickness (without cladding): | 6.5", without clad *(F)* |

| Component Description | Heat or Heat/Lot | Initial $RT_{NDT}$ (°F) | %Cu | %Ni | CF | CF Method | 3/4T 23.6 EFPY Fluence Factor *(A)* | $\Delta RT_{NDT}$ (°F) | $\sigma_I$ | $\sigma_\Delta$ | Margin (°F) | ART (°F) *(E)* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nozzle Belt Forging | 122P237 | +50 | 0.11 | 0.82 | 77 | Table | 0.4702 | 36.21 | 0 | 17 | 34 | 120 |
| Intermediate Shell Plate | A9811-1 | +1 | 0.20 | 0.06 | 88 | Table | 0.8955 | 78.8 | 26.9 | 17 | 63.64 | 143 |
| " | " | " | | | 79.3 | Surv. Data *(B)* | " | 71.01 | " | 8.5 | 56.42 | 128 |
| Lower Shell Plate | C1423-1 | +1 | 0.12 | 0.07 | 55.3 | Table | 0.8623 | 47.69 | 26.9 | 17 | 63.64 | 112 |
| " | " | " | | | 35.8 | Surv. Data *(B)* | " | 30.87 | " | 8.5 | 56.42 | 88 |
| Nozzle Belt to Intermed. Shell Circ Weld (100%) | 8T1762 (SA-1426) | -5 | 0.19 | 0.57 | 152.4 | Table | 0.4702 | 71.66 | 19.7 | 28 | 68.47 | 135 |
| Intermediate Shell Long Seam (ID 27%) | 1P0815 (SA-812) | -5 | 0.17 | 0.52 | 138.2 | Table | N/A | N/A | 19.7 | N/A | N/A | N/A |
| Intermediate Shell Long Seam (OD 73%) | 1P0661 (SA-775) | -5 | 0.17 | 0.64 | 157.6 | Table | 0.7731 | 121.84 | 19.7 | 28 | 68.47 | 185 |
| Intermed. To Lower Shell Circ. Weld (100%) | 71249 (SA-1101) | +10 | 0.23 | 0.59 | 167.6 | Table *(C)* | 0.8623 | 144.52 | 0 | 28 | 56 | $\boxed{211\ (G)}$ |
| Lower Shell Long Seam (100%) | 61782 (SA-847) | -5 | 0.23 | 0.52 | 157.4 | Table | 0.7502 | 118.08 | 19.7 | 28 | 68.47 | 182 |
| " | " | " | | | 161.1 | Surv. Data *(D)* | " | 120.86 | " | 14 | 48.34 | 164 |

Footnotes:

*(A)* See Table 1.

*(B)* Credible Surveillance Data; see BAW-2325 for evaluation.

*(C)* Non-credible surveillance data; see BAW-2325 for evaluation. Table CF conservative because difference between ratio-adjusted measured $\Delta RT_{NDT}$ and predicted $\Delta RT_{NDT}$ based on Table CF is less than $2\sigma$ (56°F).

*(D)* Credible Surveillance Data; see Framatome Technologies, Inc. letter FTI-98-2563, August 26, 1998, "Reevaluation of Weld Wire Heat 61782," utilizing latest time-weighted temperature data for Point Beach Unit 1, which supersedes BAW-2325.

*(E)* Adjusted reference temperature (ART) calculated per Regulatory Guide 1.99, Rev. 2. ART = Initial $RT_{NDT}$ + $\Delta RT_{NDT}$ + Margin, where $\Delta RT_{NDT}$ = Chemistry Factor x Fluence Factor, and Margin = $2(\sigma_I^2 + \sigma_\Delta^2)^{0.5}$, with $\sigma_I$ defined as the standard deviation of the Initial $RT_{NDT}$, and $\sigma_\Delta$ defined as the standard deviation of $\Delta RT_{NDT}$. For example, for nozzle belt forging, heat no. 122P237, ART = 50 +(77 x 0.4702) + 34 = 120°F. Calculated ART values are rounded to the nearest °F in accordance with the rounding-off method of ASTM Practice E29.

*(F)* Instruction Manual, 132-Inch I.D. Reactor Pressure Vessel, Babcock & Wilcox, September 1969.

*(G)* By inspection, for these limiting material properties, the applicability date of 23.6 EFPY for P-T limits in Calculation N-94-058 Revision 2 based on a 3/4T ART of 219.5°F is conservative for Unit 1, since the newly calculated value of 211°F is lower.

