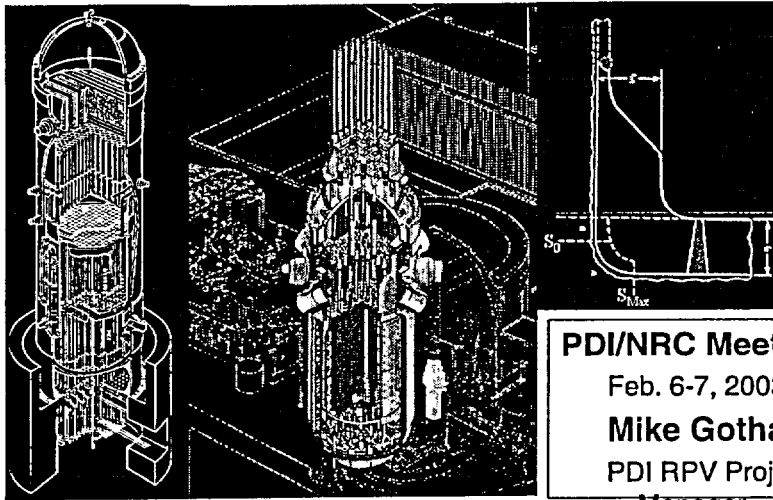




## PDI - Reactor Pressure Vessel Project



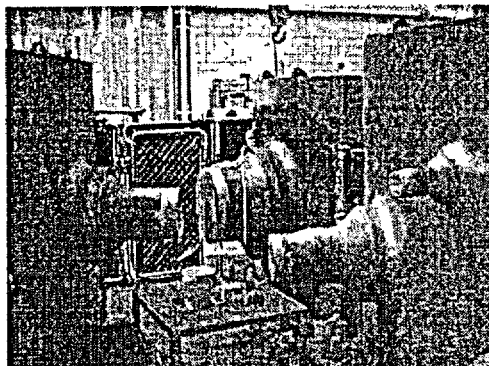
**PDI/NRC Meeting**  
Feb. 6-7, 2003  
**Mike Gothard**  
PDI RPV Project  
Manager



## Status of RPV Demonstration Program

### ▼ Introduction

- Supplement 5.
  - Nozzle inside radius section.
- Supplement 7.
  - Nozzle to vessel welds.
- Relate above to:
  - ID examinations.
  - OD examinations.
  - Manual.
  - Automated.
  - Procedures.
  - Personnel.
- Thickness expansions.

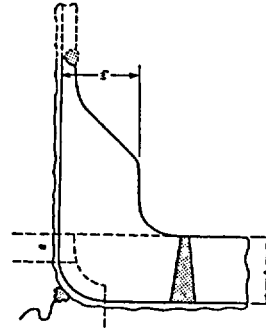




## Status of RPV Demonstration Program

### ▼ Supplement 5 – From the ID (PWR)

- Most utilities electing to do enhanced VT-1 exams.
- Little activity.



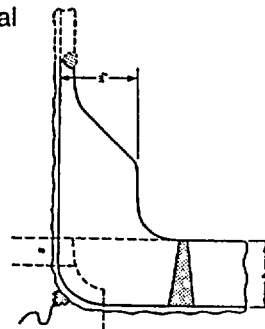
Nozzle Inside Radius Section



## Status of RPV Demonstration Program

### ▼ Supplement 5 – From the ID (PWR)

- One vendor collected automated conventional and phased array data.
  - Testing starts in March.



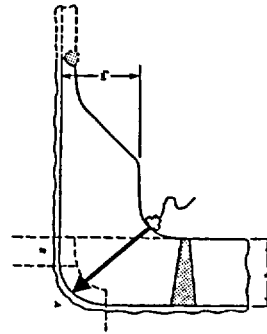
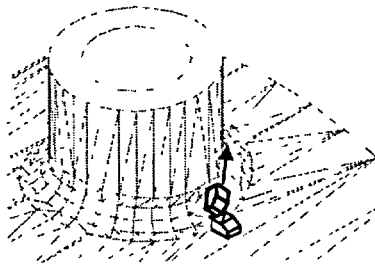
Nozzle Inside Radius Section



## Status of RPV Demonstration Program

### ▼ Supplement 5 – From the OD (BWR)

- Code Case N-552 per 10CFR50.55a...(xv)(J).
- Compound curvature requires modeling.



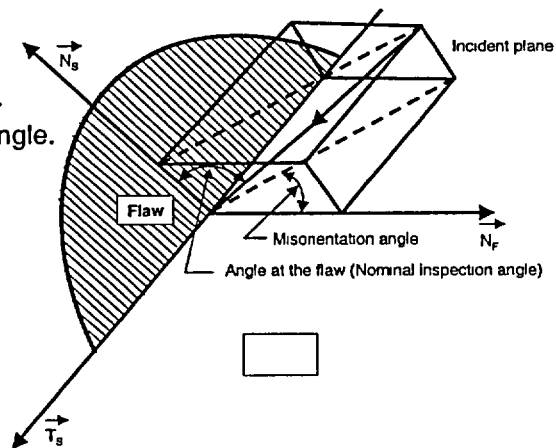
Nozzle Inside Radius Section



## Status of RPV Demonstration Program

### ▼ Supplement 5 – From the OD (BWR)

- Modeling establishes:
  - Misorientation angle.
  - Maximum metal path.
  - Nominal inspection angle.

