Proposed ASME Section XI Code Cases

Changes to Inspection and Flaw Evaluation of CASS PWR Piping Components

DJ Shim, *EPRI-MRP*
Carl Latiolais, *EPRI-NDE*

K. Fuhr, G. White, C. Casarez, and T. Meurer
Dominion Engineering, Inc.

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Outline

- ASME Code Record 23-2033: Inspection of CASS without Axial Flaw Detection Capability
  - Review of Technical Basis
  - Process Overview
  - Proposed Code Case
- ASME Code Record 24-1062: Evaluation of Circumferential Flaws without Crediting Depth Sizing
  - Review of Technical Basis
  - Process Overview
  - Proposed Code Case
- Conclusions

Inspection without Crediting Axial Flaw Detection (ASME Record 23-2033)

MRP-479 Conclusions: Axial Cracking

Background

- **PFM modeling results show that periodic examination to detect axially oriented flaws is unnecessary to ensure pipe structural and leak tight integrity for the following cases:**
  - WEC main loop piping in both base load PWRs and PWRs operating under flexible power operation (FPO)
  - CE surge lines in base load PWRs
- For WEC main loop piping:
  - The analyses show a benefit for significantly reduced fatigue crack growth when the power ramp rate is limited to less than 0.5% per minute for routine loading and unloading operation
- For CE surge lines:
  - The analyses show a benefit for significantly reduced fatigue crack growth when insurge and outsurge events are reduced in frequency
  - Under FPO, there is an increased concern for fatigue crack growth due to the potential for a large number of insurge/outsurge transients to be triggered by FPO power shifts

Periodic examination to detect axially oriented flaws is unnecessary

Overview of Record 23-2033

- Alternative inspection requirements that do not require examinations to detect axial cracking in CASS piping components at circumferential butt welds in the main loop and surge line
  - The Code Case applies to axial flaws in PWSCC-resistant weld material if the beam would need to pass through CASS to examine that volume
  - Examinations still required to be demonstrated to detect axial flaws in PWSCC-susceptible or ferritic material and to detect circumferential flaws
- Scope includes PWR piping and vessel nozzle butt welds with CASS base materials
  - Does not apply to AP-1000 SG to RCP nozzle-to-nozzle weld

ASME Code Action	Date
Review & comment ballot 24-1894 to TG-I	Initiated 6/13
Address comments at TGI	August
Present at WG PQVE, WG ISC, WG PFE	
Potential Letter Ballot (WG PQVE, WG ISC, WG PFE)	Prior to November
Address comments at WG PQVE, WG ISC, WG PFE	November
Present at SG NDE, SG WCS, SG ES	
Potential Letter Ballot (SG NDE, SG WCS, SG ES)	Prior to February
Address comments at SG NDE, SG WCS, SG ES	February
Present at BPV XI	

Red are Review & Comment Ballots

Record 23-2033: Proposed Code Case for Axial Flaws

Alternative Volumetric Examination Requirements for Class 1 PWR Piping and Vessel Nozzle Circumferential Butt Welds with Cast Austenitic Stainless Steel Base Materials

Section XI, Division 1

Inquiry: For Class 1 PWR piping and vessel nozzle circumferential butt welds with cast austenitic stainless steel base materials and categorized under Section XI, Table IWB-2500-1, Examination Category B-F (Item Nos. B5.10, B5.40, or B5.70) or Examination Category B-J (Item No. B9.11) and located in the main loop hot or cold leg piping or in the surge line piping, may volumetric examination of the portions of the examination volume for which the ultrasonic beam must pass through cast austenitic stainless steel base material exclude detection of transverse flaws?

Reply: It is the opinion of the Committee that, for Class 1 PWR piping and vessel nozzle circumferential butt welds with cast austenitic stainless steel base materials and categorized under Section XI, Table IWB-2500-1, Examination Category B-F (Item Nos. B5.10, B5.40, or B5.70)[1] or Examination Category B-J (Item No. B9.11) and located in the main loop hot or cold leg piping or in the surge line piping, with the exception of pressurizer surge line piping components in PWRs operating under flexible power operation, volumetric examination of the portions of the examination volume for which the ultrasonic beam must pass through cast austenitic stainless steel base material may exclude detection of transverse flaws.