## Table 6. Point Beach Unit 2 RPV 3/4T Beltline Material Adjusted Reference Temperatures at 23.6 EFPY

Unless otherwise noted, all ART input data obtained from BAW-2325, "Response to Request for Additional Information (RAI) Regarding Reactor Pressure Vessel Integrity," May 1998, including the most recent best-estimate chemistry values for welds, applying current B&WOG mean-of-the-sources approach. All beltline materials are included for comparison.

| | |
|---|---|
| Vessel Manufacturer: | Babcock & Wilcox and Combustion Engineering |
| Plate and Weld Thickness (without cladding): | 6.5", without clad *(F)* |

| Component Description | Heat or Heat/Lot | Initial $RT_{NDT}$ (°F) | %Cu | %Ni | CF | CF Method | 3/4T 23.6 EFPY Fluence Factor *(A)* | $\Delta RT_{NDT}$ (°F) | $\sigma_I$ | $\sigma_\Delta$ | Margin (°F) | ART (°F) *(E)* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nozzle Belt Forging | 123V352 | +40 | 0.11 | 0.73 | 76 | Table | 0.4742 | 36.04 | 0 | 17 | 34 | 110 |
| Intermediate Shell Forging | 123V500 | +40 | 0.09 | 0.70 | 58 | Table *(B)* | 0.9081 | 52.67 | 0 | 17 | 34 | 127 |
| Lower Shell Forging | 122W195 | +40 | 0.05 | 0.72 | 31 | Table | 0.8685 | 26.92 | 0 | 17 | 34 | 101 |
| " | " | " | | | 42.8 | Surv. Data *(C)* | " | 37.17 | " | 8.5 | 17 | 94 |
| Nozzle Belt to Intermed. Shell Circ Weld (100%) | 21935 | -56 | 0.18 | 0.70 | 170 | Table *(H)* | 0.4742 | 80.61 | 17 | 28 | 65.51 | 90 |
| Intermed. To Lower Shell Circ. Weld (100%) | 72442 (SA-1484) | -5 | 0.26 | 0.60 | 180 | Table *(D)* | 0.8668 | 156.02 | 19.7 | 28 | 68.47 | 219 *(G)* |

Footnotes:

*(A)* See Table 2.

*(B)* Non-credible surveillance data; see BAW-2325 for evaluation. Table CF conservative because difference between measured $\Delta RT_{NDT}$ and predicted $\Delta RT_{NDT}$ based on Table CF is less than $2\sigma$ (34°F).

*(C)* Credible surveillance data; see BAW-2325 for evaluation.

*(D)* Non-credible surveillance data; Table CF value based on best-estimate chemistry is higher than best fit calculated using surveillance data, and therefore conservative.

*(E)* Adjusted reference temperature (ART) calculated per Regulatory Guide 1.99, Rev. 2. ART = Initial $RT_{NDT}$ + $\Delta RT_{NDT}$ + Margin, where $\Delta RT_{NDT}$ = Chemistry Factor x Fluence Factor, and Margin = $2(\sigma_I^2 + \sigma_\Delta^2)^{0.5}$, with $\sigma_I$ defined as the standard deviation of the Initial $RT_{NDT}$, and $\sigma_\Delta$ defined as the standard deviation of $\Delta RT_{NDT}$. For example, for nozzle belt forging, heat no. 123V352, ART = 40 +(76 x 0.4742) + 34 = 110°F. Calculated ART values are rounded to the nearest °F in accordance with the rounding-off method of ASTM Practice E29.

*(F)* Instruction Manual, Reactor Vessel, Point Beach Nuclear Plant No. 2, Combustion Engineering, CE Book #4869, October 1970.

*(G)* By inspection, for these limiting material properties, the applicability date of 23.6 EFPY for P-T limits in Calculation N-94-058 Revision 2 based on a 3/4T ART of 219.5°F is conservative for Unit 2, since the newly calculated value of 219°F is lower.

*(H)* Table CF value based on best-estimate chemistry data from CEOG Report "Best Estimate Copper and Nickel Values in CE Fabricated Reactor Vessel Welds," CE NPSD-1039, Revision 2, Final Report, June 1997.

