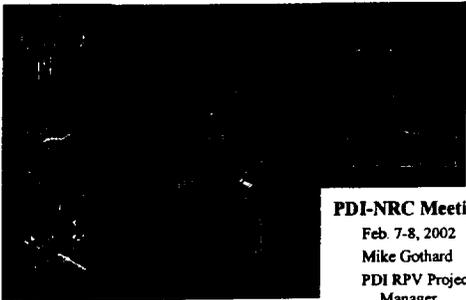


PDI - Reactor Pressure Vessel



PDI-NRC Meeting
Feb. 7-8, 2002
Mike Gothard
PDI RPV Project
Manager

RPV Expansion - Generic Procedure - 11" t

◆ **RPV Extension - 11" t**

- Current technique appears viable.
 - Positives
 - Specified 60° RL probe has a large depth-of-field.
 - Negatives
 - Much longer scan distances (impacts qualification times).
- Treating as extension unless it's a new personnel qualification.



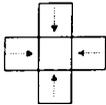
RPV Expansion - Generic Procedure - SSA

◆ **Single Side Access - BWR**

- Supplement 4 and 6 - 6.88" t sample.
 - Complete for Appendix VIII single side access.
- Thanks to TVA, PP&L, EXELON, and GE.

◆ **Issues**

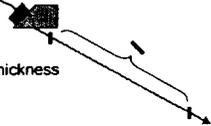
- False Calls based on scan area.
 - Code Inquiries prepared for Supplement 4 and 6 for December Code meeting, re-submitted in February as inquiry & Code Case.
- 11" thick samples remain.
- Treating as new personnel qualification.
- Applicability considerations (discussed later).
- Off-axis (45°) Flaws.



RPV Expansion - Generic Procedure - Off-Axis

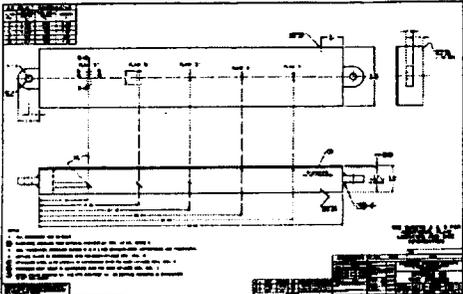
◆ **Off-axis flaw**

- 10CFR50...(G)(2) if the clad-to-base-metal-interface procedure demonstrates detectability of flaws with a tilt angle relative to the weld centerline of at least 45 degrees, the remainder of the examination volume is considered fully examined if coverage is obtained in one parallel and one perpendicular direction.
- Generic Procedure PDI-UT-6, using only a 60° Refracted Longitudinal is proven capable of detecting planar (+/- 10°) flaws throughout a 6.88 inch thick component.
- Can it detect 45° off-axis flaws?
- Since technique doesn't change with thickness should be able to test capability at any point in the qualified thickness range.



RPV Expansion - Generic Procedure - Off-Axis

◆ **Off-axis Block**



RPV Expansion - Generic Procedure - Off-Axis

◆ **Off-axis Manual Data**

Flaw	Amplitude				Size						
	Based on procedure BCAN		Based on SEN DAC		Depth			Length			
	Min. Opt. Side	Opt. Side	Min. Opt. Side	Opt. Side	Min. Opt. Side	Opt. Side	Trunk	% t	Min. Opt. Side	Opt. Side	Trunk
A	178% D	224% D	37%	42%	30"	30"	0.27"	18.6%	1.5"	2.2"	3.6"
B	333% D	155% D	77%	77%	77"	40"	0.68"	18.3%	1.5"	2.0"	3.0"
C	178% D	316% D	37%	62%	30"	16"	0.15"	4.3%	1.4"	1.4"	1.22"
D	80% F	119% F	18%	30%	30"	16"	0.090"	2.3%	1.1"	1.1"	0.88"
E	141% F	125% F	17%	17%	30"	34"	0.12"	3.3%	1.2"	1.2"	1.11"

D = ¼ DAC - 141 SCM @90% FSH +14db
F = ¼ FSH - 30% clad roll

- Worst case is Flaw D in Non-optimum direction.
- S/N ratio is 4:1 exceeding the procedures recording criteria of 3:1

FDI RPV Expansion - Generic Procedure - Off-Axis

♦ Off-axis Automated Data

Non-Optimum Optimum

FDI Nozzle ICR Qualifications

♦ Nozzle Inside Corner Region

- I.D. Qualifications
 - Supplement 5
- O.D. Qualifications
 - Code Case N-552 (Modeling)
- Issues (See next slides)

FDI Nozzle ICR Qualifications (Cont.)

