UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

July 20, 2000

LICENSEE: Wisconsin Public Service Corporation

FACILITY: Kewaunee Nuclear Power Plant

SUBJECT: MEETING BETWEEN THE WISCONSIN PUBLIC SERVICE CORPORATION AND THE NUCLEAR REGULATORY COMMISSION STAFF CONCERNING MASTER CURVE SUBMITTAL FOR EVALUATING THE KEWAUNEE REACTOR PRESSURE VESSEL CIRCUMFERENTIAL WELD (TAC NOS. MA8585 AND MA8586)

The Nuclear Regulatory Commission (NRC) staff met with representatives from Wisconsin Public Service Corporation (WPSC) at NRC Headquarters on July 6, 2000, concerning WPSC's submittal to evaluate the integrity of the Kewaunee Reactor Pressure Vessel (RPV) circumferential beltline weld using a Master Curve-based methodology. Enclosure 1 lists the meeting participants. A public meeting notice for the subject meeting was issued on June 20, 2000, and a copy of the meeting notice was posted on the NRC's external (public) web page.

The purpose of the meeting was to address several specific items from the staff's review of WPSC's submittal, dated June 7, 1999, supplemented on February 4, 2000. The meeting agenda consisted of three topical areas: (1) the staff's conclusions regarding regulatory implementation issues, (2) the staff's evaluation of technical issues necessary to support a Master Curve-based approach, and (3) open items in the staff's evaluation requiring resolution. Enclosure 2 is a copy of the slides used during the staff's presentation.

On June 7, 1999, WPSC submitted a request for exemptions to 10 CFR 50.61, 10 CFR 50 Appendix G, and 10 CFR 50 Appendix H, to allow the use of the Master Curve-based methodology for calculating the RPV Reference Temperature for Pressurized Thermal Shock (RT_{PTS}) based on the fracture toughness data from irradiated pre-cracked Charpy V-notch specimen testing of Kewaunee and Maine Yankee surveillance welds. The Master Curve methodology is based on American Society for Mechanical Engineers (ASME) Code Case N-629 and American Society for Testing and Materials Standard (ASTM) E-1921. In its submittals, WPSC also requested a revision of the facility's Pressure-Temperature (P/T) limit curves. The WPSC request for implementing the Master Curve methodology is supported by industry groups such as the Westinghouse Owner's Group, the Electric Power Research Institute, and the Materials Reliability Project. Kewaunee is considered the lead plant for this effort. On February 4, 2000, WPSC submitted supplemental information in response to the staff's questions and comments stated in a staff letter to WPSC dated July 16, 1999, as well as comments provided during a previous meeting between the staff and WPSC held on October 6, 1999.

The staff stated during the July 6, 2000 meeting that although the NRC did not concur with the methodology proposed in the WPSC submittal, an acceptable alternative methodology could be used to apply the WPSC Master Curve data for the evaluation of the Kewaunee RPV circumferential beltline weld. Using such a methodology, the staff stated that the RT_{PTS} value for the Kewaunee RPV would be about 279.5 °F plus a bias term to account for non-conservatism associated with the use of data from irradiated pre-cracked Charpy V-notch specimen tests. The RT_{PTS} value based on the WPSC's proposed methodology was 249 °F. The staff also stated that two open items remain to be resolved prior to the completion of the staff's review: 1) determination of the magnitude of the bias term to be applied, and 2) a detailed understanding of the structure of the future Kewaunee RPV surveillance program and how it will be used to support this methodology for evaluating RPV integrity. In response to the staff's request, WPSC agreed to docket additional information in the near future to address these open issues. As discussed with Mr. T. Webb of WPSC on July 19, 2000, this meeting summary will serve as the staff's formal request for this additional information.

Following the staff's presentations, WPSC made presentations on the issue of accuracy in determining the Master Curve reference temperature from Charpy Sized Specimens, and also on its plans for the future RPV suveillance program. Enclosures 3 and 4 are copies of the slides that were used by the WPSC during its presentations.

In response to the staff's presentations, WPSC and other industry representatives commented that while they were appreciative of the staff's diligent review effort, the staff's conclusion may reduce the expected benefit of the Master Curve methodology.