# Table 7. Point Beach Unit 1 RPV Beltline Material $RT_{PTS}$ Values at 32 EFPY

Unless otherwise noted, all $RT_{PTS}$ input data obtained from BAW-2325, "Response to Request for Additional Information (RAI) Regarding Reactor Pressure Vessel Integrity," May 1998, including the most recent best-estimate chemistry values for welds, applying current B&WOG mean-of-the-sources approach. All beltline materials are included for comparison.

| | |
|---|---|
| Vessel Manufacturer: | Babcock & Wilcox |
| Plate and Weld Thickness (without cladding): | 6.5", without clad *(G)* |

| Component Description | Heat or Heat/Lot | $RT_{NDT(U)}$ (°F) | %Cu | %Ni | CF | CF Method | 32 EFPY Inner Surface Fluence (E19 n/cm$^2$) *(A)* | 32 EFPY Inner Surface Fluence Factor *(B)* | $\Delta RT_{PTS}$ (°F) | $\sigma_U$ | $\sigma_\Delta$ | Margin (°F) | $RT_{PTS}$ (°F) *(F)* | PTS Screening Criteria |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nozzle Belt Forging | 122P237 | +50 | 0.11 | 0.82 | 77 | Table | 0.547 | 0.8313 | 64.01 | 0 | 17 | 34 | 148 | 270 |
| Intermediate Shell Plate | A9811-1 | +1 | 0.20 | 0.06 | 88 | Table | 2.91 | 1.2834 | 112.94 | 26.9 | 17 | 63.64 | 178 | 270 |
| " | " | " | | | 79.3 | Surv. Data *(C)* | " | " | 101.77 | 26.9 | 8.5 | 56.42 | 159 | 270 |
| Lower Shell Plate | C1423-1 | +1 | 0.12 | 0.07 | 55.3 | Table | 2.46 | 1.2422 | 68.69 | 26.9 | 17 | 63.64 | 133 | 270 |
| " | " | " | | | 35.8 | Surv. Data *(C)* | " | " | 44.47 | 26.9 | 8.5 | 56.42 | 102 | 270 |
| Nozzle Belt to Intermed. Shell Circ Weld (100%) | 8T1762 (SA-1426) | -5 | 0.19 | 0.57 | 152.4 | Table | 0.547 | 0.8313 | 126.69 | 19.7 | 28 | 68.47 | 190 | 300 |
| Intermediate Shell Long Seam (ID 27%) | 1P0815 (SA-812) | -5 | 0.17 | 0.52 | 138.2 | Table | 1.87 | 1.1715 | 161.9 | 19.7 | 28 | 68.47 | 225 | 270 |
| Intermediate Shell Long Seam (OD 73%) | 1P0661 (SA-775) | -5 | 0.17 | 0.64 | 157.6 | Table | N/A | N/A | N/A | 19.7 | N/A | N/A | N/A | N/A |
| Intermed. To Lower Shell Circ. Weld (100%) | 71249 (SA-1101) | +10 | 0.23 | 0.59 | 167.6 | Table *(D)* | 2.46 | 1.2422 | 208.19 | 0 | 28 | 56 | **274** | 300 |
| Lower Shell Long Seam (100%) | 61782 (SA-847) | -5 | 0.23 | 0.52 | 157.4 | Table | 1.66 | 1.1397 | 179.39 | 19.7 | 28 | 68.47 | 243 | 270 |
| " | " | " | | | 161.1 | Surv. Data *(E)* | " | " | 183.61 | 19.7 | 14 | 48.34 | 227 | 270 |

Footnotes:

*(A)* Based on WCAP-12794, "Reactor Cavity Neutron Measurement Program For Wisconsin Electric Power Company Point Beach Unit 1," Rev. 3, December 1995. As intermediate input to further calculations, these values are not rounded in accordance with ASTM E29.

*(B)* The dimensionless fluence factor is calculated using the fluence factor formula from equation (2) of Regulatory Guide 1.99, Revision 2: $ff = f^{(0.28 - 0.10 \log f)}$, where f is the fluence in units of E19 n/cm$^2$. For example, the 32 EFPY inner surface fluence factor for nozzle belt forging, heat no. 122P237, $ff = 0.547^{(0.28 - 0.10 \log 0.547)} = 0.8313$.

*(C)* Credible surveillance data; see BAW-2325 for evaluation.

*(D)* Non-credible surveillance data; see BAW-2325 for evaluation. Table CF conservative because difference between ratio-adjusted measured $\Delta RT_{NDT}$ and predicted $\Delta RT_{NDT}$ based on Table CF is less than $2\sigma$ (56°F).