♦ Other Considerations for Nozzle ICR Qualifications

- Code Case N-552 addresses the misorientation angle and metal path, but not the beam angle at the flaw?
- Code Inquiry prepared for December Meeting - Task group requested additional justification/information, to be provided in February.
- VIII-2100(d)(2)(b) specifies the nominal inspection angle as an essential variable. For ICR examinations this only has meaning when related to the flaw.

FDI Nozzle ICR Qualifications (Cont.)

♦ Other Considerations for Nozzle ICR Qualifications (Continued).

- Verification of incident and skew angle for compound angle blend radius search units.

FDI Nozzle Weld Qualifications

♦ Nozzle-to-Shell Weld From the I.D. - Bore

- 100% T
- Supplement 7 (as modified by 10CFR50...(K)(1)(i,ii,iii)).
- Issues - From a Vendor
- Can bore exam be used for coverage of flaws perpendicular to the weld, in accordance with 10CFR50...(xvi)(A)?
- Supplement 7 only references Supplement 6 as prerequisite

FDI Nozzle Weld Qualifications (Continued)

(i) For examination of nozzle-to-vessel welds conducted from the bore, the following provisions are required to qualify the procedures, equipment, and personnel:

(i) For detection, a minimum of four flaws in one or more full-scale nozzle mock-ups must be added to the test set. The specimens must comply with Supplement 6, Paragraph 1.1, to Appendix VIII, except for flaw locations specified in Table VIII S6-1. Flaws may be either notches, fabrication flaws or cracks. Seventy five percent of the flaws must be cracks or fabrication flaws. Flaw locations and orientations must be selected from the choices shown in §50.55a(b)(2)(xv)(K)(4), Table VIII-S7091-Modified, except flaws perpendicular to the weld are not required. There may be no more than two flaws from each category, and at least one subsurface flaw must be included.

(ii) For length sizing, a minimum of four flaws as in §50.55a(b)(2)(xv)(K)(1)(i) must be included in the test set. The length sizing results must be added to the results of combined Supplement 4 to Appendix VIII and Supplement 6 to Appendix VIII. The combined results must meet the acceptance standards contained in §50.55a(b)(2)(xv)(E)(3)

(iii) For depth sizing, a minimum of four flaws as in §50.55a(b)(2)(xv)(K)(1)(i) must be included in the test set. Their depths must be distributed over the ranges of Supplement 4, Paragraph 1.1, to Appendix VIII, for the inner 15 percent of the wall thickness and Supplement 6, Paragraph 1.1, to Appendix VIII, for the remainder of the wall thickness. The depth sizing results must be combined with the sizing results from Supplement 4 to Appendix VIII for the inner 15 percent and to Supplement 6 to Appendix VIII for the remainder of the wall thickness. The combined results must meet the depth sizing acceptance criteria contained in §§50.55a(b)(2)(xv)(C)(1), 50.55a(b)(2)(xv)(E)(1), and 50.55a(b)(2)(xv)(F)(3)

FDI
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Nozzle Weld Qualifications (Continued)

(G) When applying Supplement 4 to Appendix VIII, Supplement 6 to Appendix VIII, or combined Supplement 4 and Supplement 6 qualification, the following additional provisions must be used, and examination coverage must include:

- (1) The clad to base metal interface, including a minimum of 15 percent T (measured from the clad to base metal interface), shall be examined from four orthogonal directions using procedures and personnel qualified in accordance with Supplement 4 to Appendix VIII. (The reason for the following question)
- (2) If the clad-to-base-metal-interface procedure demonstrates detectability of flaws with a tilt angle relative to the weld centerline of at least 45 degrees, the remainder of the examination volume is considered fully examined if coverage is obtained in one parallel and one perpendicular direction. This must be accomplished using a procedure and personnel qualified for single-side examination in accordance with Supplement 6. Subsequent examinations of this volume may be performed using examination techniques qualified for a tilt angle of at least 10 degrees.