Tae Kim, Senior Project Manager, Section 1 /RA/
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-305

Enclosures: As stated

cc w/encls: See next page

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B. Sheron
J. Strosnider
R. Wessman
J. Zwolinski
S. Black
C. Craig
M. Mayfield
M. Leach, RIII
J. Lara, RIII

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Tae Kim

Tae Kim, Senior Project Manager, Section 1
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

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cc w/encls: See next page

Kewaunee Nuclear Power Plant

cc:

Foley & Lardner
ATTN: Bradley D. Jackson
One South Pinckney Street
P.O. Box 1497
Madison, WI 53701-1497

Chairman
Town of Carlton
Route 1
Kewaunee, WI 54216

Harold Reckelberg, Chairman
Kewaunee County Board
Kewaunee County Courthouse
Kewaunee, WI 54216

Attorney General
114 East, State Capitol
Madison, WI 53702

U.S. Nuclear Regulatory Commission
Resident Inspectors Office
Route #1, Box 999
Kewaunee, WI 54216

Regional Administrator - Region III
U.S. Nuclear Regulatory Commission
801 Warrenville Road
Lisle, IL 60532-4531

James D. Loock, Chief Engineer
Public Service Commission
of Wisconsin
610 N. Whitney Way
Madison, WI 53707-7854

MEETING ATTENDEES

NAME	AFFILIATION
Bill Bateman	NRC
Keith Wichman	NRC
Matthew A. Mitchell	NRC
T.J Kim	NRC
John G. Lamb	NRC
Mark Kirk	NRC
Andrea Lee	NRC
Stewart Bailey	NRC
Ed Hackett	NRC
Allen Hiser	NRC
Barry Elliot	NRC
Daniel Collins	NRC
Tom Webb	WPSC
Ken Weinhauer	WPSC
Charles A. Tomes	WPSC
Bill Server	ATI Consulting
Randy Lott	Westinghouse
C. Kim	Westinghouse
James Pfefferle	WEPCO
Ken Yoon	FTI
Bob Hardies	BGE
Dennis Weakland	FENOC/Beaver Valley
Majorie Natishan	PEAI

ENCLOSURE 1

NRC Staff Assessment of the Wisconsin Public Service Corporation's Master Curve Submittal for Evaluating the Kewaunee Reactor Pressure Vessel Circumferential Weld

July 6, 2000

Matthew A. Mitchell
Materials and Chemical Engineering Branch
Office of Nuclear Reactor Regulation

ENCLOSURE 2

Background

⇨ June 7, 1999 - WPSC submits a request to utilize data from testing of irradiated precracked Charpy V-notch (PCVN) specimens for evaluating the Kewaunee RPV circ. weld.

- Based on American Society for Mechanical Engineers (ASME) Code Case N-629 and American Society for Testing and Materials Standard E-1921.
- Requested reevaluation of the RPV's RT_{PTS} value at end-of-license extended (EOLE); granting of exemptions to enable use of the Master Curve-based methodology; and, a revision of the facility's pressure-temperature limit curves.

⇨ July 16, 1999 - NRC issues letter to WPSC noting that the submittal was "incomplete" and did not appear to adequately address all sources of uncertainty (chemistry and material property variability) identified in the PTS Rule (10 CFR 50.61). No detailed NRC review of submittal would commence until these issues were addressed.

Background (Continued)

- ⇨ October 6, 1999 - Meeting between WPSC and the NRC to discuss WPSC response to the issues raised in the NRC staff's July 16, 1999 letter.

- ⇨ February 4, 2000 - WPSC submits docketed response to the NRC staff's July 16, 1999 letter. Response included report EDRE-EMT-1467 which provided the technical details of the WPSC response to issues raised by the staff.

- ⇨ July 6, 2000 - NRC staff review nearly complete.

  - The NRC staff has been able to adequately address most technical issues based on information submitted by WPSC.

  - Two open items remain for resolution (details regarding the future Kewaunee RPV surveillance program and an issue regarding the potential for bias in the use of PCVN specimens to determine T_0).

Topical Agenda

(1) Discussion of NRC staff conclusions regarding regulatory implementation issues (i.e., exemptions).

(2) Discussion of NRC staff evaluation on the use of the available data for the evaluation of the Kewaunee RPV (technical issues).

- Staff's resolution of implicit margin issues.
- Staff's determination of an explicit margin to be included to account for chemistry and initial property variability.
- Staff's development of an alternate methodology for applying irradiated data points to the RPV EOLE conditions.
- Identification of a potential PCVN bias issue.

(3) WPSC/NRC discussion of open items requiring resolution.