*(E)* Credible Surveillance Data; see Framatome Technologies, Inc. letter FTI-98-2563, August 26, 1998, "Reevaluation of Weld Wire Heat 61782," utilizing latest time-weighted temperature data for Point Beach Unit 1, which supersedes BAW-2325.

*(F)* $RT_{PTS}$ calculated per 10 CFR 50.61. $RT_{PTS} = RT_{NDT(U)} + \Delta RT_{NDT} + \text{Margin}$, where $RT_{NDT(U)}$ = unirradiated initial $RT_{NDT}$, $\Delta RT_{NDT}$ = Chemistry Factor x Fluence Factor, and Margin $= 2(\sigma_U^2 + \sigma_\Delta^2)^{0.5}$, with $\sigma_U$ defined as the standard deviation of the $RT_{NDT(U)}$, and $\sigma_\Delta$ defined as the standard deviation of $\Delta RT_{NDT}$. For example, for nozzle belt forging, heat no. 122P237, $RT_{PTS} = 50 + (77 \times 0.8313) + 34 = 148$°F. Calculated $RT_{PTS}$ values are rounded to the nearest °F in accordance with the rounding-off method of ASTM Practice E29.

*(G)* Instruction Manual, 132-Inch I.D. Reactor Pressure Vessel, Babcock & Wilcox, September 1969.

## Table 8. Point Beach Unit 2 RPV Beltline Material $RT_{PTS}$ Values at 32 EFPY

Unless otherwise noted, all $RT_{PTS}$ input data obtained from BAW-2325, "Response to Request for Additional Information (RAI) Regarding Reactor Pressure Vessel Integrity," May 1998, including the most recent best-estimate chemistry values for welds, applying current B&WOG mean-of-the-sources approach. All beltline materials are included for comparison.

| | |
|---|---|
| Vessel Manufacturer: | Babcock & Wilcox and Combustion Engineering |
| Plate and Weld Thickness (without cladding): | 6.5", without clad *(G)* |

| Component Description | Heat or Heat/Lot | $RT_{NDT(U)}$ (°F) | %Cu | %Ni | CF | CF Method | 32 EFPY Inner Surface Fluence (E19 n/cm$^2$) *(A)* | 32 EFPY Inner Surface Fluence Factor *(B)* | $\Delta RT_{PTS}$ (°F) | $\sigma_U$ | $\sigma_\Delta$ | Margin (°F) | $RT_{PTS}$ (°F) *(F)* | PTS Screening Criteria |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nozzle Belt Forging | 123V352 | +40 | 0.11 | 0.73 | 76 | Table | 0.548 | 0.8318 | 63.22 | 0 | 17 | 34 | 137 | 270 |
| Intermediate Shell Forging | 123V500 | +40 | 0.09 | 0.70 | 58 | Table *(C)* | 3.01 | 1.292 | 74.94 | 0 | 17 | 34 | 149 | 270 |
| Lower Shell Forging | 122W195 | +40 | 0.05 | 0.72 | 31 | Table | 2.52 | 1.248 | 38.69 | 0 | 17 | 34 | 113 | 270 |
| " | " | " | | | 42.8 | Surv. Data *(D)* | " | " | 53.41 | " | 8.5 | 17 | 110 | 270 |
| Nozzle Belt to Intermed. Shell Circ Weld (100%) | 21935 | -56 | 0.18 | 0.70 | 170 | Table *(H)* | 0.548 | 0.8318 | 141.41 | 17 | 28 | 65.51 | 151 | 300 |
| Intermed. To Lower Shell Circ. Weld (100%) | 72442 (SA-1484) | -5 | 0.26 | 0.60 | 180 | Table *(E)* | 2.49 | 1.245 | 224.1 | 19.7 | 28 | 68.47 | $\boxed{288}$ | 300 |

Footnotes:

*(A)* Based on WCAP-12795, "Reactor Cavity Neutron Measurement Program For Wisconsin Electric Power Company Point Beach Unit 2," Rev. 3, August 1995. As intermediate input to further calculations, these values are not rounded in accordance with ASTM E29.

*(B)* The dimensionless fluence factor is calculated using the fluence factor formula from equation (2) of Regulatory Guide 1.99, Revision 2: $ff = f^{(0.28 - 0.10 \log f)}$, where f is the fluence in units of E19 n/cm$^2$. For example, the 32 EFPY inner surface fluence factor for nozzle belt forging, heat no. 123V352, $ff = 0.548^{(0.28 - 0.10 \log 0.548)} = 0.8318$.