(xvi) Appendix VIII single side ferritic vessel and piping and stainless steel piping examination.

(A) Examinations performed from one side of a ferritic vessel weld must be conducted with equipment, procedures, and personnel that have demonstrated proficiency with single side examinations. To demonstrate equivalency to two sided examinations, the demonstration must be performed to the requirements of Appendix VIII as modified by this paragraph and §§50.55a(b)(2)(xv)(B) through (G). (Does this imply Supplement 7 with single side access?) on specimens containing flaws with non-optimum sound energy reflecting characteristics (Does this imply Supplement 7 with off-axis flaws?) or flaws similar to those in the vessel being examined.

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Nozzle Weld Qualifications (Continued)

◆ **Nozzle-to-Shell Weld From the I.D. - Vessel Shell**

- Part 1 - Inner 15% T
 - Supplement 4 in 4 orthogonal directions
 - augmented by Supplement 7 bore exam if needed for 4 direction coverage
- Issue -
 - What if 4 direction coverage not achievable? RFR?
 - Other? Supplement 4 Single Side Access? Does this exist?
- Part 2 - Outer 85% T
 - Supplement 7 Bore Exam, or
 - Supplement 6 with Single Side Access (Radial scan only?)
- Issue - How does 10CFR50...(G) fit in? See following slides

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Nozzle Weld Qualifications (Continued)

(2) For examination of reactor pressure vessel nozzle-to-vessel welds conducted from the inside of the vessel,

- (i) The clad to base metal interface and the adjacent examination volume to a minimum depth of 15 percent T (measured from the clad to base metal interface) must be examined from four orthogonal directions using a procedure and personnel qualified in accordance with Supplement 4 to Appendix VIII as modified by §§50.55a(b)(2)(xv)(B) and 50.55a(b)(2)(xv)(C).
- (ii) When the examination volume defined in §50.55a(b)(2)(xv)(K)(2)(i) cannot be effectively examined in all four directions, the examination must be augmented by examination from the nozzle bore using a procedure and personnel qualified in accordance with §50.55a(b)(2)(xv)(K)(1).
- (iii) The remainder of the examination volume not covered by §50.55a(b)(2)(xv)(K)(2)(i) or a combination of §50.55a(b)(2)(xv)(K)(2)(i) and §50.55a(b)(2)(xv)(K)(2)(ii), must be examined from the nozzle bore using a procedure and personnel qualified in accordance with §50.55a(b)(2)(xv)(K)(1), or from the vessel shell (Radial Scan only ?) using a procedure and personnel qualified for single sided examination in accordance with Supplement 6 to Appendix VIII, as modified by §§50.55a(b)(2)(xv)(D), 50.55a(b)(2)(xv)(E), 50.55a(b)(2)(xv)(F), and 50.55a(b)(2)(xv)(G).

FDI
PERFORMANCE
INITIATIVE

Nozzle Weld Qualifications (Continued)

(G) When applying Supplement 4 to Appendix VIII, Supplement 6 to Appendix VIII, or combined Supplement 4 and Supplement 6 qualification, the following additional provisions must be used, and examination coverage must include:

- (1) The clad to base metal interface, including a minimum of 15 percent T (measured from the clad to base metal interface), shall be examined from four orthogonal directions using procedures and personnel qualified in accordance with Supplement 4 to Appendix VIII. (Prerequisite requirement ?)
- (2) If the clad-to-base-metal-interface procedure demonstrates detectability of flaws with a tilt angle relative to the weld centerline of at least 45 degrees (prerequisite requirement ?), the remainder of the examination volume is considered fully examined if coverage is obtained in one parallel and one perpendicular direction (Radial Scan only ?). This must be accomplished using a procedure and personnel qualified for single-side examination in accordance with Supplement 6. Subsequent examinations of this volume may be performed using examination techniques qualified for a tilt angle of at least 10 degrees.
- (3) The examination volume not addressed by §50.55a(b)(2)(xv)(G)(1) is considered fully examined if coverage is obtained in one parallel and one perpendicular direction, (Radial Scan only ?) using a procedure and personnel qualified for single sided examination when the provisions of §50.55a(b)(2)(xv)(G)(2) are met.
- (4) Where applications are limited by design to single side access, credit may be taken for the full volume provided the examination volume is covered from a single direction perpendicular to the weld and the weld volume is examined from at least one direction parallel to the weld (Radial Scan only ?).

