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Nondestructive Evaluation: American Society of Mechanical Engineers Section XI Development: Update 2007

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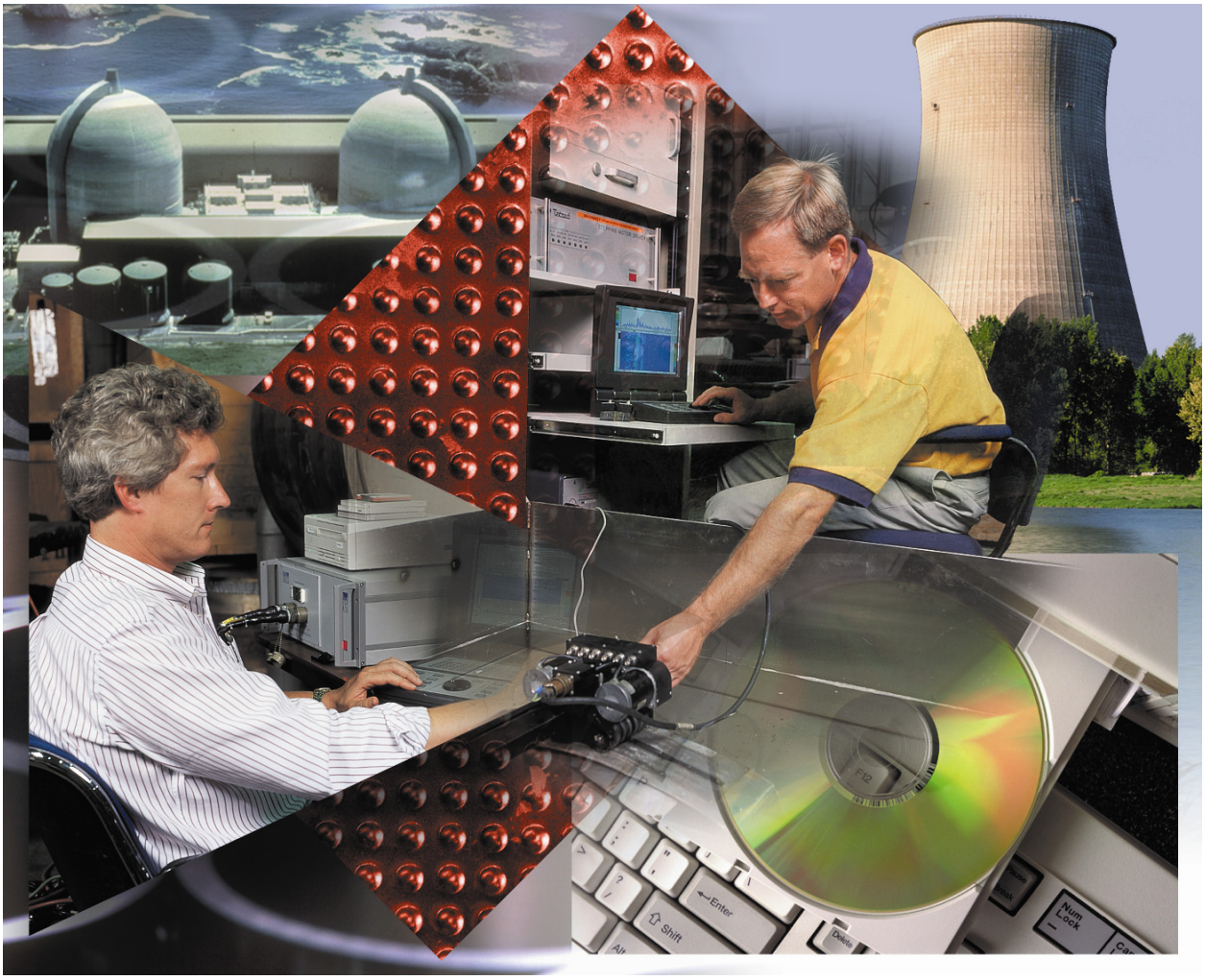