Regulatory Implementation Issues

⇨ In their June 7, 1999 submittal, WPSC identified several exemptions that would be necessary to enable the use of Master Curve data (K_{JC}) and a Master Curve-based methodology for evaluating the Kewaunee RPV.

- 10 CFR 50.61 - To revise methodology for calculating RT_{PTS}.
- 10 CFR 50, Appendix G - To revise methodology for establishing P-T limit curve reference temperatures.
- 10 CFR 50, Appendix H - To revise RPV surveillance program to be based on the acquisition of Master Curve data along which Charpy impact testing data.

⇨ The NRC staff concurs that the issuance of these exemptions appears to be necessary for the implementation of a Master Curve-based approach to RPV integrity assessment. However, final resolution will await discussions with the NRC's Office of the General Counsel.

Technical Issue #1: Implicit Margin

- ⇨ WPSC contended that the ASME Code Case N-629 methodology for establishing $RT_{T0} = T_0 + 35$ °F contained 18 °F of implicit margin beyond that necessary to be consistent with the implicit margin contained in the current Charpy and Drop Weight-based indexing approach.
  - ▸ Based on observing the amount of conservatism in indexing the K_{IC} curve using Master Curve (K_{JC}) data relative to the K_{IC} data in the original K_{IC} database for the limiting material HSST-02.
- ⇨ The NRC staff disagrees. <u>The staff has concluded that 2 °F of implicit margin in the $RT_{T0} = T_0 + 35$ °F relationship will be credited in the Kewaunee review.</u>
  - ▸ Based on observing the average amount of conservatism in indexing the K_{IC} curve using Master Curve (K_{JC}) data relative to the all K_{IC} data in the original K_{IC} database.

ENCLOSURE 2

Technical Issue #1: Implicit Margin (Continued)

⇨ The NRC staff's position on this issue:

- Appears to be consistent with the intent of the ASME Code in the development of Code Case N-629. The NRC staff's understanding is that there was no obvious intent by the Code to "embed" additional margin and that the Code's intent was for RT_{T0} to be an equivalent to RT_{NDT}.

- Appears to be consistent with the development of the original K_{IC} curve in that a set of materials is considered instead of a single limiting material. In fact, an acceptable statistical level of "bounding" can only be attributed to the K_{IC} curve if all of the materials from the original K_{IC} database are considered.

- Appears to be a more "stable" definition of implicit margin. WPSC's reliance on a small population of data from HSST-02 to establish the margin in the current methodology could be subject to considerable change if more data for HSST-02 were acquired. Using an average from the overall database lessens the perturbation that would result from adding additional data points.

Technical Issue #2: Explicit Margins

- ⇨ WPSC's submittal included an explicit margin of 24 °F ($2\sigma_{T0}$) based on the uncertainty in the Master Curve testing methodology. WPSC concluded in their February 7, 2000 response that, considering this explicit margin along with the 18 °F of implicit margin, "the original submittal has a reasonable amount of margin included to accommodate specific uncertainties that are needed for the direct fracture toughness measurement approach." (EDRE-EMT-1467, page 15)

- ⇨ The NRC staff disagrees. As will be shown, while the σ_{T0} is <u>almost</u> sufficient in the case of Combustion Engineering Linde 1092 weld heats to cover the equivalent of σ_I in the current methodology, it is inadequate to address issue of chemistry and fluence uncertainty.

- ⇨ Consistent with the bases of the current regulations, the NRC staff determined the amount of explicit margin to be assessed for the Kewuanee application by separating the margin into two parts: σ_{IT0} which represents uncertainty in the initial properties of 1P3571 welds and σ_Δ which represents the uncertainty in irradiation response.

Technical Issue #2: Explicit Margins, σ_{IT0}

- To assess a value for σ_{IT0} for 1P3571 welds, NRR requested RES support in identifying Combustion Engineering weld wire heats for which more than one unirradiated weld sample had been tested for Master Curve data. This included Linde 1092, 0124, and 0091 flux welds.

- For each weld wire heat, the available data were pooled and random samplings were conducted. The 1σ variablities in T_0 as a result of this sampling were observed for each weld wire heat.

- A characteristic value of 14 °F was found to adequately cover the observed variability in simulated T_0 values for each Combustion Engineering weld wire heat.

- Therefore, the NRC staff accepts that 14 °F is an adequate value for σ_{IT0} in the case of the Kewaunee application.