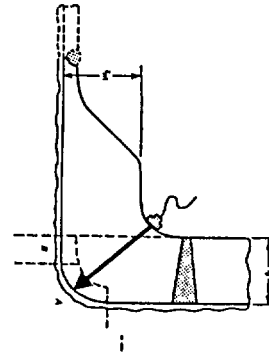




## Status of RPV Demonstration Program

### ▼ Supplement 5 – From the OD (BWR)

- One vendor qualified automated.
  - Detection – 5 individuals.
  - Sizing – 4 individuals.
- One vendor qualified manually.
  - Detection – 6 individuals.
  - Sizing – 2 individuals.
- One vendor qualified manually.
  - Detection – 3 individuals.
  - Sizing – In process.
- Additional vendor qualified manually
  - Detection - 3 individuals.
  - Sizing – In process.



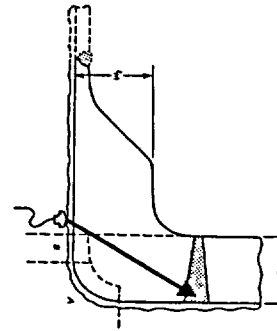
Nozzle Inside Radius Section



## Status of RPV Demonstration Program

### ▼ Supplement 7 – From the ID (PWR)

- Augmented examination to obtain 4 direction coverage in the inner 15% and radial coverage in outer 85%.



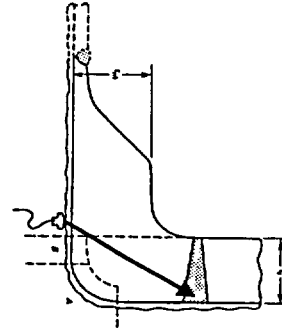
Nozzle to vessel weld



## Status of RPV Demonstration Program

### ▼ Supplement 7 – From the ID (PWR)

- One vendor qualified automated.
  - Detection – 6 individuals.
  - Sizing – 6 individuals.
- One vendor acquired automated conventional and phased array data.



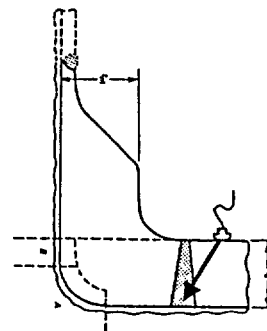
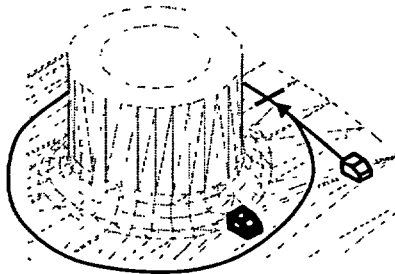
Nozzle to vessel weld



## Status of RPV Demonstration Program

### ▼ Supplement 7 – From the OD (BWR)

- Code Case N-552 – Extension of Supplement 5 Qualification for inner 15% circumferential scans. Compound curvature requires modeling.



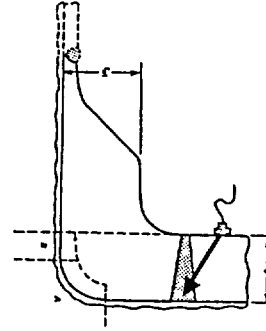
Nozzle to vessel weld



## Status of RPV Demonstration Program

### ▼ Supplement 7 – From the OD (BWR)

- One vendor qualified automated
  - Detection – 5 individuals.
  - Sizing – 4 individuals.
- One vendor qualified manually.
  - Detection – 6 individuals.
  - Sizing – 2 individuals.
- One vendor qualified manually.
  - Detection – 3 individuals.
  - Sizing – In process.
- Additional vendor qualified manually.
  - Detection – 3 individuals.
  - Sizing – In process.



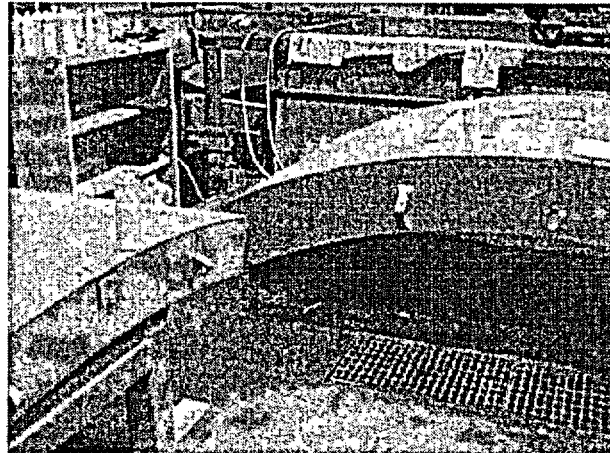
Nozzle to vessel weld



## Status of RPV Demonstration Program

### ▼ Supplement 4 and 6 OD Thickness Expansion

- 6.88" to 11.07"
- One vendor
  - Automated.
  - Detection.
  - Sizing.
  - Single side access.