*(C)* Non-credible surveillance data; see BAW-2325 for evaluation. Table CF conservative because difference between measured $\Delta RT_{NDT}$ and predicted $\Delta RT_{NDT}$ based on Table CF is less than $2\sigma$ (34°F).

*(D)* Credible surveillance data; see BAW-2325 for evaluation.

*(E)* Non-credible surveillance data; Table CF value based on best-estimate chemistry is higher than best fit calculated using surveillance data, and therefore conservative.

*(F)* $RT_{PTS}$ calculated per 10 CFR 50.61. $RT_{PTS} = RT_{NDT(U)} + \Delta RT_{NDT}$ + Margin, where $RT_{NDT(U)}$ = unirradiated initial $RT_{NDT}$, $\Delta RT_{NDT}$ = Chemistry Factor x Fluence Factor, and Margin $= 2(\sigma_U^2 + \sigma_\Delta^2)^{0.5}$, with $\sigma_U$ defined as the standard deviation of the $RT_{NDT(U)}$, and $\sigma_\Delta$ defined as the standard deviation of $\Delta RT_{NDT}$. For example, for nozzle belt forging, heat no. 123V352, $RT_{PTS} = 40 + (76 \times 0.8318) + 34 = 137$°F. Calculated $RT_{PTS}$ values are rounded to the nearest °F in accordance with the rounding-off method of ASTM Practice E29.

*(G)* Instruction Manual, Reactor Vessel, Point Beach Nuclear Plant No. 2, Combustion Engineering, CE Book #4869, October 1970.

*(H)* Table CF value based on best-estimate chemistry data from CEOG Report "Best Estimate Copper and Nickel Values in CE Fabricated Reactor Vessel Welds," CE NPSD-1039, Revision 2, Final Report, June 1997.

**Calculations (cont'd):**

II. **Fluence Projection to January 1, 2001 (Calender Date Used as Input to LTOP Setpoints in Calculation No. 98-0046, Revision 0)**

A) Maximum rated reactor thermal output: 1518.5 MWTh (Ref. 12)

The total thermal output for each unit as of March 1, 1998, is (Ref. 11):

Unit 1: Total thermal output = 273,540,535 MW hours - thermal

Unit 2: Total thermal output = 266,886,275 MW hours - thermal

Converting to EFPY:

**Unit 1:**

$$273{,}540{,}535 \text{ MWTh} \times \frac{\text{eff. full power}}{1518.5 \text{ MWTh}} \times \frac{1 \text{ day}}{24 \text{ hrs.}} \times \frac{1 \text{ year}}{365.25 \text{ days}} = 20.5 \text{ EFPY}$$

**Unit 2:**

$$266{,}886{,}275 \text{ MWTh} \times \frac{\text{eff. full power}}{1518.5 \text{ MWTh}} \times \frac{1 \text{ day}}{24 \text{ hrs.}} \times \frac{1 \text{ year}}{365.25 \text{ days}} = 20.0 \text{ EFPY}$$

B) EFPY until 1/1/2001

Calender years from 3/1/1998 to 1/1/2001 is 2.83 years; an 80% capacity factor is assumed (Assumption 1):

2.83 years x 0.80 = 2.3 EFPY

C) Total EFPY through 1/1/2001:

Unit 1: 20.5 EFPY + 2.3 EFPY = 22.8 EFPY

Unit 2: 20.0 EFPY + 2.3 EFPY = 22.3 EFPY

**Results and Conclusions:**

This calculation demonstrates that the current Technical Specification P-T limits are conservative through the current licensing basis applicability date of 23.6 EFPY for Unit 1.

For Unit 2, as a result of small, conservative changes from the inputs used in Calculation N-94-058 Revision 2, based on the latest understanding of initial $RT_{NDT}$ and $\sigma_I$ for limiting beltline weld SA-1484, the applicability date of the current licensing basis P-T limits is reduced slightly, to 23.4 EFPY. Administrative requirements to restrict operation of the

Unit 2 reactor vessel to no more than 23.4 EFPY using the current licensing basis P-T limits must be established. This calculation demonstrates that this value of EFPY will not be exceeded before the January 1, 2001 calender applicability date used in Calculation No. 98-0046, Revision 0, for LTOP pressure setpoints and enable temperature.

This calculation demonstrates that the PTS Screening Criteria are not exceeded through 32 EFPY.

The LTOP pressure setpoint and enable temperature established in Calculation No. 98-0046, Rev. 0 are unchanged through January 1, 2001, because that calculation used the same material property inputs and fluence estimation bases as this calculation.