Technical Issue #2: Explicit Margins, σ_Δ

- Next, the staff evaluated an appropriate value for σ_Δ based on observing copper and nickel variability for 1P351 and other copper-coated CE weld wires and uncertainty in the Kewaunee fluence determination.

- For 1P3571, the staff's analysis used a mean copper value of 0.287 percent and a mean nickel value of 0.756 percent as reported by Kewaunee in WCAP-15074.

- For uncertainties in copper and nickel the staff referenced the CE NPSD-1039, Revision 2 report from Generic Letter 92-01 activities. The 1σ uncertainty for nickel was taken as 0.042 percent and two possibilities were considered for copper: 0.07 percent based on 1P3571 and 0.05 percent based on all copper-coated CE weld wire heats.

- The staff's analysis assumed a best-estimate EOLE fluence for the Kewaunee RPV weld of 4.7×10^{19} n/cm^2 and an uncertainty of ± 20 percent.

Technical Issue #2: Explicit Margins, σ_Δ (Continued)

- The staff then performed a Monte Carlo simulation using the designated inputs and the Regulatory Guide 1.99, Revision 2 embrittlement correlation for welds to calculate simulated values of ΔRT_{NDT} (the uncertainty in the T_0 shift is assumed to be the same as the uncertainty in ΔRT_{NDT}).

- Depending on which value of copper variability was selected and what level of input distribution truncation was used, the 1σ uncertainty in the distribution of ΔRT_{NDT} ranged from 25 °F to 33 °F. The staff observed that these values were consistent with the currently value of σ_Δ, 28 °F.

- Therefore, the staff has concluded that there is no compelling evidence to suggest that a value other than 28 °F should be used for σ_Δ.

Technical Issue #2: Explicit Margins (Continued)

- ⇨ Therefore, based on the general methodology of Regulatory Guide 1.99, Revision 2 to combine uncertainties by a square-root-sum-squares method, the margin term for the Kewaunee application becomes:

$$M = 2\sqrt{(\sigma_{IT0}^2 + \sigma_{\Delta}^2)} = 2\sqrt{(14^2 + 28^2)} = 62.5\ °F$$

- ⇨ The NRC staff recognizes that this margin term does not reflect any credit for "credible" surveillance data as addressed in Regulatory Guide 1.99, Revision 2, Position 2.1.

- ⇨ <u>The data used in this application do not reflect the data upon which the Regulatory Guide 1.99, Revision 2 correlations or structure are based. RG 1.99, Rev. 2 correlations may be used to model the behavior (i.e. shift) of T_0 as an assumption of the analysis, but the NRC staff's position is that the full (2σ) margins shall be maintained intact, at least until a formal analysis of the shift behavior of T_0 is completed and reviewed by the staff.</u>

Technical Issue #3: Adjustment of T_0 Data

- In order to utilize the irradiated T_0 data from the Maine Yankee (MY, 223 °F*) and Kewaunee (K, 136 °F) surveillance specimens, the test results must be "shifted" to the Kewaunee RPV EOLE (or EOL) conditions.

- The data from both the Maine Yankee and Kewaunee surveillance welds test must be applied to the evaluation of either EOLE or EOL conditions.

  - Note, the WPSC submittal proposed to evaluate the RPV EOLE conditions by using the MY data and the RPV EOL conditions by using the K data.

- Since the existing models for comparing the effect of different material chemistries and fluence levels are expressed in the shift in a material parameter (i.e. ΔRT_{NDT}), this evaluation must consider the shift in T_0 when making the necessary corrections to evaluate Kewaunee RPV conditions.

Technical Issue #3: Adjustment of T_0 Data (Continued)

⇨ The method acceptable to the staff for this adjustment is:

$$T_{0\text{-}RPV} = T_{0\text{-}SW} - (\Delta T_{0\text{-}SW}) * [1 - (CF_{RPV}/CF_{SW}) * (FF_{RPV}/FF_{SW})]$$

where:
- $T_{0\text{-}RPV}$ is the value associated with the RPV weld
- $T_{0\text{-}SW}$ is the value of T_0 in the irradiated condition from a surv. weld
- $\Delta T_{0\text{-}SW}$ is the shift in T_0 for that surv. weld
- CF_{RPV} is the chemistry factor for the RPV weld from RG 1.99 Rev. 2 tables
- CF_{SW} is the chemistry factor for the surv. weld from RG 1.99 Rev. 2 tables
- FF_{RPV} is the fluence factor for the RPV weld at the time/location of interest
- FF_{SW} is the fluence factor for the surv. weld test data

⇨ For the Kewaunee application, this calculation must be carried out for each irradiated data point (MY, K). The resulting RT_{PTS} values must be averaged to determine the RT_{PTS} value for the RPV circumferential weld.