Nondestructive Evaluation: American Society of Mechanical Engineers Section XI Development: Update 2007

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Technical Update, November 2007

EPRI Project Manager

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PRODUCT DESCRIPTION

This project identifies areas in the American Society of Mechanical Engineers (ASME) Section XI Code that require revisions or enhancements and addresses those areas by means of intent and requirements inquiries, relief requests, Code Cases, Code changes, and supporting technical justifications. It also supports codifying new items coming out of the Boiling Water Reactor Vessel Internals Project (BWRVIP), Materials Technical Advisory Group (MTAG), Materials Executive Oversight Group (MEOG), Materials Reliability Program (MRP), and Change Initiative (CI) Programs.

Results and Findings

This project provides the coordination of Code-related activities among issue program projects and in other areas identified by member utilities. For example, the project supported Code improvements for dissimilar metal (DM) welds, Code coverage, Figures IWB-2500 7(a), (b), (c), and (d) revisions to eliminate the cladding from the examination volume, guidance for sizing of axial flaws, and completed Code changes needed to align it with 10CFR50.55a and the Performance Demonstration Initiative (PDI) Program.

Challenges and Objectives

Regulatory and Code processes are slow and not always conducive to the introduction of new ideas that can address strategic objectives; in addition, many inspections required by Code or by regulation add considerable cost and dose burden without a commensurate safety or reliability benefit. Utilities, when compared with the burden of implementing regulatory and Code requirements, are under represented and need dedicated resources available to serve their interests. The burden of proof for technical justification of alternative requirements or the elimination of exams is onerous and is otherwise not commercially viable.

Applications, Values, and Use

The project products will be delivered in several different forms depending upon their urgency and cause. Intent inquiries would be used to resolve minor areas of confusion (for example, applicability of Appendix VIII, Supplement 1). They do not involve a change to the Code and would be applicable immediately. More complex issues would be resolved by preparing a Code Case, frequently accompanied by a Code change. The Code Case would be usable after a relief submittal (for example, N-695 for DM Weld qualification). Less urgent concerns could be addressed with a Code change (for example, ultrasonic testing [UT] coverage).

EPRI Perspective

The work performed under this project has led to the Electric Power Research Institute's (EPRI's) gaining considerable expertise in navigating the complex ASME Section XI Code process. It provides utilities with a ready source of Code-related information and represents their best interests. It allows technical achievements resulting from MEOG, MRP, and other programs to be rapidly assimilated into the Code.

Approach

One of the final steps in the technology transfer process is incorporating nondestructive examination (NDE) enhancements into the in-service inspection requirements of ASME Section XI, for subsequent approval in the Code of Federal Regulations (10CFR50.55a).

Keywords

Nondestructive examination
ASME Code
Section XI
Appendix VIII

ACKNOWLEDGEMENTS

Code enhancement needs are identified through the Boiling Water Reactor Vessel and Internals Project (BWRVIP), the Materials Reliability Program (MRP), the Performance Demonstration Initiative (PDI), and other nuclear utility sponsored organizations and programs. Prior to incorporation into ASME Section XI, the new requirements must be reviewed and approved by several diverse groups and committees, and a coordinated effort is required to implement them in an expeditious manner. Dennis Swann is the primary sponsor for these activities.