## RPV Related Code Activities

### ◆ Current Activities

- Addressed CRC in Appendix VIII as “in course of preparation” and revising Appendix III as appropriate
- Revised Supplement 4 and 6 false call requirements
- Included clad/unclad into Appendix VIII, Supplement 6

### ◆ Future activities

- Revise Supplement 5 to address modeling (CC N-552) and include lessons learned
- Revise Supplement 7 to address augmented bore qualification, modeling, and include lessons learned



## Piping Related Code Activities

### ◆ Current Activities

- Revised Supplement 10 to include:
  - Alternative flaw mechanisms
  - Revision of sample set composition
- Created Supplement 14 to address coordinated ID qualification for DM, SS, and Fe

### ◆ Future activities

- Revise Supplement 11 to update WOR requirements

# Coverage Requirements for the BWR RPV Nozzle to Shell Weld

Presentation to NRC

February 6, 2003

Larry Becker

EPRI NDE Center



# Nozzle-to-Shell Coverage

- Background
  - PDI program for nozzle-to-shell welds discussed and agreed to during Code and NRC review process.
  - Recent NRC interpretations indicate that the outer 85% of the nozzle-to-shell weld should be examined using at least one examination direction perpendicular and one direction parallel to the weld for flaws using the procedures qualified to Supplement 6 (RPV shell welds).
  - The current procedures are qualified to Supplement 6 and also qualified to detect flaws perpendicular to the weld in the inner 15% of the nozzle to shell weld.

- PDI program does not address transverse flaws in the outer 85% of RPV nozzle-to-shell weld. This is supported by Table VIII-S7-1 in 10CFR50.55a(b)(2)(xv)(K)(4), i.e., flaws perpendicular to the weld in the outer 85% are not included in the qualification.
- “flaws perpendicular to the located in the outer eighty-five (85) percent of the weld are not required to be included in the qualification test sample.” Federal Register/ Vol. 67, No. 187 /Thursday September 26, 2002, p 60533 and p 60541.

# Coverage

- PDI believes that the procedures qualified to the PDI Program meet the requirements of 10CFR50.55a and the ASME Code Appendix 1 and Appendix VIII.

# Coverage

- Supplement 6 procedures are not applicable for circumferential scanning of the nozzle to shell weld examined from the outside surface. This is supported by 10CFR .... (K)(3)(i) which recognizes Supplement 5 as the appropriate qualification for transverse flaws on the inner 15% of the vessel.
- Sub paragraph (K)(3)(ii) states that for the outer 85% only one radially inward scan for flaws parallel to the weld is required and should be qualified according to Supplement 6. This is being accomplished and is included in the qualification process.

performance of the examinations in Item E1.11 of Table IWE-2500-1 must be examined using the VT-3 examination method. Flaws or degradation identified during the performance of a VT-3 examination must be examined in accordance with the VT-1 examination method. The criteria in the material specification or IWB-3517.1 must be used to evaluate containment bolting flaws or degradation. As an alternative to performing VT-3 examinations of containment bolted connections that are disassembled during the scheduled performance of Item E1.11, VT-3 examinations of containment bolted connections may be conducted whenever containment bolted connections are disassembled for any reason.

*Paragraph (b)(2)(ix)(I).* This paragraph requires that the UT examination acceptance standard specified in the 1997 Addenda, 1998 Edition, 1999 Addenda, and 2000 Addenda of IWE-3511.3 for Class MC pressure-retaining components also apply to metallic liners of Class CC pressure-retaining components.

*Paragraph (b)(2)(xi).* This paragraph extends the applicability of the existing regulation on the use of IWB-1220 to the 1997 Addenda, 1998 Edition, 1999 Addenda, and 2000 Addenda of Section XI of the ASME BPV Code. Licensees using editions and addenda later than the 1989 Addenda of Section XI are prohibited from exempting components from volumetric and surface examination as allowed by IWB-1220.

*Paragraph (b)(2)(xii).* This paragraph prohibits the use of the irradiated material underwater weld provisions in the 1997 Addenda, 1998 Edition, 1999 Addenda, and 2000 Addenda of IWA-4660. Licensees must obtain NRC authorization in accordance with § 50.55a(a)(3) of the method used to weld irradiated material underwater.

*Paragraph (b)(2)(xiv).* This paragraph allows 8 hours of annual practice as described in VII-4240 of Supplement VII of Section XI, 1999 Addenda and 2000 Addenda, to be performed in place of the existing hands-on training requirement in paragraph (b)(2)(xiv), provided that the supplemental practice is performed on material or welds that contain cracks, or by analyzing prerecorded data from material or welds that contain cracks. In either case, training must be completed no earlier than 6 months prior to performing ultrasonic examinations at a licensee's facility.

*Paragraph (b)(2)(xv).* This paragraph extends the applicability of the existing regulations on Appendix VIII specimen set and qualification requirements to the

1997 Addenda, 1998 Edition, 1999 Addenda, and 2000 Addenda of Section XI of the ASME BPV Code. Licensees choosing to use these modifications are required to apply all the modifications under paragraph (b)(2)(xv) except for those in (b)(2)(xv)(F) which are optional.

*Paragraphs (b)(2)(xv)(A), (A)(1), and (A)(2).* These paragraphs update the UT examination coverage criteria to include examination coverage criteria for dissimilar metal piping welds when using personnel, procedures and equipment that are qualified in accordance with Supplement 10 of Appendix VII to Section XI. Dissimilar metal welds must be examined axially and circumferentially. Where examination from both sides is not possible on dissimilar metal welds, full coverage credit from a single side may be claimed only after completing a successful single-sided Appendix VIII demonstration using flaws on the opposite side of the weld. Dissimilar metal weld qualifications must be demonstrated from the austenitic side of the weld and may be used to perform examinations from either side of the weld.