⇨ At EOLE (using a fluence value of 4.7×10^{19} n/cm^2), the T_0 value for the RPV circumferential weld calculated from the MY data was 174 °F. The T_0 value calculated from the K data was 194 °F.

Technical Issue #4: PCVN Bias

- ⇨ Although not addressed in the WPSC submittal, the NRC staff has concluded that sufficient evidence exists to suggest that, when the test methodology in ASTM E1921-97 is used, a non-conservative bias exists when comparing T_0 values obtained from PCVN specimens to T_0 values obtained from larger specimens.

- ⇨ The apparent cause of this bias is a lower level of constraint in the smaller PCVN specimens.

- ⇨ Since the WPSC submittal relies on the testing of PCVN specimens in both the irradiated and unirradiated (to establish ΔT_0 values for the surveillance materials) PCVN data, the bias in each of these data sets must be accounted for in this application.

- ⇨ The bias from each data set (MY, K) is then added to the calculated T_0 values when RT_{PTS} for the RPV is determined.

Technical Issue #4: PCVN Bias (Continued)

⇨ Working through the mathematics:

$$B_{T0\text{-}RPV\text{-}MY} = B_{MY\text{-}U} + [(CF_{RPV}/CF_{MY}) * (FF_{RPV}/FF_{MY}) * (B_{MY\text{-}I} - B_{MY\text{-}U})$$

$$B_{T0\text{-}RPV\text{-}K} = B_{K\text{-}U} + [(CF_{RPV}/CF_{K}) * (FF_{RPV}/FF_{K}) * (B_{K\text{-}I} - B_{K\text{-}U})$$

where: $B_{T0\text{-}RPV\text{-}MY}$ is the bias in the T_0 value calculated for the RPV using the MY data
$B_{T0\text{-}RPV\text{-}k}$ is the bias in the T_0 value calculated for the RPV using the K data

⇨ <u>The resolution of the appropriate bias term to be associated with each data set in the WPSC submittal has been identified by the staff as an open item for further discussion between WPSC and the NRC.</u>

Determination of Kewaunee RT_{PTS} Value at EOLE

⇨ Based on the information presented, the NRC staff's conclusion is that the RT_{PTS} value for the Kewaunee circumferential weld may be calculated from the existing Master Curve (K_{JC}) data using the following relationships:

$$RT_{PTS\text{-}MY} = (T_{0\text{-}RPV\text{-}MY} + 35\ °F) - (2\ °F) + (62.5\ °F) + B_{T0\text{-}RPV\text{-}MY}$$
$$= (174\ °F + 35\ °F) - (2\ °F) + (62.5\ °F) + B_{T0\text{-}RPV\text{-}MY}$$
$$\mathbf{= 269.5\ °F + B_{T0\text{-}RPV\text{-}MY}}$$

$$RT_{PTS\text{-}K} = (T_{0\text{-}RPV\text{-}K} + 35\ °F) - (2\ °F) + (62.5\ °F) + B_{T0\text{-}RPV\text{-}K}$$
$$= (194\ °F + 35\ °F) - (2\ °F) + (62.5\ °F) + B_{T0\text{-}RPV\text{-}K}$$
$$\mathbf{= 289.5\ °F + B_{T0\text{-}RPV\text{-}K}}$$

$$RT_{PTS} = (RT_{PTS\text{-}MY} + RT_{PTS\text{-}K})/2$$

$$\underline{RT_{PTS} = 279.5\ °F + (B_{T0\text{-}RPV\text{-}MY} + B_{T0\text{-}RPV\text{-}K})/2}$$

ENCLOSURE 2

Conclusions

- The NRC staff has developed an acceptable methodology for the application of the WPSC Master Curve data for the evaluation of the Kewaunee RPV circumferential weld.

- Based upon current information, the staff has concluded that the RT_{PTS} value for the Kewaunee RPV would be 279.5 °F plus a bias term to account for non-conservatism in the use of PCVN specimen testing.