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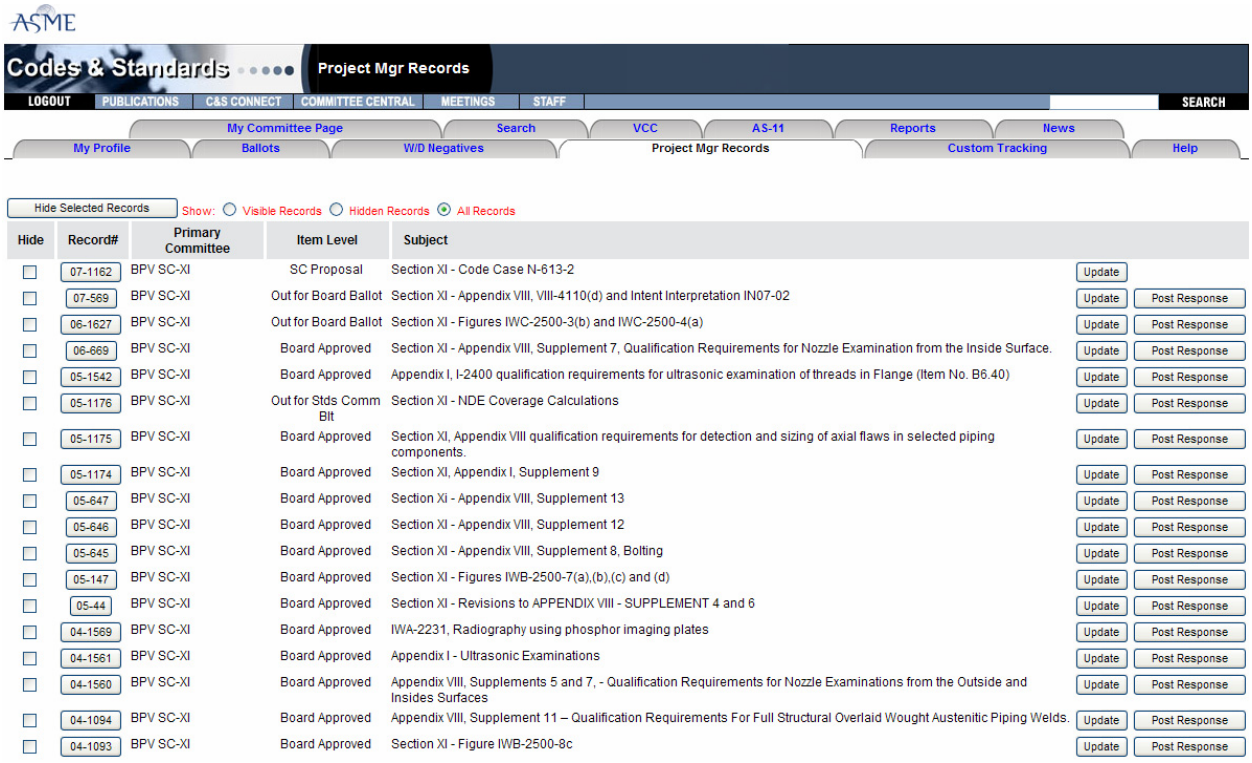
ASME SECTION XI DEVELOPMENT 2007

Project Manager Records

Figure 1-1 was taken directly from the American Society of Mechanical Engineers (ASME) web page and identifies projects initiated under this three-year project authorization. During this time, the primary emphasis was placed on the reconciliation of all differences among 10CFR50.55a, the Performance Demonstration Initiative (PDI) Program, and ASME Section XI, Appendices I and VIII. Effective with the 2007 edition of ASME Section XI, the differences are fully reconciled. Each of the projects is described in detail in this section. For additional information, contact Mike Gothard at 704.595.2131 or mgothard@epri.com.