FRAMATOME
TECHNOLOGIES

August 26, 1998
FTI-98-2563

Mr. J. R. Pfefferle
Wisconsin Electric Power Company
231 W. Michigan Street
P. O. Box 2046
Milwaukee, WI 53201

Subject: Reevaluation of Weld Wire Heat 61782

Attachment: FTI Calculation 32-5002184-00

Dear Mr. Pfefferle:

The attached calculation summarizes the reevaluation of weld wire heat 61782 for Point Beach 1 for an irradiation temperature of 538°F.

If you should have any questions regarding this calculation summary, please feel free to call me at 804/832-3293 or Matt Devan at 804/832-3160.

Sincerely,

DLHowell

D. L. Howell
Project Manager
B&W Owners Group Management

DLH/mcl
Attachment

3315 Old Forest Road, P.O. Box 10935, Lynchburg, VA 24506-0935
Telephone: 804-832-3000 Fax: 804-832-3663
Internet: http://www.framatech.com

SEP 1 1998

20697-3 (12/95)

FRAMATOME TECHNOLOGIES

# CALCULATIONAL SUMMARY SHEET (CSS)

DOCUMENT IDENTIFIER 32-5002184-00

TITLE Chemistry Factor For Weld Wire Heat 61782

| PREPARED BY: | | REVIEWED BY: | |
|---|---|---|---|
| NAME | M. J. DeVan | NAME | J. B. Hall |
| SIGNATURE | M J DeVan | SIGNATURE | J B Hall |
| TITLE | Engineer IV DATE 8/21/98 | TITLE | Engineer III DATE 8-21-98 |
| COST CENTER | 41020 REF. PAGE(S) 7 | TM STATEMENT: REVIEWER INDEPENDENCE | JBH |

PURPOSE AND SUMMARY OF RESULTS:

## PURPOSE:

The purpose of this calculation is to provide an evaluation of the weld wire heat 61782 surveillance data for assessing the integrity of the Point Beach Unit 1 reactor vessel.

## SUMMARY OF RESULTS

In accordance with the NRC guidelines provided at the November 12, 1997 meeting, the surveillance data for weld wire heat 61782 was evaluated with respect to the Point Beach Unit 1 reactor vessel. The R. E. Ginna plant-specific weld metal surveillance data was used in the assessment because it requires the least amount of adjustments to the measured data. The plant-specific weld metal surveillance data from R. E. Ginna was determined to be credible with respect to the five criteria specified in both Regulatory Guide 1.99, Revision 2 and 10 CFR 50.61. Using the R. E. Ginna plant-specific weld metal data and making the required adjustments to the data, the surveillance data chemistry factor was calculated to be 161.1°F.

THE FOLLOWING COMPUTER CODES HAVE BEEN USED IN THIS DOCUMENT:

| CODE / VERSION / REV | CODE / VERSION / REV |
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THIS DOCUMENT CONTAINS ASSUMPTIONS THAT MUST BE VERIFIED PRIOR TO USE ON SAFETY-RELATED WORK

YES ( ) NO ( X )

## RECORD OF REVISIONS

| REVISION | DESCRIPTION |
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## 1.0 Introduction

Both Regulatory Guide 1.99, Revision 2[1] and 10 CFR 50.61[2] state that surveillance data (if available) be considered in evaluating reactor vessel integrity. The best-estimate copper and nickel chemical compositions are used in the evaluation of the surveillance data. The process of evaluating surveillance data includes a credibility assessment against five criteria and the calculation of the chemistry factor based on the surveillance data. The NRC provided guidance on performing evaluation of surveillance data in a public meeting between the Staff, Nuclear Energy Institute (NEI), and industry representatives on November 12, 1997. A summary of this meeting is documented in a meeting summary dated November 19, 1997.[3]

This calculation provides the evaluation and use of weld wire heat 61782 surveillance data for assessing the integrity of the Point Beach Unit 1 reactor vessel. The guidelines, provided by the Staff in the November 12, 1997 meeting, are used to determine the chemistry factor.