- Two open items remain to be resolved prior to the completion of the staff's review:

  - The magnitude of the bias term to be applied

  - A detailed understanding of the structure of the future Kewaunee reactor pressure surveillance program and how it will be used to support this methodology for evaluating RPV integrity.

Comparison of Licensee and NRC Staff Positions (Kewaunee EOLE Conditions)

	Licensee	Staff
Basic Eqn.:	$RT_{PTS} = RT_{T0} + \text{Ratio Adj.} + M$ $= 257 + (-32) + 24$ $= 249$ F	$RT_{PTS} = RT_{T0\text{-}ADJ} + M + B$ $= 219 + 62.5 + B$ $= 279.5^{*}$ F + B (*with 2 F of implicit margin removed)
Data Used for Conclusion:	Maine Yankee	Maine Yankee, Kewaunee
Fluence Used at EOLE:	5.1×10^{19} n/cm^2	4.7×10^{19} n/cm^2
Implicit Margin :	18 F (in $RT_{T0} = T_0 + 35$ F)	2 F (in $RT_{T0} = T_0 + 35$ F)
Explicit Margin:	24 F (based on $2\sigma_{T0}$)	62.5 F (based on $2\sqrt{(\sigma_{IT0}^2 + \sigma_{\Delta}^2)}$) ($\sigma_{IT0} = 14$ F, $\sigma_{\Delta} = 28$ F)
Ratio Adjustment:	-32 F from MY data to Kewaunee RPV	Use ratio of CFs and FFs to get a multiplier to move data points to the RPV conditions.
Bias Term:	None included	Open Item.

ENCLOSURE 2

Kewaunee Master Curve Submittal

Meeting with NRC

July 6, 2000

Tom Webb
Ken Weinhauer
Chuck Tomes
Bill Server
Randy Lott
Charles Kim

ENCLOSURE 3

Can T_O be Accurately Determined from Charpy Sized Specimens?

ENCLOSURE 3

T_o Determined from Charpy Size Specimens

- WPSC included an evaluation of this issue in June 1999 to the NRC and in WCAP-15075
  - Our evaluation suggested no definable bias for Charpy size specimens
  - ASTM E8 Committee did not include any bias restriction in ASTM E 1921-97
- This issue is still an area of debate for some members of E8, but no change has been made for the revision to E1921 to include a bias term
- T_o results for Kewaunee surveillance weld material included testing of larger than Charpy size specimens (1/2-T Compacts and 1X-WOL)