Hide	Record#	Primary Committee	Item Level	Subject		
☐	07-1162	BPV SC-XI	SC Proposal	Section XI - Code Case N-613-2	Update	
☐	07-569	BPV SC-XI	Out for Board Ballot	Section XI - Appendix VIII, VIII-4110(d) and Intent Interpretation IN07-02	Update	Post Response
☐	06-1627	BPV SC-XI	Out for Board Ballot	Section XI - Figures IWC-2500-3(b) and IWC-2500-4(a)	Update	Post Response
☐	06-669	BPV SC-XI	Board Approved	Section XI - Appendix VIII, Supplement 7, Qualification Requirements for Nozzle Examination from the Inside Surface.	Update	Post Response
☐	05-1542	BPV SC-XI	Board Approved	Appendix I, I-2400 qualification requirements for ultrasonic examination of threads in Flange (Item No. B6.40)	Update	Post Response
☐	05-1176	BPV SC-XI	Out for Stds Comm Bit	Section XI - NDE Coverage Calculations	Update	Post Response
☐	05-1175	BPV SC-XI	Board Approved	Section XI, Appendix VIII qualification requirements for detection and sizing of axial flaws in selected piping components.	Update	Post Response
☐	05-1174	BPV SC-XI	Board Approved	Section XI, Appendix I, Supplement 9	Update	Post Response
☐	05-647	BPV SC-XI	Board Approved	Section Xi - Appendix VIII, Supplement 13	Update	Post Response
☐	05-646	BPV SC-XI	Board Approved	Section XI - Appendix VIII, Supplement 12	Update	Post Response
☐	05-645	BPV SC-XI	Board Approved	Section XI - Appendix VIII, Supplement 8, Bolting	Update	Post Response
☐	05-147	BPV SC-XI	Board Approved	Section XI - Figures IWB-2500-7(a),(b),(c) and (d)	Update	Post Response
☐	05-44	BPV SC-XI	Board Approved	Section XI - Revisions to APPENDIX VIII - SUPPLEMENT 4 and 6	Update	Post Response
☐	04-1569	BPV SC-XI	Board Approved	IWA-2231, Radiography using phosphor imaging plates	Update	Post Response
☐	04-1561	BPV SC-XI	Board Approved	Appendix I - Ultrasonic Examinations	Update	Post Response
☐	04-1560	BPV SC-XI	Board Approved	Appendix VIII, Supplements 5 and 7, - Qualification Requirements for Nozzle Examinations from the Outside and Insides Surfaces	Update	Post Response
☐	04-1094	BPV SC-XI	Board Approved	Appendix VIII, Supplement 11 – Qualification Requirements For Full Structural Overlaid Wought Austenitic Piping Welds.	Update	Post Response
☐	04-1093	BPV SC-XI	Board Approved	Section XI - Figure IWB-2500-8c	Update	Post Response

Figure 1-1
Project Managers' List from the ASME Web Site

BC07-1162 – Code Case N-613-2

This Code action revises the examination volume in Figure 1 from ts/2 to 1/2 in. (12.7 mm) to be consistent with Figures 2 and 3. In Figure 1, despite the reduction in the nozzle-to-vessel weld examination volume from ts/2 to 1/2 in. (12.7 mm), the nozzle boss side of the weld continues to extend the region to ts/2. This is inconsistent with the other figures. For nozzles examined from

the bore, this results in excess scanning during critical path. Additionally, this area is virtually impossible to examine from the outside, resulting in unwarranted reductions in examination coverage. It also removes remnant ts/2 dimensions from the nozzle boss. The ts/2 dimension located in the center of the nozzle boss in Figure 1 is an extraneous remnant from the original Code figure. B3.20 and B3.100 were added to include the nozzle inner corner region (NICR). Figure 4 and new points Q and R were added to remove the clad from the NICR and changed the examination volume from M-N-O-P to O-P-Q-R. The new points eliminate the clad from the examination volume, consistent with the board-approved change made in BC 05-147. The intent was to avoid future confusion over the intent of the Code Case.

BC07-569 – Intent Interpretation 07-02 and VIII-4110(d)

Intent Interpretation IN07-02 and the accompanying Code change clarify the applicability of VIII-4110(d) to examination system components other than the pulser, receiver, and search unit.

Article VIII-2000 addresses General Examination System Requirements and includes the instrument or system (VIII-2100(d)(1), search units (VIII-2100(d)(2), and search unit cables (VIII-2100(d)(3) as essential variables in the examination system.

