

**On the Unacceptability of the  
25<sup>0</sup>F Embrittlement Exclusion in the  
Beltline Region TLR  
(TLR-RES/DE/CIB-2013-01)**

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# Topics

- Technical Letter Reports
- TLR-RES/DE/CIB-2013-01
- Perspective Related to Excluding  $\Delta T < 25^{\circ}\text{F}$

# Issue

- Industry has taken a conclusion statement (related to exclusion of irradiation embrittlement effects for  $\Delta T < 25^{\circ}\text{F}$ ) from an RES technical letter report (TLR) and implemented it in plant-specific license amendment requests and a generic report as if it is an acceptable “NRC staff position”
- As the NRC has begun to issue requests for additional information on the use of this proposal, there has been confusion by the industry on why its use is not acceptable
- The NRC approved one license amendment request (LAR) with this proposal, which in this case did not affect the acceptability of the LAR
  - The safety evaluation did not explicitly address the unacceptable use of the  $\Delta T < 25^{\circ}\text{F}$  exclusion

# Clarification of TLRs – Purpose, Processes and Significance

- Purpose of RES Technical Letter Reports (TLRs):
  - Provide a status update to NRR for research projects once a critical milestone has been achieved to document research findings, surveys, state-of-the-art assessments, data analysis, etc.
  - Document one part of a large research project that will be integrated with others
- More complete or important information, including conclusions and incorporating NRR review comments, generally are “published” in documents such as formal NUREG and NUREG/CR reports

# Comparisons with NUREG Reports

- Process for NUREGs is established, structured and generally includes extensive internal review – publication is a significant agency action
  - No comparable formal review and issuance process for TLRs
  - Use of TLRs facilitates expedited communication of findings
- NUREGs include disclaimer statement and (for RES reports) a Foreword to provide context to the report
  - TLRs include no comparable provisions
- Historically, NUREGs have been one of the primary means of NRC's communication
  - More recent posting of TLRs as “public” in ADAMS enables easy access
  - This has created confusion on the acceptability, relevance and utility of results made “public” in TLRs

# NRC Staff Regulatory Positions

- NRC staff regulatory positions are provided in regulations, regulatory guides and other formal documents labeled as such
- In general, statements in NUREG reports, NUREG-CRs, TLRs are not NRC staff regulatory positions
- Exceptions include the GALL and GALL-SLR reports, which provide guidance on acceptable aging management programs for license renewal and SLR, respectively

# TLR on RPV Beltline

- TLR-RES/DE/CIB-2013-01, "Evaluation of the Beltline Region for Nuclear Reactor Pressure Vessels," (ML14318A177)
  - Issued November 14, 2014
  - One of a series of planned technical letter reports planned by RES to support a possible 10 CFR Part 50, Appendix G rulemaking
- As stated in Section 4, "the RES staff recommends":
  - Embrittlement effects may be neglected for any region of the RPV if either of the following conditions are met:
    - 1) neutron fluence is less than  $1 \times 10^{17}$  n/cm<sup>2</sup> (E > 1.0 MeV) at EOL, or
    - 2) the mean value of  $\Delta T_{30}$  estimated using an ETC [embrittlement trend curve] acceptable to the staff is less than 25°F at EOL. The estimate of  $\Delta T_{30}$  at EOL shall be made using best-estimate chemistry values."

Item 1) is consistent with Regulations – not an issue.

Item 2) is not consistent with Regulations – a basis for this provision is not provided in the TLR.

# Regulatory Issue Summary 2014-11

## “Information on Licensing Applications for Fracture Toughness Requirements for Ferritic Reactor Coolant Pressure Boundary Components”

- Issued October 14, 2014
- “to provide guidance . . . on the scope and detail of information that should be provided in reactor vessel fracture toughness and associated pressure-temperature (P-T) limits licensing applications”
- “all ferritic components within the entire reactor vessel must be considered in the development of P-T limits, and the effects of neutron radiation must be considered for any locations that are predicted to experience a neutron fluence exposure greater than  $1 \times 10^{17}$  n/cm<sup>2</sup> (E > 1 MeV) at the end of the licensed operating period.”
- No discussion regarding exclusion of embrittlement effects if  $\Delta T_{30}$  is less than 25°F.

# 25<sup>o</sup>F TLR Recommendation

- Basis is not clearly postulated, discussed nor supported in the TLR – first stated in the summary of results with one accompanying graph
- Conflicts with relevant regulations and not consistent with RIS 2014-11

# Relevant Regulations

- 10 CFR 50 Appendix G, II.F – Beltline or Beltline region of reactor vessel means the region of the reactor vessel . . . that are predicted to experience sufficient neutron radiation damage to be considered in the selection of the most limiting material with regard to radiation damage
- 10 CFR 50 Appendix H, III.A – No material surveillance program is required for reactor vessels for which . . . the peak neutron fluence at the end of the design life of the vessel will not exceed  $10^{17}$  n/cm<sup>2</sup> (E > 1 MeV).
- 10 CFR 50 Appendix G, IV.A – For the reactor vessel beltline materials, including welds, plates and forgings, the values of  $RT_{NDT}$  and Charpy upper-shelf energy must account for the effects of neutron radiation

# More Relevant Regulations

- 10 CFR 50.61 – PTS Rule
  - (a)(3) Reactor Vessel Beltline means the region of the reactor vessel . . . that are predicted to experience sufficient neutron radiation damage to be considered in the selection of the most limiting material with regard to radiation damage – same definition as 10 CFR 50, Appendix G
  - (a)(4)  $RT_{NDT}$  means the reference temperature for a reactor vessel material, under any conditions. For the reactor vessel beltline materials,  $RT_{NDT}$  must account for the effects of neutron radiation
  - (a)(7)  $RT_{PTS}$  means the reference temperature,  $RT_{NDT}$ , evaluated for the EOL Fluence for each of the vessel beltline materials, using the procedures of paragraph (c) of this section
  - (c)(1)(iv)  $\Delta RT_{NDT}$  is the mean value of the transition temperature shift, or change in  $RT_{NDT}$ , due to irradiation, and must be calculated using Equation 3.

