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Status Update of NRC Evaluation of BTP 5-3 to Estimate T_{NDT}, $RT_{NDT(u)}$, and Upper-Shelf Energy

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Background

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- January 30, 2014 – AREVA letter with an attached PVP paper (PVP2014-28897) claims that Position 1.1(4) of BTP 5-3 is sometimes non-conservative for A508-2 forgings.
- June 4, 2014 – NRC and industry each presented initial assessments of all BTP 5-3 positions in the NRC/EPRI annual materials issue information exchange meeting.
- February 19, 2015 – NRC and industry each presented assessments of all BTP 5-3 positions and their impact on operating plants in a public meeting on reactor pressure vessel issues.
- June 2, 2015 – NRC and industry each presented updated assessments of all BTP 5-3 positions in the NRC/EPRI annual materials issue information exchange meeting.
- September 23, 2015 – EPRI and PWROG provided MRP-401 (BWRVIP-287) and PWROG-15003-NP for information.

BTP 5-3 Evaluation Objectives

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- Evaluate the potential impact on safety due to the issues raised by AREVA.
- Evaluate the need to revise BTP 5-3.

RG 1.99, Rev. 2 Guidance on Use of Generic RT_{NDT} Values

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"[G]eneric mean values for that class* of material may be used if there are sufficient test results to establish a mean and standard deviation for the class."

*The class for estimating initial RT_{NDT} is generally determined, for the welds with which this guide is concerned, by the type of welding flux (Linde 80 or other); for base metal, by the ASTM Standard Specification.

$$\text{Margin} = 2(\sigma_i^2 + \sigma_\Delta^2)^{1/2}$$

Current Practice in Using BTP 5-3 to Determine RT_{NDT} Values

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- BTP 5-3 positions were developed based on generic Charpy test data.
- Except for two units, all plants that used BTP 5-3 used a σ_i of zero in determining the margin of the RT_{NDT} values for the relevant RPV plates or forgings.

$$\text{Margin} = 2(\sigma_i^2 + \sigma_\Delta^2)^{1/2} = 34\ ^\circ\text{F}$$

Position 1.1(1) on T_{NDT}

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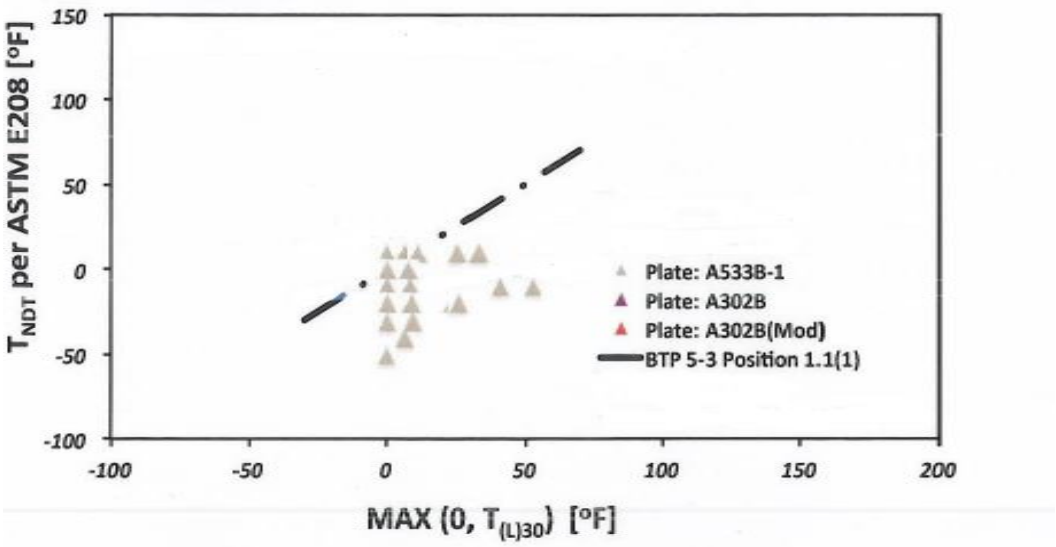
T_{NDT} is the Max (test temp. at 30 ft-lb of the Charpy curve, 0 °F) for SA-533 B, Cl 1 plate and weld

NRC Evaluation:



Observation: (1) One way to address the nonconservatism is to determine a σ_i value that makes this position conservative.