June 1999 T_o Bias Figure

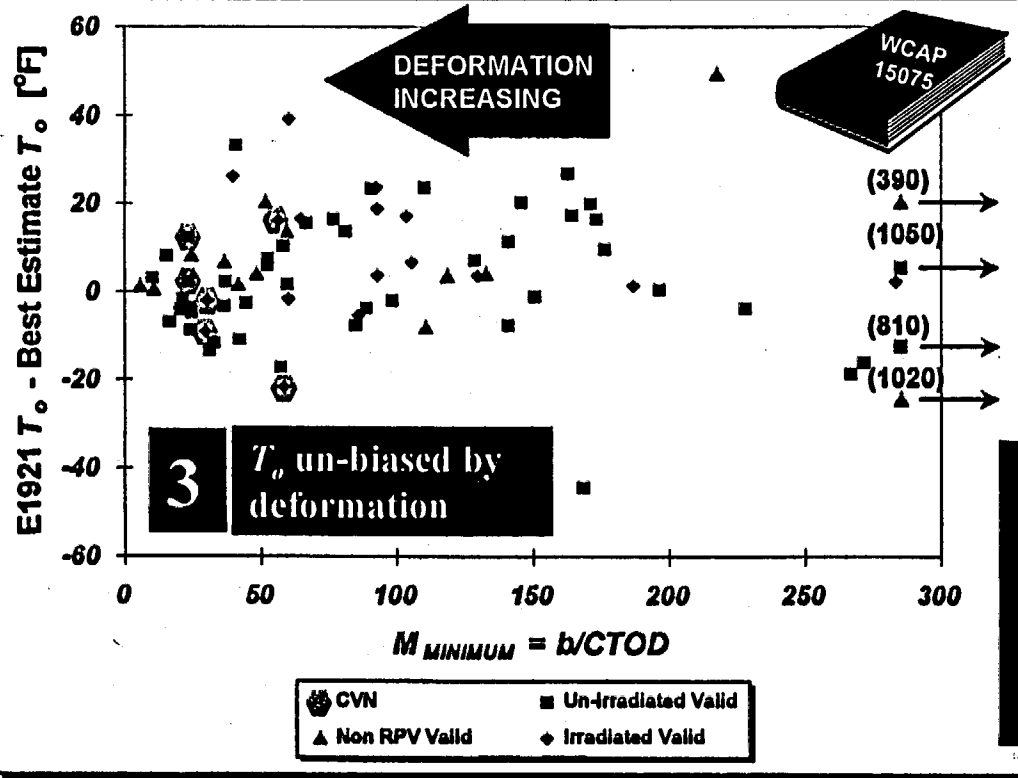
ASTM E1921

Size Effects: Constraint Limits

1

EPFM **size limits permit testing of precracked Charpy specimens.**

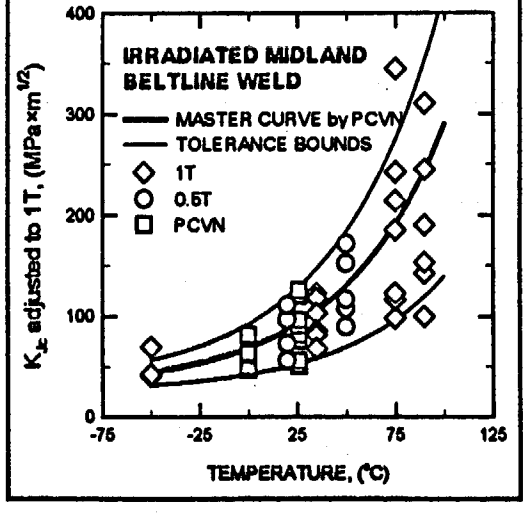
$$\frac{E \cdot b \cdot \sigma_{ys}}{K_{Jc}^2} \propto \frac{b}{CTOD} \geq 30 \equiv M$$



3 T_o un-biased by deformation

2

PC-CVN T_o values bound large specimen data.



Direct Measurement using Surveillance Specimens

ENCLOSURE 3

Recent Related Results

- Analytical modeling results continue to suggest a possible bias, especially for low M values
- NRC has ongoing work both analytically and experimentally related to this issue -- unresolved
- Some data suggest a small effect (< 10°F) at low M values, while other data do not
- Data generated using Charpy size specimens for 1P3571 weld metal were at relatively high values of M for unirradiated and irradiated conditions

M_{median} Values for 1P3571 Data

- Unirradiated
  - Charpy Size
    - » Kewaunee Whole and Reconstituted: 71
    - » Maine Yankee Whole: 65
  - ½-T Compact
    - » Kewaunee: 214
  - ◎ T_o determined for Kewaunee used combined ½-T Compacts and Charpy size specimens
- Irradiated
  - Charpy Size
    - » Kewaunee Reconstituted: 39
    - » Maine Yankee Reconstituted: 70
  - ◎ T_o determined for Kewaunee used combined 1-X WOL and Charpy size specimens

ENCLOSURE 3

Does a Bias Exist?

- WPSC believes that the current state of knowledge does not support the existence of a bias between Charpy size To values and To values determined using larger compact-type specimens
- T_o results for Kewaunee surveillance weld material included testing of larger than Charpy size specimens (1/2-T Compacts and 1X-WOL)
- Even if a bias does exist, it is very small (especially for the conditions used to test the 1P3571 weld metal)
- No adjustment to the margins in the original submittal for this bias are required.

Kewaunee Master Curve Submittal

Meeting with NRC

July 6, 2000

Tom Webb
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Charles Kim

ENCLOSURE 4

Plans for Continued Surveillance

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Background

KNPP Surveillance Program

- Designed by Westinghouse Electric Corporation
  - Based on **ASTM E185-70,** *Recommended Practice for Surveillance Tests on Nuclear Reactor Vessels*
  - Surveillance Program Described in **WCAP-8107,** *Wisconsin Public Service Corporation Kewaunee Nuclear Plant Reactor Vessel Radiation Surveillance Program*
    - » Six Capsules
    - » Material Identical to the KNPP Reactor Beltline Weld
    - » Surveillance Weld Metal <u>and</u> Beltline Weld
      - * Fabricated From 3/16 inch Diameter B-4 (single Arc) Weld Wire,
      - * Heat Number 1P3571
      - * Linde 1092 Flux, Lot Number 3958