*Paragraph (b)(2)(xv)(G)(4).* Paragraph (b)(2)(xv)(G)(4) is removed. This requirement is redundant given the requirement in paragraph (b)(2)(xv)(G)(3) and is unnecessary. As a result, this revision involves no substantive change.

*Paragraph (b)(2)(xv)(K)(1)(i).* This paragraph clarifies that flaws perpendicular to the weld located in the outer eighty-five (85) percent of the weld are not required to be included in the qualification test sample. The revision neither increases nor decreases current requirements, but clarifies conflicting requirements that currently exist.

*Paragraph (b)(2)(xv)(M).* This paragraph clarifies that only the provisions in Supplement 12 to Appendix VIII that are related to the coordinated implementation of Supplement 3 to Supplement 2 performance demonstrations are required to be implemented.

*Paragraph (b)(2)(xvii).* This paragraph extends the applicability of the existing regulation on reconciliation of quality requirements to the 1997 Addenda, 1998 Edition, 1999 Addenda, and 2000 Addenda of Section XI of the ASME BPV Code. Licensees using IWA-4200 of this edition and these addenda are required to procure replacement and repair items under its approved quality assurance program required by Appendix B of 10 CFR 50. The limitation does not permit licensees to use IWA-4200 to procure repair and

replacement items to be used in ASME Code safety-related applications that are manufactured under a non-nuclear code or non-nuclear standard without an approved quality assurance program.

*Paragraph (b)(2)(xviii)(A).* This paragraph requires that Level I and II NDE personnel be recertified on a 3-year interval in lieu of the 5-year interval specified in IWA-2314.

*Paragraph (b)(2)(xviii)(B).* This paragraph requires that IWA-2316 may only be used to qualify personnel that observe for leakage during system leakage and hydrostatic tests conducted in accordance with IWA-5211(a) and (b).

*Paragraph (b)(2)(xviii)(C).* This paragraph requires that when qualifying VT-3 examination personnel in accordance with IWA-2317, the proficiency of the training must be demonstrated by administering an initial qualification examination and administering subsequent examinations on a 3-year interval.

*Paragraph (b)(2)(xix).* This paragraph prohibits the use of the provisions in IWA-2240 and IWA-4520(c) which would allow alternative examination methods, a combination of methods, or newly developed techniques to be substituted for the methods specified in the Construction Code during repair and replacement activities.

*Paragraph (b)(2)(xx).* This paragraph supplements the 1997 Addenda, 1998 Edition, 1999 Addenda, and 2000 Addenda of IWA-5213(a) to require a 10-minute hold time after attaining test pressure for Class 2 and Class 3 components that are not in use during normal operating conditions, and no hold time for the remaining Class 2 and Class 3 components provided that system has been in operation for at least 4 hours for insulated components or 10 minutes for uninsulated components.

*Paragraph (b)(2)(xxi)(A).* This paragraph requires that licensees perform pressurizer and steam generator nozzle inside-radius inspections of Table IWB-2500-1, Examination Category B-D, Items B3.40 and B3.60 (Inspection Program A) and Items B3.120 and B3.140 (Inspection Program B) of the 1998 Edition. The 1999 Addenda and the 2000 Addenda of Section XI are not permitted to be used. A visual examination with enhanced magnification that has a resolution sensitivity to detect a 1-mil width wire or crack, using the allowable flaw length criteria in Table IWB-3512-1, may be performed in place of a UT examination.

*Paragraph (b)(2)(xxi)(B).* This paragraph requires that the CRD bolting examinations of Table IWB-2500-1, Examination Category B-G-2, Item

(1) Piping must be examined in two axial directions, and when examination in the circumferential direction is required, the circumferential examination must be performed in two directions, provided access is available. Dissimilar metal welds must be examined axially and circumferentially.

(2) Where examination from both sides is not possible, full coverage credit may be claimed from a single side for ferritic welds. Where examination from both sides is not possible on austenitic welds or dissimilar metal welds, full coverage credit from a single side may be claimed only after completing a successful single-sided Appendix VIII demonstration using flaws on the opposite side of the weld. Dissimilar metal weld qualifications must be demonstrated from the austenitic side of the weld and may be used to perform examinations from either side of the weld.

\* \* \* \* \*

(K) \* \* \*  
(1) \* \* \*

(j) 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 (75) percent of the flaws must be cracks or fabrication flaws. Flaw locations and orientations must be selected from the choices shown in paragraph (b)(2)(xv)(K)(4) of this section, Table VIII-S7-1—Modified, with the exception that flaws in the outer eighty-five (85) percent of the weld need not be perpendicular to the weld. There may be no more than two flaws from each category, and at least one subsurface flaw must be included.

\* \* \* \* \*

(M) When implementing Supplement 12 to Appendix VIII, only the provisions related to the coordinated implementation of Supplement 3 to Supplement 2 performance demonstrations are to be applied.

\* \* \* \* \*

(xvii) *Reconciliation of Quality Requirements.* When purchasing replacement items, in addition to the reconciliation provisions of IWA-4200, 1995 Edition through the latest edition and addenda incorporated by reference in paragraph (b)(2) of this section, the replacement items must be purchased, to the extent necessary, in accordance with the licensee's quality assurance program description required by 10 CFR 50.34(b)(6)(ii).

(xviii) *Certification of NDE personnel.*

(A) Level I and II nondestructive examination personnel shall be recertified on a 3-year interval in lieu of the 5-year interval specified in the 1997 Addenda and 1998 Edition of IWA-2314, and IWA-2314(a) and IWA-2314(b) of the 1999 Addenda through the latest edition and addenda incorporated by reference in paragraph (b)(2) of this section.