Article VIII-4000 addresses Essential Variable Tolerances, and VIII-4100 addresses Procedure Modifications. VIII-4110(a) provides requirements for the instrument settings, VIII-4110(b) provides requirements for evaluating the pulsers and receivers, and VIII-4110(c) provides requirements for evaluating search units. VIII-4110(d) provides requirements for evaluating examination systems and states: Examination systems shall be evaluated using Supplement 1.

VIII-4110(d) is under the heading of VIII-4110, which is titled Pulsers, Receivers, and Search Units. Unfortunately, this causes some confusion; for example, does VIII-4110 limit the application of VIII-4110(d) to pulsers, receivers, and search units or does the examination system definition contained in VIII-2100 expand that applicability to other components, including cables, pre-amplifiers, filtering hardware, and so on?

BC06-1627 – Figures IWC-2500-3(b) and IWC-2500-4(a)

This Code action redefines the examination surface as 1/2 in. (12.7 mm) from the toe of the weld. For Class 2 pressure-retaining nozzle welds in vessels a surface examination is required for Item C2.21 (Nozzles without Reinforcing Plate in Vessels > 1/2 in. (12.7 mm) in Nominal Thickness). The examination figure referenced is either IWC-2500-4(a) or (b). The nozzle-to-vessel weld that meets the requirements of IWC-2500-4(a) has the surface examination area defined as A-B. Point A is not clearly defined, but it is shown as some distance from the weld toe. Point B, as well as all other points except point A in Figure IWC-2500-3(b), is defined as 1/2 in. (12.7 mm) from the weld toe. The dimension **r** for the outer diameter (OD) radius of the nozzle is not defined.

To be consistent with the other nozzle illustrations, Point A should be defined as 1/2 in. (12.7 mm) from the toe of the weld. If Point A is intended to include the nozzle radius, it can increase the examination area by a large amount. In Figure 1-2, the examiner's left hand is pointing to the weld toe closest to the nozzle, and his right hand is pointing toward the tangent point between the nozzle radius and the nozzle boss, illustrating the increased area.

Figure 1-2
Surface Examination Area

BC06-669 – Appendix VIII, Supplement 7, Nozzle Examination from the ID

This Code change resolves a discrepancy with 10CFR50.55a requirements. Supplement 7 currently requires qualification of the examination procedure and equipment; other than qualification in accordance with Supplements 4 and 6, there are no performance demonstration requirements for personnel. Recent experience indicates that differences between the examination of the vessel and the examination of the nozzle are sufficient to require a performance demonstration for personnel. This action was requested by the U.S. Nuclear Regulatory Commission (NRC) and was unanimously supported by vendor representatives on the Appendix VIII Task Group.

BC05-1542 – Threads in Flange

Intent inquiry IN05-19 and the accompanying Code change correct a reference error in the Code. Effective with the 2003 Addenda, ASME Section V, Article 4, was modified, and bolting requirements were moved to Article 5. ASME Section XI still refers to Article 4 so this must be corrected by an intent inquiry. Additionally, a revision is being proposed that allows for use of either Section V, Article 5, or Section XI, Appendix VIII, Supplement 8, as qualified on the reactor pressure vessel stud.

BC05-1176 – NDE Coverage Calculations

This proposed change establishes NDE coverage requirements in IWA-2200(c) and includes a non-mandatory appendix to provide guidelines for determining examination coverage percentages. NDE examination coverage requirements are contained in Section XI, Appendix I-3000, and 10CFR50.55a (xv). Supplemental requirements defining acceptable coverage as greater than 90% of the examination volume or area are contained in Code Case N-460 and NRC Information Notice 98-42. The proposed change to IWA-2200(c) consolidates the supplemental requirements and establishes a minimum coverage standard, and, at the same time, the non-mandatory Appendix provides a guideline to facilitate uniform coverage calculations. Several utilities have voluntarily implemented the guideline provisions without difficulty.