(2) Deletion is considered if it is confirmed that no plants used it.

Position 1.1(2) on T_{NDT}

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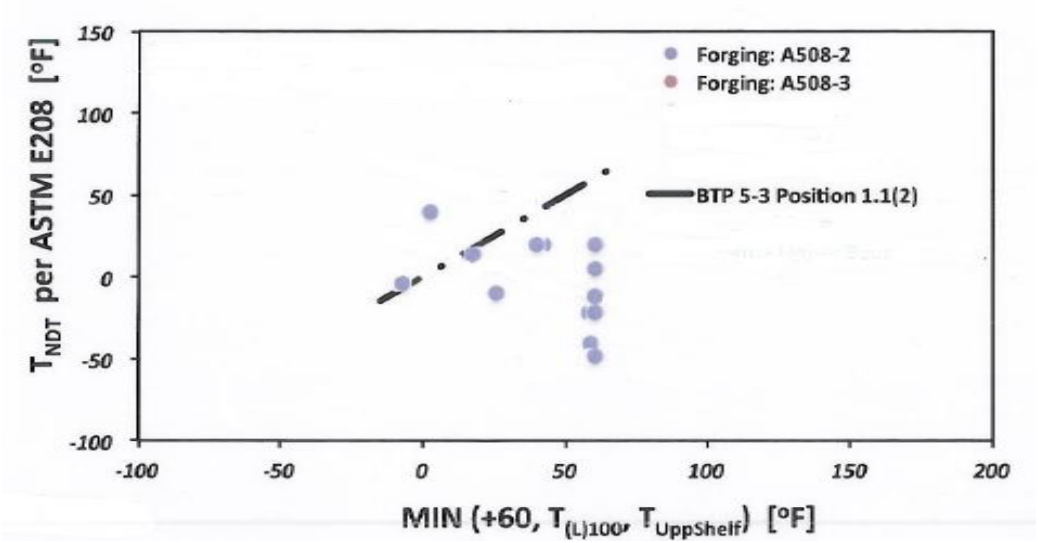
T_{NDT} is the Min (60 °F, test temp. at USE, test temp. at 100 ft-lbs if USE > 100 ft-lbs) for SA-508, Cl II forging

NRC Evaluation:



Observation:

(1) The potential outlier has a T_{NDT} of 40°F and ($CVN_{50\ ft\text{-}lb}$-60°F) of -94°F.

(2) One way to address the nonconservatism is to determine a σ_i value that makes this position conservative

(3) Deletion is considered if it is confirmed that no plants used it.