However, this code case is not applicable to detection of transverse flaws located in UNS N06082 or UNS W86182 weld filler material, nor in ferritic base material joined to the cast austenitic stainless steel base material with a dissimilar metal weld.

[1] This code case is not applicable to welds directly attaching a component other than a piping system (such as a pump) to a vessel nozzle.

Evaluation of Circumferential Flaws without Crediting Depth Sizing (ASME Record 24-1062)

MRP-479 Conclusions: Circumferential Cracking

- PFM modeling results show that the alternative flaw evaluation methodology that does not rely on depth sizing information ensures pipe structural integrity for one fuel cycle (up to 2 years) of continued operation when applied to circumferential cracking in WEC main loop CASS piping components
  - This methodology does not generically apply to flaws with a full-length (2θ) longer than 32° or to flaws in surge line locations, but a component- or plant-specific analysis may justify its use at these locations
  - Limit of applicability recognizes that the Z-factor approach provides greater margin for shorter flaws
- The assumption of an idealized through-wall crack for both the PFM and modified flaw evaluation methodology addresses the lack of a qualified depth sizing process

Alternative flaw evaluation methodology applies to flaws in main loop piping with total length ≤ 32°

Overview of Record 24-1062

- Proposed Code Case for alternative to IWB-3642 for flaw evaluation requirements for circumferentially oriented flaws in CASS piping components (to address flaw-depth sizing challenge for CASS)
  - Alternative flaw evaluation follows the Nonmandatory Appendix C process, except that a depth (a/t) of 1.0 is assumed
  - Alternative permits acceptance of flaws not demonstrated to have an *a*/*t* less than 0.75, but flaws that are visibly leaking remain unacceptable per IWB-3522
- Scope includes PWR main loop piping and vessel nozzle circumferential butt welds with CASS materials
  - Surge line piping not included

ASME Code Action	Date
Review & comment ballot 24-1894 to TG-I	Initiated 6/13
Address comments at TGI	August
Present at WG PFE, WG PQVE	
Potential Letter Ballot (WG PFE, WG PQVE)	Prior to November
Address comments at WG PFE, WG PQVE	November
Present at SG ES, SG NDE	
Potential Letter Ballot (SG ES, SG NDE)	Prior to February
Address comments at SG ES, SG NDE	February
Present at BPV XI	

Red are Review & Comment Ballots

Record 24-1062: Proposed Code Case for Circumferential Flaws
(1 of 2)

Alternative Circumferential Flaw Evaluation Requirements for Class 1 PWR Piping and Vessel Nozzles with Cast Austenitic Stainless Steel Base Materials

Section XI, Division 1

Inquiry: For Class 1 PWR piping and vessel nozzle circumferential butt welds with cast austenitic stainless steel base materials and categorized under Section XI, Table IWB-2500-1, Examination Category B-F (Item Nos. B5.10 or B5.70) or Examination Category B-J (Item No. B9.11) and located in the large-diameter (greater than NPS 14 (DN 350)) reactor coolant main loop hot or cold leg piping, what alternative to the flaw analytical evaluation procedures of IWB-3642 may be applied for a circumferential flaw for which its depth sizing would require that the ultrasonic beam pass through cast austenitic stainless steel base material?