(B) Paragraph IWA-2316 of the 1998 Edition through the latest edition and addenda incorporated by reference in paragraph (b)(2) of this section, may only be used to qualify personnel that observe for leakage during system leakage and hydrostatic tests conducted in accordance with IWA-5211(a) and (b), 1998 Edition through the latest edition and addenda incorporated by reference in paragraph (b)(2) of this section.

(C) When qualifying visual examination personnel for VT-3 visual examinations under paragraph IWA-2317 of the 1998 Edition through the latest edition and addenda incorporated by reference in paragraph (b)(2) of this section, the proficiency of the training must be demonstrated by administering an initial qualification examination and administering subsequent examinations on a 3-year interval.

(xix) *Substitution of alternative methods.* The provisions for the substitution of alternative examination methods, a combination of methods, or newly developed techniques in the 1997 Addenda of IWA-2240 must be applied. The provisions in IWA-2240, 1998 Edition through the latest edition and addenda incorporated by reference in paragraph (b)(2) of this section, are not approved for use. The provisions in IWA-4520(c), 1997 Addenda through the latest edition and addenda incorporated by reference in paragraph (b)(2) of this section, allowing the substitution of alternative examination methods, a combination of methods, or newly developed techniques for the methods specified in the Construction Code are not approved for use.

(xx) *System leakage tests.* When performing system leakage tests in accordance IWA-5213(a), 1997 Addenda through the latest edition and addenda incorporated by reference in paragraph (b)(2) of this section, a 10-minute hold time after attaining test pressure is required for Class 2 and Class 3 components that are not in use during normal operating conditions, and no hold time is required for the remaining Class 2 and Class 3 components provided that the system has been in operation for at least 4 hours

for insulated components or 10 minutes for uninsulated components.

(xxi) *Table IWB-2500-1 examination requirements.* (A) The provisions of Table IWB-2500-1, Examination Category B-D, Full Penetration Welded Nozzles in Vessels, Items B3.40 and B3.60 (Inspection Program A) and Items B3.120 and B3.140 (Inspection Program B) in the 1998 Edition must be applied when using the 1999 Addenda through the latest edition and addenda incorporated by reference in paragraph (b)(2) of this section. A visual examination with enhanced magnification that has a resolution sensitivity to detect a 1-mil width wire or crack, utilizing the allowable flaw length criteria in Table IWB-3512-1, 1997 Addenda through the latest edition and addenda incorporated by reference in paragraph (b)(2) of this section, may be performed in place of an ultrasonic examination.

(B) The provisions of Table IWB-2500-1, Examination Category B-G-2, Item B7.80, that are in the 1995 Edition are applicable only to reused bolting when using the 1997 Addenda through the latest edition and addenda incorporated by reference in paragraph (b)(2) of this section.

(C) The provisions of Table IWB-2500-1, Examination Category B-K, Item B10.10, of the 1995 Addenda must be applied when using the 1997 Addenda through the latest edition and addenda incorporated by reference in paragraph (b)(2) of this section.

(3) As used in this section, references to the OM Code refer to the ASME Code for Operation and Maintenance of Nuclear Power Plants, and include the 1995 Edition through the 2000 Addenda subject to the following limitations and modifications:

\* \* \* \* \*

(ii) *Motor-Operated Valve testing.* Licensees shall comply with the provisions for testing motor-operated valves in OM Code ISTC 4.2, 1995 Edition with the 1996 and 1997 Addenda, or ISTC-3500, 1998 Edition through the latest edition and addenda incorporated by reference in paragraph (b)(3) of this section, and shall establish a program to ensure that motor-operated valves continue to be capable of performing their design basis safety functions.

(iii) *Code Case OMN-1.* As an alternative to paragraph (b)(3)(ii) of this section, licensees may use Code Case OMN-1, "Alternative Rules for Preservice and Inservice Testing of Certain Electric Motor-Operated Valve Assemblies in Light Water Reactor Power Plants," Revision 0, in