Position 1.1(3)a,b on Charpy Test Temp at 50 ft-lbs

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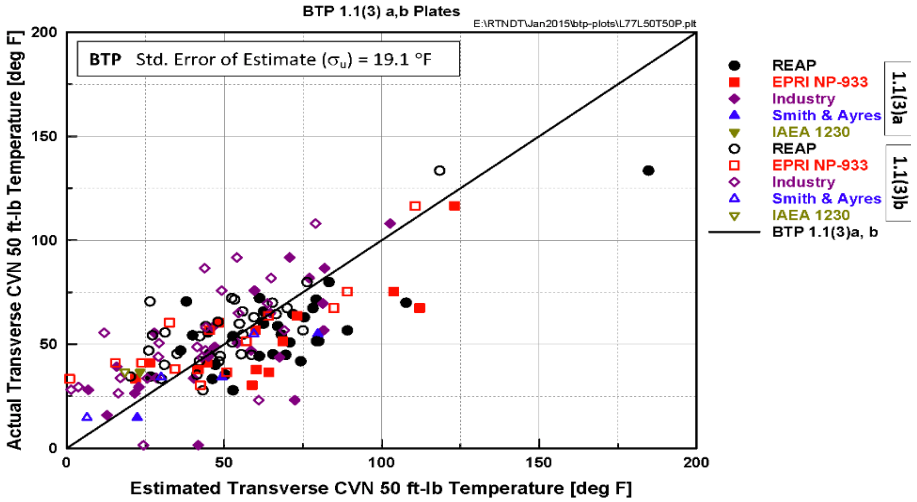
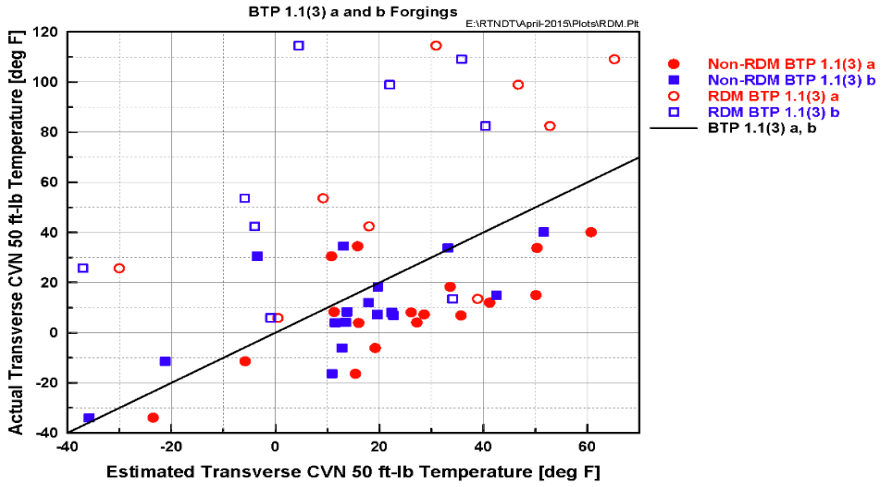
<u>1.1(3)a, apply 0.65 to the longitudinal Charpy curve; 1.1(3)b, use test temp. at 50 ft-lbs of the longitudinal Charpy curve + 20°F</u>

EPRI Evaluation: MRP-401 (BWRVIP-287), specifically, Figures 4-5 and 4-7 below (Courtesy of EPRI)





Observation: One way to address the nonconservatism is to determine a σ_i value that makes this position conservative (Using a σ_i of 20°F for plates and non-Rotterdam forging, and 60°F for Rotterdam forging will bound 95% of the data)*.

* PWRs having Rotterdam forgings based on this position are not affected.