Reply: It is the opinion of the Committee that, for Class 1 PWR piping and vessel nozzle circumferential butt welds with cast austenitic stainless steel (CASS) base materials and categorized under Section XI, Table IWB-2500-1, Examination Category B-F (Item Nos. B5.10 or B5.70)[1] or Examination Category B-J (Item No. B9.11) and located in the large-diameter (greater than NPS 14 (DN 350)) reactor coolant main loop hot or cold leg piping, the following may be applied as an alternative to IWB-3642 for a circumferential flaw for which its depth sizing would require that the ultrasonic beam pass through cast austenitic stainless steel base material:

(a) Piping containing flaws for which the acceptance standards of IWB-3514 are not shown to be satisfied may be analytically evaluated using procedures described in Nonmandatory Appendix C as modified by this Code Case and is acceptable for continued service during the evaluated time period when the critical flaw parameters satisfy the criteria in Nonmandatory Appendix C as modified by this Code Case. Flaw acceptance criteria are based on allowable flaw length or allowable stress. Circumferential flaws with total angular extent greater than 32 degrees (0.559 radians) are unacceptable. This code case is not applicable to evaluation of flaws located in UNS N06082 or UNS W86182 weld filler material, nor in ferritic base material joined to the cast austenitic stainless steel base material with a dissimilar metal weld.

(b) The time period of continued service prior to reexamination, repair/replacement activity, or corrective measure shall be no greater than the time until the next refueling outage.

(c) The procedures and acceptance criteria of Nonmandatory Appendix C shall be applied with the following modifications:

[1] *This code case is not applicable to welds directly attaching a component other than a piping system (such as a pump) to a vessel nozzle.*

Record 24-1062: Proposed Code Case for Circumferential Flaws

(2 of 2)

...

(1) In C-2200 "Flaw Shape," circumferential flaws shall conservatively be evaluated as a circumferential planar through-wall area that completely bounds the flaw, as illustrated by Figure 1. As in C-2200, the flaw half-angle, θ, is defined to encompass half of the maximum circumferential extent of the flaw. The flaw depth, a, shall be conservatively assumed to equal the wall thickness, t. The flaw length, ℓ, shall completely bound the detected flaw as projected radially to the outside surface. These modifications to the flaw shape characterization shall apply for the purposes of calculating subcritical crack growth and evaluating fracture.

(2) Instead of C-2610 "Acceptance Criteria," piping containing flaws exceeding the acceptance standards and analytically evaluated is acceptable for continued service during the evaluated time period if the critical flaw parameters satisfy the criteria in C-2612. The procedure of C-2611 that considers flaw depth shall not be applied.

(3) In C-3200 "Subcritical Flaw Growth Analysis," the flaw growth calculation shall be performed conservatively assuming a through-wall flaw in accordance with *(1)*. The final flaw length, ℓ_f, at the end of the evaluation period shall be determined by consideration of subcritical flaw growth.

(4) In C-5300 "Circumferential Flaws," instead of C-5300(a), (b), and (c), analytical equations for allowable pipe stresses given in C-5320 shall be solved using specified or measured (when available) material properties to determine the allowable end-of-evaluation-period flaw length.

(5) When applying C-5321 and C-5322, a value of 1.0 for a/t shall be used. The limit of applicability is extended to a/t = 1.0.

(6) In C-6300 "Circumferential Flaws," instead of C-6300(a), (b), and (c), analytical equations for allowable pipe stresses given in C-6320 shall be solved using Z-factors given in C-6330 to determine the allowable end-of-evaluation-period flaw length.

(7) When applying C-6321 and C-6322, a value of 1.0 for a/t shall be used when calculating σ_b^c from C-5320. The limit of applicability is extended to a/t = 1.0.

(8) Additionally, the final length of the circumferential flaw shall meet the following constraint:

$$\theta_f \leq 16\frac{\pi}{180}$$

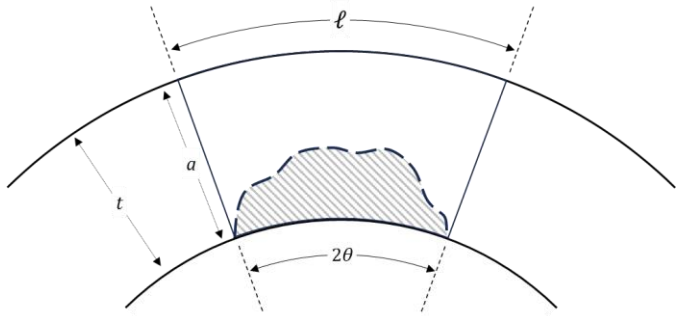
where

θ_f = final half-angle of the flaw at the end of the evaluation period, expressed as $\theta_f = \ell_f/D$