# More Relevant Regulations

- 10 CFR 50.61a – Alternate PTS Rule
  - (a) Terms in this section have the same meaning as those presented in 10 CFR 50.61(a), with the exception of the term “ASME Code.”
  - (c)(1) Each licensee shall have projected values of  $RT_{MAX-X}$  for each reactor vessel beltline material for the EOL fluence of the material. The assessment of  $RT_{MAX-X}$  values must use the calculation procedures given in paragraphs (f) and (g) of this section.

# More Relevant Regulations

- 10 CFR 50, Appendix H
  - (I) the test procedures and reporting requirements must meet the requirements of ASTM E 185-82 to the extent practicable . . .
- ASTM E 185-82
  - 10.2.1 Determine the radiation induced transition temperature shifts by measuring the difference in the 41-J (30-ft-lbf) . . . index temperatures before and after irradiation. The index temperatures shall be obtained from the average curves.

# Regulatory Guide 1.99, Rev. 2

## Radiation Embrittlement of Reactor Vessel Materials

- The adjusted reference temperature (ART) for each material in the beltline is given by the following expression:
  - $ART = \text{Initial } RT_{NDT} + \Delta RT_{NDT} + \text{Margin (1)}$
- $\Delta RT_{NDT}$  is the mean value of the adjustment in reference temperature caused by irradiation and should be calculated as follows:
  - $\Delta RT_{NDT} = (CF) f^{(0.28 - 0.10 \log f)}$

# Perspective – Part 1

- RES TLR and RIS were under development during the same time frame.
- The 25°F recommendation was included in the RES TLR as a consideration by the RES staff – the regulatory position espoused in the RIS specifically did not include this provision.
- A public comment on GALL-SLR RPV material surveillance program guidance recommended implementation of the 25°F exclusion – this recommendation was rejected by the staff.

# Technical Assessment

- Highest ART (and potential nozzle stresses) define P-T limit curves
  - $ART = \text{Initial } RT_{NDT} + \Delta RT_{NDT} + \text{Margin}$
- Changing shifts of up to 25°F to 0°F results in decreasing ART by up to 50°F, by also reducing the margin term. This can be a significant change.
- In certain cases, the 25°F proposal may impact identification of limiting materials for ART, resulting in development of incorrect (non-conservative) P-T limits.
- Related but not determinative item – Research programs examining neutron fluence (revision of RG 1.190) indicate that fluence projections for extended beltline materials and nozzles may be underpredicted;  $\Delta RT_{NDT}$  would increase for these materials.

# Summary of Regulatory Provisions and Technical Assessment

- Relevant regulations state that calculations must account for radiation effects for those materials with fluence greater than  $10^{17}$  n/cm<sup>2</sup> ( $E > 1$  MeV), as described in RIS 2014-11.
- No provision in any of the regulations permits exclusion of  $\Delta RT_{NDT}$  or  $\Delta T_{30}$  less than 25°F.
- Acceptance of the TLR proposal could result in plant operation with non-conservative P-T limits (Appendix G violation).
- Current view:  
**Disallow elimination of embrittlement effects  
if  $\Delta RT_{NDT}$  or  $\Delta T_{30}$  less than 25°F**

# Perspective – Part 2

- Regulations related to reactor pressure vessel integrity do not permit exclusion of  $\Delta RT_{NDT}$  or  $\Delta T_{30}$  less than 25°F.
- TLR does not provide an adequate technical basis for an exemption from the regulatory requirements.
- Use of all  $\Delta RT_{NDT}$  or  $\Delta T_{30}$  (even  $< 25^\circ\text{F}$ ) is a conservative position to estimate RPV toughness, which has been a longstanding goal.
- Plant submittals and topical reports should not use this provision without an adequate technical basis to support an exemption request or staff approval, as required.
- For prior submittals and industry topical reports:
  - If the resulting P-T limits remain unchanged, supplement with the correct ART value for each RPV beltline material.
  - If the resulting P-T limits change, need to ensure that the correct ART value for each RPV beltline material are used to revise P-T limits in the LAR, and the plant-specific application report.

# Conclusions

- TLR is not an acceptable basis for neglecting embrittlement effects if  $\Delta RT_{NDT}$  or  $\Delta T_{30}$  less than 25°F.
- Current NRC position is described in RIS 2014-11: RPV toughness calculations must account for radiation effects for those materials with fluence greater than  $10^{17}$  n/cm<sup>2</sup> (E > 1 MeV), without exclusion even if  $\Delta RT_{NDT}$  or  $\Delta T_{30}$  less than 25°F.

# Conclusions

- As always, NRC staff is prepared to review any industry proposal which provides an adequate technical basis for the proposal.