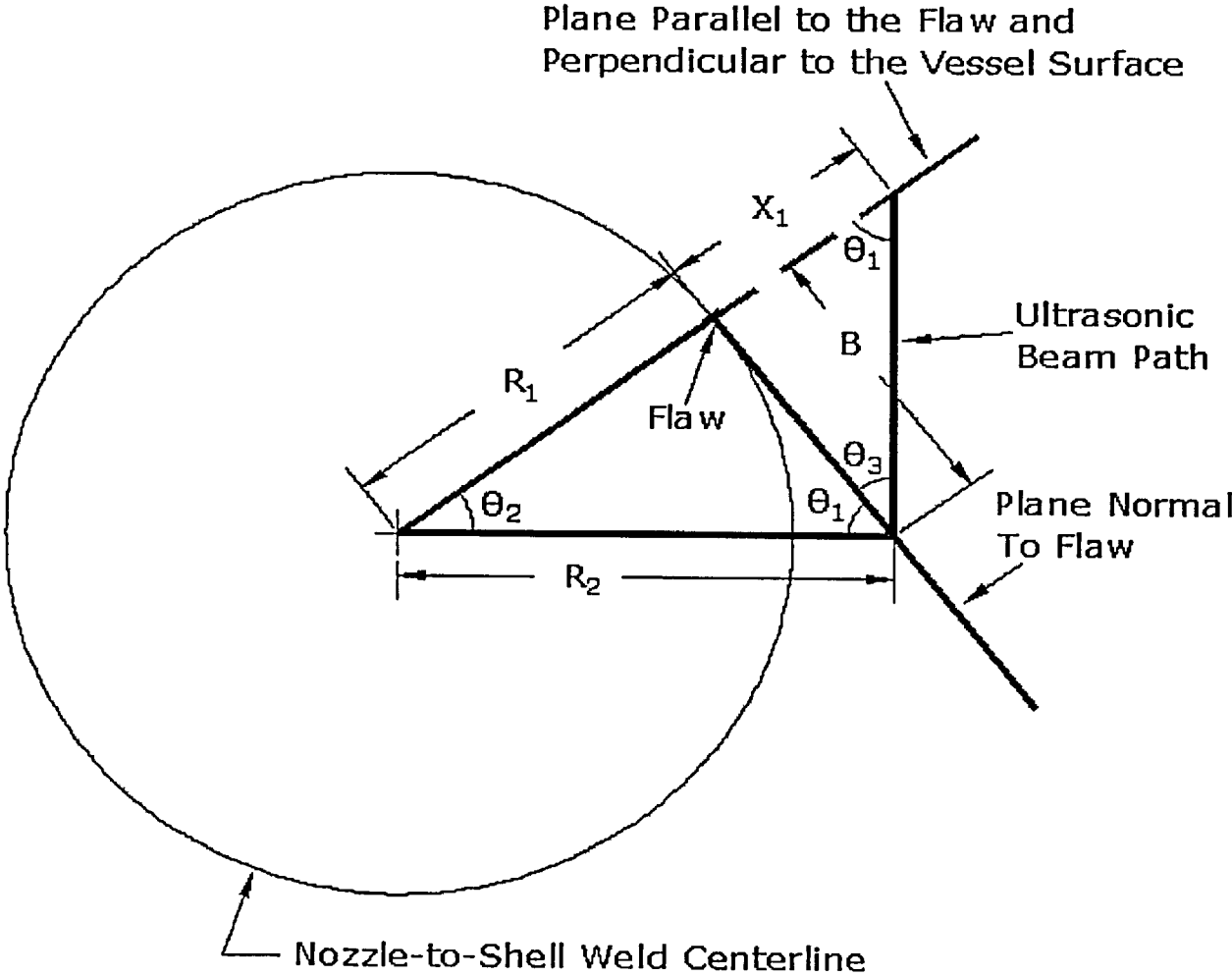
# Table from 10CFR50.55a

**TABLE S7-1  
FLAW LOCATIONS AND ORIENTATIONS**

---

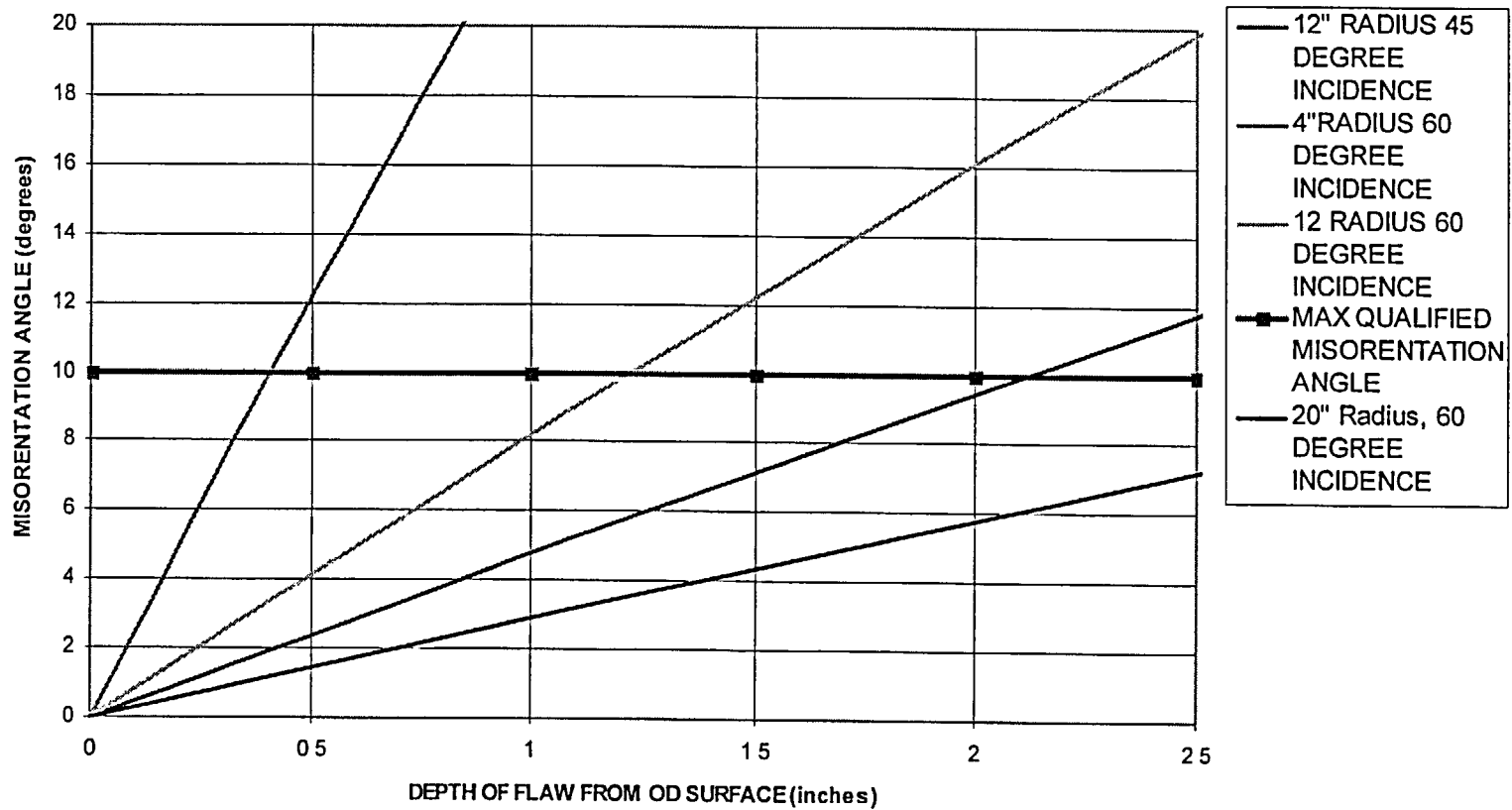
	Parallel to Weld	Perpendicular to Weld
Inner 15%	X	X
OD Surface	X	
Subsurface	X	