ℓ_f = final flaw length at the end of the evaluation period

D = outside diameter of piping

Figure 1
Flaw Characterization — Circumferential Flaws Without Qualified Depth Sizing Information for Class 1 PWR Piping and Vessel Nozzles with Cast Austenitic Stainless Steel Base Materials

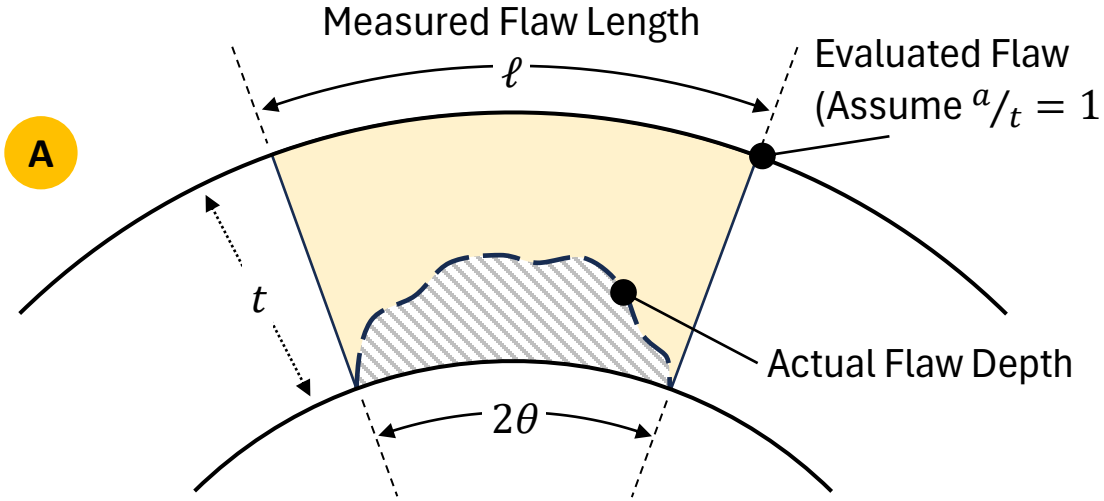


Record 24-1062: Summary

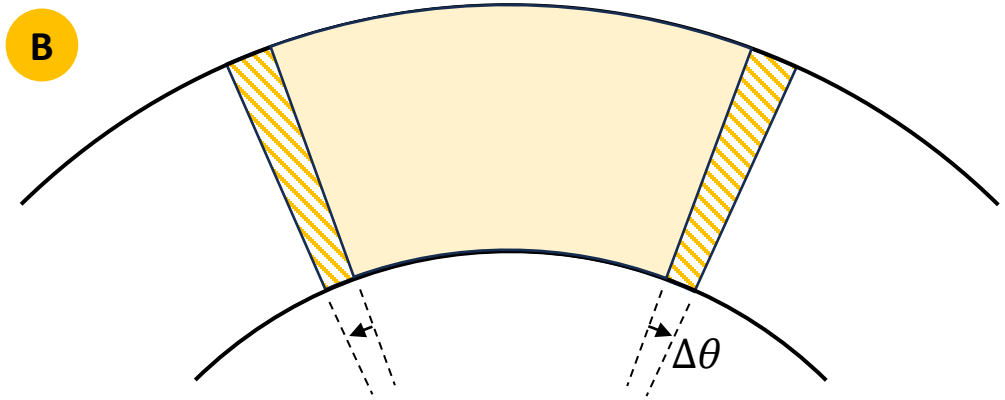
(*a*) Discusses Code Case scope

(*b*) Limits evaluation period duration to until next refueling outage

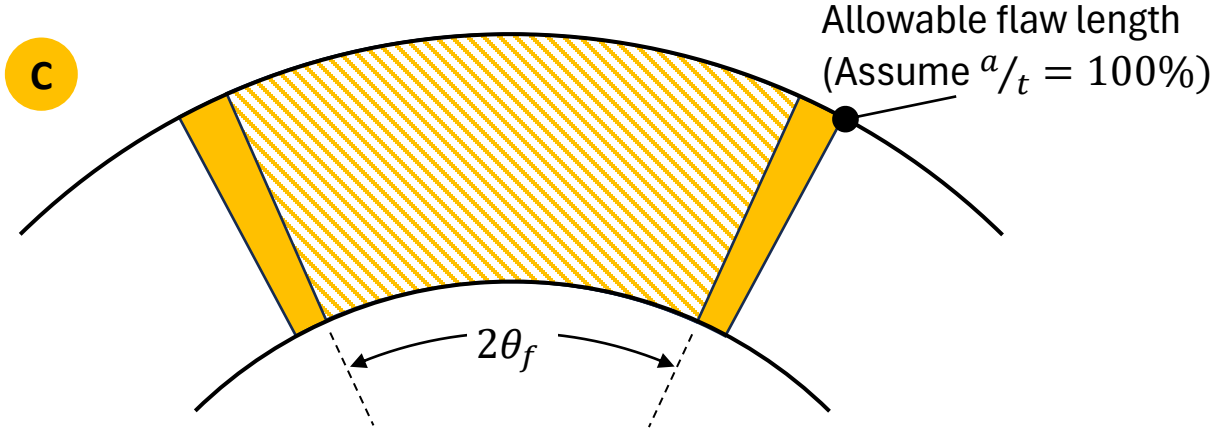
(*c*) Provides modifications to Nonmandatory Appendix C approach as shown by these figures



Consistent with (*c*)(*1*), characterize the flaw as a circumferential planar through-wall flaw bounding the measured flaw length (per qualified procedure)



Obtain predicted end-of-evaluation-period flaw length ($\theta_f = \theta + \Delta\theta$), with growth per IWB-3641(d) and consistent with (*c*)(*3*), for an evaluation period no longer than until the next refueling outage, consistent with (*b*)



Calculate allowable flaw angle per C-6320 as modified by (*c*)(*4*), -(*5*), -(*6*), and -(*7*) such that $^{a}/_{t} = 1.0$

Consistent with (*c*)(*2*), compare allowable flaw angle versus end-of-evaluation-period flaw length to determine acceptability of detected flaw; as required by (*c*)(*8*), $2\theta_f$ must also be $\leq 32°$

Conclusions

Upcoming ASME Code Plans

- Support consideration of the proposed Code Cases by the ASME process
- Develop Section XI, Mandatory Appendix VIII, Supplement 9
- In the longer term:
  - Fold axial Code Case (Record 23-2033) Alternative into IWB-2500
  - Fold circumferential Code Case (Record 24-1062) Alternative into IWB-3640

Conclusions

- Developing new ASME Code Cases to provide alternate requirements for CASS piping
  - ASME Record 23-2033 proposes a Code Case to exclude applicable CASS locations from requirement to detect axially oriented flaws during volumetric examinations
  - ASME Record 24-1062 proposes a Code Case implementing an alternative to IWB-3642 for flaw evaluation of circumferentially oriented flaws without crediting depth sizing capability
  - EPRI report 3002023893 (MRP-479) provides technical basis for both ASME Records 23-2033 and 24-1062
    - Freely downloadable at: https://www.epri.com/research/products/000000003002023893
- Review and comment ballot currently open for TG-Inspectability
- Plan to open letter ballots after August Code Week
  - ASME Record 23-2033 to be balloted with WG PQVE and WG ISC
  - ASME Record 24-1062 to be balloted with WG PFE

Questions?

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