KNPP RV Surveillance Capsule Program

Status

- Four Capsules (V, R, P, S) Removed/Tested to Date
  - Capsule Results Documented in WCAP Reports
    - » **V** WCAP-8908 (*ASTM E185-70*)
    - » **R** WCAP-9878 (*ASTM E185-70*)
    - » **P** WCAP-12020 (*ASTM E185-82*)
    - » **S** WCAP-14279, Rev. 1 (*ASTM E185-82*)
- Two Capsules (N, T) Remain in Reactor Vessel for Future Testing

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Master Curve Testing of Weld 1P3571

Completed Tests *(ASTM E1921-97)*

- Pre-cracked Three Point Bend Tests
  - Kewaunee Capsule S (Reconstituted)
  - Maine Yankee Capsule A-35 (Reconstituted)
  - KNPP Unirradiated Surveillance Capsule Material
  - Maine Yankee Unirradiated Surveillance Capsule Material
- ½-T Compact Tension Tests
  - Kewaunee Unirradiated Surveillance Capsule Material
- 1X-WOL Specimens
  - Kewaunee Capsule S

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Remaining Capsules 1P3571Material

- KNPP Surveillance Capsule N
  - Target Fluence is Approximately $5x10^{19}$ n/cm^2
  - Corresponds to 60 Years Plant Operation
- KNPP Surveillance Capsule T
  - (Standby)
- Maine Yankee Surveillance Capsule 343
  - Fluence is Approximately $1.5x10^{19}$ n/cm^2

Objectives

Surveillance Program Objectives

- Provide Confirmation of Reactor Vessel Integrity Evaluations (HU/CD, LTOP, PTS)
- Assess/Monitor KNPP Beltline Weld Metal Fracture Toughness Through EOLE Term

Material Specific Objectives

- 1P3571 Weld Metal
  - Obtain Master Curve RT_{T0} Transition Temperatures Via ASTM E1921 and WCAP-15075
- Forging and Correlation Monitor Material
  - Satisfy ASTM E185-82

Priorities For Testing 1P3571

Philosophy: *Design a program that allows flexibility that will meet the operational needs of the plant.*

- First Priority is Determination of RT_{To}
  - Reconstitute un-tested HAZ.
  - Test Pre-cracked HAZ specimens
  - Test as many weld specimens as required to define RT_{To}
- Secondary Priority Charpy V-notch Data
  - If an adequate number of un-tested weld Charpy specimens remain after satisfying first priority, will produce partial or full transition curve.

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1P3571 Test Specimens Available For Future Testing

- KNPP Surveillance Capsule N
  - Charpy, 8 Weld Metal Specimens
  - Charpy, 8 HAZ Specimens
- KNPP Surveillance Capsule T
  - Charpy, 8 Weld Metal Specimens
  - Charpy, 8 HAZ Specimens
- Maine Yankee Capsule
  - Charpy, 12 Weld Specimens
  - Tensile, 3 Specimens

Basis for Sequencing of Weld Tests

- Goals
  - ① Fracture Toughness Testing of Charpy Size 3-Point Bend Specimens
    - » Eight to ten (8-10) specimens
  - ② Standard Charpy V-notch Impact Testing
    - » Remaining weld specimens
- Test Fracture Toughness Specimens First
  - – Surveillance Program Now Based on Fracture Toughness
  - – Pre-Cracked Specimens Better Suited for Reconstitution (*if necessary*)
    - » Charpy V-Notch Impact Testing on the Upper Shelf can Cause More Extensive Plastic Deformation of Test Specimen
    - » Charpy Size Pre-cracked Three Point Bend Testing Causes Little Plastic Deformation and Better Lends Itself to Reconstitution

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Sequencing of Future Tests for 1P3571 Weld Metal

- Plans for Surveillance Charpy Specimens
  - Kewaunee Capsule N *(8 Weld and 8 HAZ Specimens)*
    - » Reconstitute HAZ specimens
    - » Determine RT_{To}
    - » Charpy V-notch curve <u>if feasible without reconstitution</u>
  - Kewaunee Capsule T *(8 Weld and 8 HAZ Specimens)*
    - » Hold for Standby
  - Maine Yankee Capsule 343 *(12 Weld Specimens)*
    - » Determine RT_{To}
    - » No Reconstitution Planned
    - » No Charpy V-notch Testing Planned

Note: Forging and Correlation material to be tested per ASTM E185-82