Position 1.1(4) on RT_{NDT} Based on Charpy Data at a Single Temp

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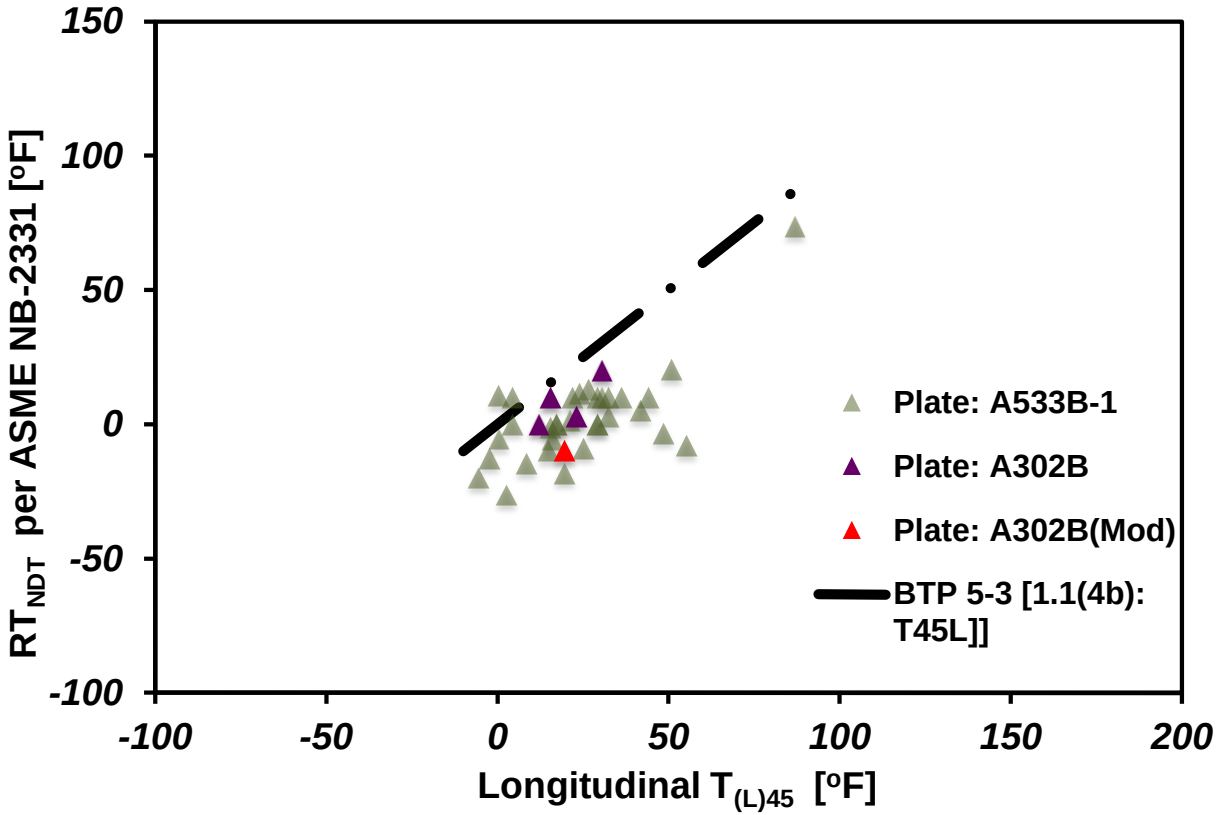
RT_{NDT} is the test temp if all Charpy data ≥ 45 ft-lbs; test temp + 20°F if the minimum value < 45 ft-lbs

NRC Evaluation for Plates:



Position 1.1(4) on RT_{NDT} Based on Charpy Data at a Single Temp - Continued

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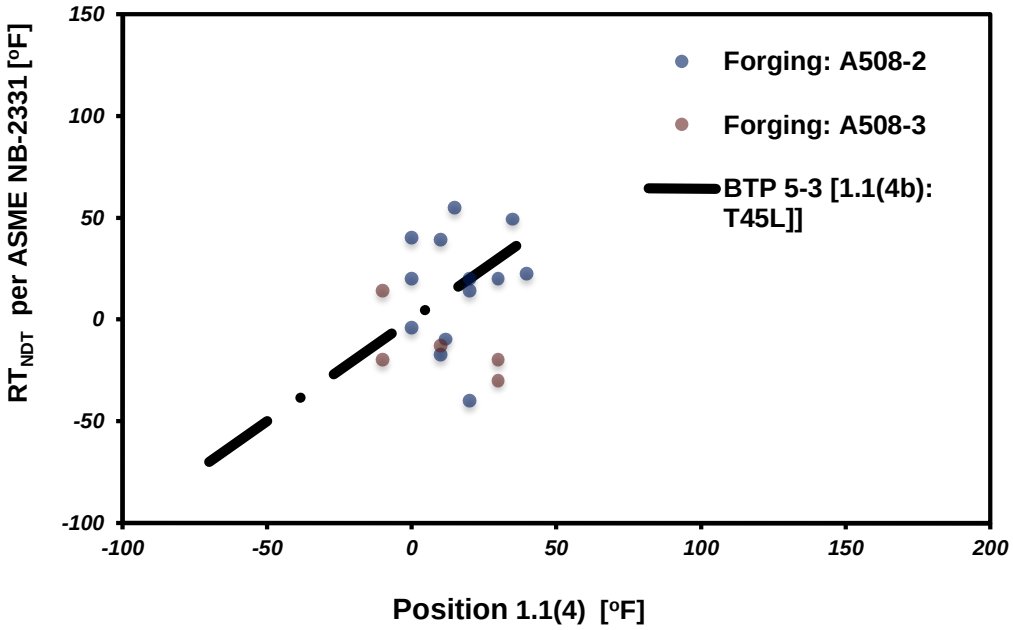
NRC Evaluation for Forgings:



Observations:

(1) Virtually all the plate data is bounded by the existing BTP line.