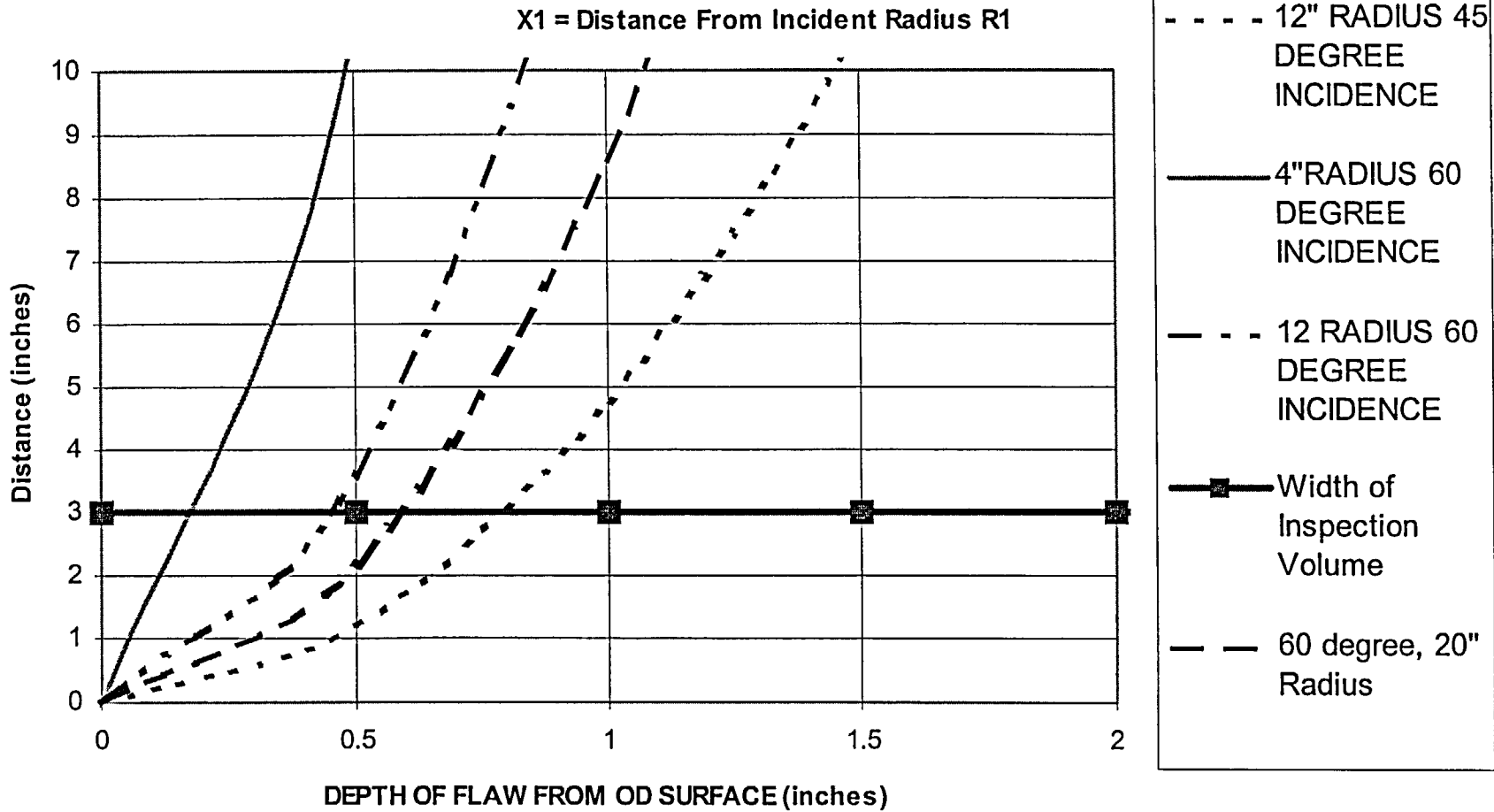
Figure 1. Plan View of the Nozzle-to-Shell Weld Examination Geometry for a Circular Weld in a Flat Plate





### MISORIENTATION ANGLE





# Technical Basis for Reduction of BWR Nozzle Examinations

- **From ASME Code Presentation Dec. 10, 2002**
- “Examination history and examination effectiveness justify reduced sampling frequency”
- “Probability of failure determined to be extremely small for 0%, 25% and 90% inspection sampling”
- “Total probabilities of failure  $<10^{-9}$  over 40 years ( $2.5 \times 10^{-11}$ /year)” (for flaws located at the clad to base metal interface)
- ( Failure probability is even lower for flaws located in the outer 85% of the vessel).