## 2.0 Summary of Results

In accordance with the NRC guidelines provided at the November 12, 1997 meeting, the surveillance data for weld wire heat 61782 was evaluated with respect to the Point Beach Unit 1 reactor vessel. The R. E. Ginna plant-specific weld metal surveillance data was used in the assessment because it requires the least amount of adjustments to the measured data. The plant-specific weld metal surveillance data from R. E. Ginna was determined to be credible with respect to the five criteria specified in both Regulatory Guide 1.99, Revision 2 and 10 CFR 50.61. Using the R. E. Ginna plant-specific weld metal data and making the required adjustments to the data, the surveillance data chemistry factor was calculated to be 161.1°F.

## 3.0 Assumptions

No major assumptions are contained in this report.

## 4.0 Evaluation and Use of Weld Wire Heat 61782 Surveillance Data

The lower shell longitudinal weld, found in the Point Beach Unit 1 reactor vessel, was fabricated using the weld wire heat 61782. The best estimate copper and nickel chemical compositions for this wire heat are as follows:

Cu = 0.23 wt% Ni = 0.52 wt%

Weld wire heat 61782 surveillance data are not available from the Point Beach Unit 1 plant-specific surveillance program, but are available from other sources. The available weld wire heat 61782 surveillance data are presented in Table 4-1.

Table 4-1. Available Surveillance Data For Weld Wire Heat 61782

| Capsule ID (including source) | Cu wt% | Ni wt% | Irradiation Temperature (°F) | Fluence ($x10^{19}$ n/cm$^2$) | Measured $\Delta RT_{NDT}$, (°F) (TANH) |
|---|---|---|---|---|---|
| B&WOG: Capsule DB1-LG1<br>SA-1135: ONS-2 Nozzle Belt Dropout Matl. | 0.27 | 0.59 | 556 | 1.03 | 141 |
| R. E. Ginna: Capsule V<br>SA-1036: Plant Specific RVSP Material | 0.24 | 0.52 | 545 | 0.556 | 146 |
| R. E. Ginna: Capsule R<br>SA-1036: Plant Specific RVSP Material | 0.24 | 0.52 | 545 | 1.15 | 167 |
| R. E. Ginna: Capsule T<br>SA-1036: Plant Specific RVSP Material | 0.24 | 0.52 | 545 | 1.97 | 169 |
| R. E. Ginna: Capsule S<br>SA-1036: Plant Specific RVSP Material | 0.24 | 0.52 | 545 | 3.87 | 222 |

The B&WOG Capsule DB1-LG1 was irradiated in the Davis-Besse reactor vessel which Babcock & Wilcox is the NSSS vendor. The weld metal surveillance data for R. E. Ginna was irradiated as part of their plant-specific surveillance program.

Examination of the available surveillance data for weld wire 61782 reveals that the magnitude of the temperature adjustment with respect to Point Beach Unit 1 is lower for R. E. Ginna than Davis-Besse. In addition, Point Beach Unit 1 and R. E. Ginna have the same NSSS vendor, Westinghouse. Therefore, only the R. E. Ginna weld metal 61782 surveillance data is used in assessing the integrity of the Point Beach Unit 1 vessel.

## 4.1. Credibility Assessment

Since the R. E. Ginna weld metal 61782 surveillance data are from one (1) source, a best-fit line is determined relating the measured (unadjusted) $\Delta RT_{NDT}$ to the fluence factor (determined from the capsule fluence). Table 4-2 presents the credibility assessment for weld wire heat 61782 using only the R. E. Ginna plant-specific weld metal surveillance data.

*Slope of the Best-Fit Line = 159.0 °F*

Table 4-2 Credibility Assessment for Weld Wire Heat 61782

| Capsule Designation | Cu wt% | Ni wt% | Chem. Factor | Irrad. Temp. (°F) | Fluence Factor | Meas. $\Delta RT_{NDT}$, (°F) (TANH) | Predicted $\Delta RT_{NDT}$ from Best Fit Line (°F) | (Measured - Predicted) $\Delta RT_{NDT}$ (°F) |
|---|---|---|---|---|---|---|---|---|
| R. E. Ginna: Capsule V Plant-Specific RVSP Material | 0.24 | 0.52 | 161.4 | 545 | 0.836 | 146 | 132.9 | 13.1 |
| R. E. Ginna: Capsule R Plant-Specific RVSP Material | 0.24 | 0.52 | 161.4 | 545 | 1.039 | 167 | 165.2 | 1.8 |
| R. E. Ginna: Capsule T Plant-Specific RVSP Material | 0.24 | 0.52 | 161.4 | 545 | 1.185 | 169 | 188.4 | -19.4 |
| R. E. Ginna: Capsule S Plant-Specific RVSP Material | 0.24 | 0.52 | 161.4 | 545 | 1.349 | 222 | 214.5 | 7.5 |

where: *Predicted $\Delta RT_{NDT}$ = $(Slope_{best\ fit})$ * Fluence Factor*

These data are credible since the scatter is less than ±28°F for all surveillance capsule data points.