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INITIATIVE

Nozzle Weld Qualifications (Continued)

◆ **Nozzle-to-Shell Weld From the O.D.**

- Part 1 - Inner 15% T
 - Supplement 4 in one radial direction
- Issue - Supplement 4 qualified for single side access?
 - Supplement 4 in two opposing circumferential directions with Code Case N-552 (Modeling) as a mandatory option?
- Part 2 - Outer 85% T
 - Supplement 6 with Single Side Access in one radial direction
- Issues - How does 10CFR50...(G) fit in?



FDI
PERFORMANCE
INITIATIVE

Nozzle Weld Qualifications (Continued)

(2) For examination of reactor pressure vessel nozzle-to-shell welds conducted from the outside of the vessel,

- (i) The clad to base metal interface and the adjacent metal to a depth of 15 percent T, (measured from the clad to base metal interface) must be examined from one radial and two opposing circumferential directions using a procedure and personnel qualified in accordance with Supplement 4 to Appendix VIII, as modified by §§50.55a(b)(2)(xv)(B) and 50.55a(b)(2)(xv)(C), for examinations performed in the radial direction, and Supplement 5 to Appendix VIII, as modified by §50.55a(b)(2)(xv)(1), for examinations performed in the circumferential direction.
- (ii) The examination volume not addressed by §50.55a(b)(2)(xv)(K)(2)(i) must be examined in a minimum of one radial direction using a procedure and personnel qualified for single sided examination in accordance with Supplement 6 to Appendix VIII, as modified by §§50.55a(b)(2)(xv)(D), 50.55a(b)(2)(xv)(E), 50.55a(b)(2)(xv)(F), and 50.55a(b)(2)(xv)(G).



Nozzle Weld Qualifications (Continued)

(G) When applying Supplement 4 to Appendix VIII, Supplement 6 to Appendix VIII, or combined Supplement 4 and Supplement 6 qualification, the following additional provisions must be used, and examination coverage must include:

- (1) The clad to base metal interface, including a minimum of 15 percent T (measured from the clad to base metal interface), shall be examined from four orthogonal directions using procedures and personnel qualified in accordance with Supplement 4 to Appendix VIII. (Not Applicable ?)
- (2) If the clad-to-base-metal-interface procedure demonstrates detectability of flaws with a tilt angle relative to the weld centerline of at least 45 degrees (prerequisite requirement for Supplement 4 ?), the remainder of the examination volume is considered fully examined if coverage is obtained in one parallel and one perpendicular direction (Radial Seam only ?). This must be accomplished using a procedure and personnel qualified for single-side examination in accordance with Supplement 6. Subsequent examinations of this volume may be performed using examination techniques qualified for a tilt angle of at least 10 degrees.
- (3) The examination volume not addressed by §50.55a(b)(2)(xv)(G)(1) is considered fully examined if coverage is obtained in one parallel and one perpendicular direction, (Radial Seam only ?) using a procedure and personnel qualified for single sided examination when the provisions of §50.55a(b)(2)(xv)(G)(2) are met.
- (4) Where applications are limited by design to single side access, credit may be taken for the full volume provided the examination volume is covered from a single direction perpendicular to the weld and the weld volume is examined from at least one direction parallel to the weld (Radial Seam only ?).



Code Related Activities

◆ Code Activities

- Using PDI Qualified procedures on unclad components
 - Code Case prepared and through SG NDE #15
- Supplement 4 and 6 False calls
 - Code inquiry revised to better reflect "intent" question SG NDE # 16 and 17 - Code Case prepared to run in parallel
- Include CRC as "in course of preparation" and revise Appendix III
 - Inquiry revised to include comments SG NDE # 18
- Code Case N-654 - Published in 2002 and next Code Case ????
- Code Case N-613 - Recommend conditional acceptance in DG 1091
- Code Case N-648 - Recommend conditional acceptance in DG 1091 and exclusion from DG 1112
- Supplement 10 - Submit revision as Code Case/Change in February
- Supplement XX - Submit new Supplement on Coord. Imp. of Supp 2, 3, and 10 as Code Case/Change in February