(2) Position 1.1(4) conservatively estimates the mean of the forging data (the forging data has a mean error of 6.87°F and a σ_i of 30°F from the error analysis).

(3) Using a σ_i of 0°F for plates and σ_i of 30°F for forgings will bound all data.

Position 1.2 on USE

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<u>USE is 65% of the USE based on the longitudinal Charpy data</u>

Technical refs.: (1) NRC regulations on fracture toughness, USE, and PTS and (2)the June 25, 1990 memo from C.Z. Serpan (RES) to C.Y. Cheng (NRR)

Observations:

(1) The results from NRC's evaluation and MRP-401 are consistent with the 1990 evaluation, indicating that Position 1.2 is conservative for 85% of the data (the mean - 1σ approach).

(2) The NRC regulations on fracture toughness, USE, and PTS rely on applying different levels of conservatism to develop generic values for different input parameters.

(3) No change to Position 1.2 is needed.

Impact on PWRs – P-T Limits

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<u>Assess the effect of nonconservatism of BTP 5-3 on current P-T limits</u>

Technical refs.: PWROG-15003-NP and MRP-401 modified by NRC evaluation

(1) PWROG-15003 supports current P-T limits with plates or non-Rotterdam forgings - the material-orientation toughness assessment (MOTA) margin bounds the additional margin due to σ_i of 20°F.

(2) NRC evaluation supports current P-T limits with Rotterdam forgings (3 units) - the Rotterdam forging will not become the new limiting material (2 units used σ_i of 30°F).

Observation: The current P-T limits for PWRS are not affected.

Impact on PWRs – PTS

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Assess the effect of nonconservatism of BTP 5-3 on PTS

Technical refs.: NRC Evaluation and MRP-401

Observation:

NRC analysis of 19 PWRs showed that potentially only one plant would exceed PTS screening criteria of 10 CFR 50.61 prior to the end of the period of extended operation (approximately 10 years from now), if nonconservatism in BTP 5-3 is considered. The potentially affected plant would not exceed the screening criteria of 10 CFR 50.61a.

Impact on BWRs – P-T Limits

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The GE Methodology

1. Estimate the relevant portion of the longitudinal Charpy curve using longitudinal Charpy data at a single temperature (based on all available GE data).
2. Convert estimated longitudinal Charpy information to transverse Charpy information using BTP 5-3 Position 1.1(3)b + Δ.

Observation:

The December 16, 1994 SE on NEDC-32399-P, "Basis for GE RT_{NDT} Estimation Method," evaluated and accepted Part 1. Part 2 was implicitly accepted because it is based on BTP 5-3 Position 1.1(3)b with a Δ.

Impact on BWRs – P-T Limits - Continued

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Assess the effect of nonconservatism of BTP 5-3 on P-T limits

Technical refs.: NRC Evaluation of 33 BWRs and MRP-401

Observations:

(1) NRC evaluation showed some BWRs used later ASME Code edition, and some plants having weld as limiting material for hydro and pressure limits are unlikely to be affected because the current limiting material will remain limiting.

(2) MRP-401 showed that BWRs have enough margin regarding minimum temp requirements considering nonconservatism in BTP 5-3.

(3) Additional evaluation (e.g., the MOTA margin) may be needed to support the current P-T limits for remaining BWRs.

Summary of Observations

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- No immediate safety concern.
- 1.1(1) and 1.1(2): Considering deletion if it is confirmed that no plants used it.
- 1.1(3)a,b: Using a σ_i of 20°F for plates and non-Rotterdam forging and 60°F for Rotterdam forging will bound 95% of the data.
- 1.1(4): Using a σ_i of 0°F for plates and 30°F for forgings will bound all data.
- 1.2: no change is needed.

Conceptual Next Steps

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- Finalize the technical bases underlying the potential BTP 5-3 revision considering any additional industry information.
- Backfit analysis ?
- Complete processing of the proposed BTP 5-3 revision, if applicable. Public comment would be solicited.
- If BTP 5-3 is revised, communicate findings to affected plants through a generic or plant-specific communication.