# Conclusions

- Supplement 6 techniques are not qualified to detect flaws perpendicular to the weld in the outer 85% of nozzle-to-shell welds.
- Risk informed studies indicate there is little need for for this examinations on BWR vessels.
- 10CFR50.55a excludes scanning for flaws perpendicular to the weld in the outer 85% of the nozzle to shell weld for PWR vessels, which are performed from the nozzle bore.

# Recommendations

- Examination requirements should not be more stringent for a BWR units, that are examined from the outside surface, than it is for PWR units.
- Application of ineffective techniques to fulfill inappropriate requirements defeats our efforts to move toward performance based inspection requirements.
- 10CF50.55 should be revised to make it equivalent the ASME Code Section XI, 2002 Edition, Appendix I and clarify the objective of the requirement.

## ARTICLE I-3000

### EXAMINATION COVERAGE

#### I-3100 EXAMINATION

Components identified in I-2110(a), I-2220, and I-2300 shall be examined as follows.

#### I-3200 PIPING

(a) The required piping examination volume shall be examined in two axial directions. When examination in the circumferential direction is required, the circumferential examination shall be performed in two directions.

(b) When examination of ferritic welds from both sides is not possible, procedures and personnel qualified for single-side examination in accordance with Appendix VIII, Supplement 3 shall be used to examine the required volume. When examination of austenitic welds from both sides is not possible, procedures and personnel qualified for single-side examination in accordance with Appendix VIII, Supplement 2, with all flaws on the opposite side of the weld, shall be used to examine the required volume.

#### I-3300 REACTOR PRESSURE VESSEL SHELL WELDS

(a) The clad-to-base-metal interface and the adjacent volume to a depth of at least 15% of the vessel thickness,  $T$ , shall be examined from four directions, using procedures and personnel qualified in accordance with Appendix VIII, Supplements 4 and 6. The vessel thickness,  $T$ , shall be measured from the clad-to-base-metal interface. The examination shall include scans parallel and perpendicular to the weld.

(b) If access is not available, the required examination volume shall be scanned to the extent and in the directions allowed by the physical restrictions. The limitations shall be documented in the record of examination. Examination coverage of the inner 15%  $T$  is acceptable provided

(1) the required volume is examined in one direction parallel and one direction perpendicular to the weld;

(2) the procedure and personnel are qualified for single-side access in accordance with the requirements of Appendix VIII, Supplement 4, 2.3, and Appendix VIII, Supplement 6, 2.3; and

(3) the initial examination shall be performed using a procedure qualified to detect flaws with a tilt angle of 45 deg relative to the weld centerline. Subsequent examinations may be performed using procedures qualified for a tilt angle of at least 10 deg.

(c) The remaining 85% of the vessel thickness shall be examined in four directions using procedures and personnel qualified in accordance with Appendix VIII, Supplement 6. The examination shall include scans parallel and perpendicular to the weld.

(d) As an alternative to (c), the outer 85% of the vessel thickness may be examined in one direction parallel and one direction perpendicular to the weld, using procedures and personnel qualified for single-side access in accordance with the requirements of Appendix VIII, Supplement 6, 2.3.

#### I-3400 REACTOR PRESSURE VESSEL NOZZLE-TO-SHELL WELDS

##### I-3410 EXAMINATIONS CONDUCTED FROM THE INSIDE

(a) The clad-to-base-metal interface and the adjacent examination volume to a depth of at least 15%  $T$  (measured from the clad-to-base-metal interface) shall be examined from four orthogonal directions, using procedures and personnel qualified in accordance with Appendix VIII, Supplements 4 and 6.

(b) When the examination volume defined in (a) cannot be effectively examined in all four directions, the examination shall be augmented by examination from the nozzle bore, using procedures and personnel qualified in accordance with Appendix VIII, Supplement 7.

(c) The remaining 85% of the required examination volume shall be examined in at least one radial direction from

(1) the nozzle bore, using procedures and personnel qualified in accordance with Appendix VIII, Supplement 7, or

(2) the vessel shell, using procedures and personnel qualified for single-side examination in accordance with Appendix VIII, Supplement 6.

#### **I-3420 EXAMINATIONS CONDUCTED FROM THE OUTSIDE**

(a) The clad-to-base-metal interface and the adjacent examination volume to a depth of at least 15%  $T$  (measured from the clad-to-base-metal interface) shall be examined from one radial and two opposing circum-

ferential directions using procedures and personnel qualified in accordance with Appendix VIII, Supplements 4 and 6, for examination performed in the radial direction, and Appendix VIII, Supplement 5, for examination performed in the circumferential directions.

(b) The remaining 85% of the required examination volume shall be examined in at least one radial direction using procedures and personnel qualified for a single-side examination in accordance with Appendix VIII, Supplement 6.

#### **I-3500 BOLTS AND STUDS**

Bolts and studs shall be examined using procedures and personnel qualified in accordance with Appendix VIII, Supplement 8. The volume specified in IWB-2500 or IWC-2500 shall be examined.