## 4.2. Determination of Chemistry Factor

The surveillance data chemistry factor is determined from a best-fit line through the surveillance data adjusted to account form differences in chemical composition (i.e., copper and nickel contents) and irradiation environment (i.e., irradiation temperature) between the capsules and the vessel being assessed (i.e., Point Beach Unit 1).

The operating cold leg temperature ($T_{Plant}$) for the Point Beach Unit 1 reactor vessel is 538°F, and the R. E. Ginna surveillance capsules have a irradiation temperature ($T_{Capsule}$) of 545°F that is greater than $T_{Plant}$. Therefore for the capsules with $T_{Capsule}$ greater than 538°F (i.e., $T_{Plant}$), the $\Delta RT_{NDT,\ measured}$ must be adjusted by increasing the measured $\Delta RT_{NDT}$ by 1.0°F for each degree difference in irradiation temperature to yield the temperature adjusted $\Delta RT_{NDT}$ (i.e., $\Delta RT_{NDT,\ Temp.\ Adjusted}$).

To account for the differences in chemical compositions between the surveillance data and the weld wire heat best estimate, the surveillance data are normalized to the best estimate of the vessel being assessed (i.e., Point Beach Unit 1). To obtain the "ratio and temperature" adjusted $\Delta RT_{NDT}$, the surveillance data are adjusted as follows:

$$Ratio/Temperature\ Adjusted\ \Delta RT_{NDT} = \left(\frac{CF_{Table,Vessel\ Chem.}}{CF_{Table,Surv.Chem.}}\right) * \Delta RT_{NDT,Temp.Adjusted}$$

The assessment of the surveillance data for weld wire heat 61782 with respect to Point Beach Unit 1 using the R. E. Ginna plant-specific weld metal surveillance data is presented in Table 4-3.

**Table 4-3. Surveillance Data Assessment for Weld Wire Heat 61782 For Point Beach Unit 1**

| Capsule | Cu | Ni | CF | Irrad. Temp. (F) | Capsule Fluence ($n/cm^2$) | Fluence Factor (ff) | Meas. $\Delta RT_{NDT}$, (F) (TANH) | Temp. Adjusted $\Delta RT_{NDT}$, (F) | Temp., Ratio Adjusted $\Delta RT_{NDT}$, (F) |
|---|---|---|---|---|---|---|---|---|---|
| R. E. Ginna: Capsule V Plant-Specific RVSP Matl. | 0.24 | 0.52 | 161.4 | 545 | 0.556 | 0.836 | 146 | 153 | 149.2 |
| R. E. Ginna: Capsule R Plant-Specific RVSP Matl. | 0.24 | 0.52 | 161.4 | 545 | 1.15 | 1.039 | 167 | 174 | 169.7 |
| R. E. Ginna: Capsule T Plant-Specific RVSP Matl. | 0.24 | 0.52 | 161.4 | 545 | 1.97 | 1.185 | 169 | 176 | 171.6 |
| R. E. Ginna: Capsule S Plant-Specific RVSP Matl. | 0.24 | 0.52 | 161.4 | 545 | 3.87 | 1.349 | 222 | 229 | 223.3 |
| Point Beach Unit 1: Vessel Average | 0.23 | 0.52 | 157.4 | 538 | [redacted] | | | | |

The best-fit line is determined relating the "ratio and temperature" adjusted $\Delta RT_{NDT}$ to the fluence factor (determined from the capsule fluence). The slope of this best-fit line is the chemistry factor calculated from surveillance data, $CF_{Surv.\ Data}$

$$CF_{Surv.\ Data} = 161.1\ ^{\circ}F$$

## 5.0 REFERENCES

1. U. S. Nuclear Regulatory Commission, "*Radiation damage to Reactor Vessel Material,*" Regulatory Guide 1.99, Revision 2, May 1988.

2. 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,*" Federal Register, December 19, 1995.

3. Memorandum from Keith R. Wichman to Edmund J. Sullivan, "*Meeting Summary for November 12, 1997, Meeting with Owners Group Representatives and NEI Regarding Review of Responses to Generic Letter 92-01, Revision 1, Supplement 1 Responses,*" dated November 19, 1997.