BC05-1175 – Sizing of Axial Flaws

Intent inquiry IN05-18 and the accompanying Code change define qualification requirements for detection and sizing of axial flaws in those piping supplements that otherwise contain no provisions. Appendix VIII, Supplements 2, 3, 10, 11, and newly created 14 might not have provisions for qualification of procedures, personnel, and equipment for length and/or depth sizing of axial flaws. This exclusion is reasonable because axially oriented service-induced flaws are typically confined by the failure mechanism, that is, to the heat-affected zone for intergranular stress corrosion cracking (IGSCC) or the weld for primary water stress corrosion cracking (PWSCC), thus providing defined start and stop points that are within the 0.75 in. (19.05 mm) allowable root-mean-square (RMS) error. The recent initiation of PWSCC in pressurized water reactor (PWR) components increases the probability that these measurements will be needed, and this change is intended to provide guidance.

BC05-1174 – Appendix I, Supplement 9

Intent inquiry IN05-17 and the accompanying Code change clarify the intent to require use of 45- and 60-deg search units for examinations conducted from the outside surface. Section XI, Appendix I, Supplement 9, states in part: For examination conducted from the inside diameter clad surface of vessels, in addition to the two angle beams having nominal angles of 45° and 60°, a longitudinal wave beam having a nominal angle of 70° shall be used. The 45° and 60° requirement in the preceding quote can be interpreted as applicable to all examinations or just those examinations conducted from the inside surface of clad components.

BC05-647 – Appendix VIII, Supplement 13

Supplement 13 was deleted. It allowed for a coordinated implementation of Supplements 4 (clad base metal interface), 5 (nozzle inside corner region), 6 (remaining RPV welds), and 7 (nozzle-to-vessel weld). The PDI program does not allow for this coordinated implementation because the examination techniques and examination volumes associated with Supplements 4, 5, 6, and 7 are significantly different and make a coordinated implementation impractical.

BC05-646 – Appendix VIII, Supplement 12

Supplement 12 was limited. It allows for a coordinated implementation of Supplements 2 (austenitic piping welds), 3 (ferritic piping welds), 10 (dissimilar metal piping welds), and 11 (overlaid piping welds). However, 10CFR50.55a limits Supplement 12 to a coordinated implementation of Supplements 2 and 3. This limit is consistent with the current PDI program that indicates the examination techniques associated with Supplements 10 and 11 are significantly different from those of Supplement 2 and 3 and make a coordinated implementation impractical.

BC05-645 – Appendix VIII, Supplement 8

Supplement 8 requires circumferentially oriented notches at the minimum and maximum qualified metal paths. Notches located within one diameter opposite the search unit are allowed for demonstrating the maximum metal path distance, but the location tolerance for the minimum metal path is not defined. The PDI program and the proposed change use the tolerance defined in 10CFR50.55a.(xv)(L), which states: As a modification to the requirements of Supplement 8, Subparagraph 1.1(c), to Appendix VIII, notches might be located within one diameter of each end of the bolt or stud.

BC05-147 – Figures IWB-2500-7(a), (b), (c), and (d)

Appendix VIII, Supplement 5, provides the qualification requirements for the nozzle inside corner region. It references Supplement 4, paragraph 1.1, for specimen requirements that states in part in paragraph 1.1 (e)(2): All flaws shall emanate from the clad base metal interface and shall propagate predominantly into the base material. Contrary to that, Figures IWB-2500-7(a), (b), (c), and (d) include the cladding in the examination volume associated with the nozzle inside corner region (M-N-O-P). Note that the cladding is specifically excluded from the illustrations associated with all other applicable IWB-2500 components, that the nozzle figures exclude the cladding from the pressure-retaining boundary, and that the nozzle figures exclude the portion of the flaw contained in the clad from the applicable **a** dimension. This action would also alleviate some confusion that currently exists over the examination volume associated with nozzles containing unusual geometries, such as the engineered socket weldment associated with the stand-by liquid control nozzle for boiling water reactors (BWRs).

BC05-44 – Appendix VIII, Supplements 4 and 6

This change redefines the flaw depth distributions in Supplements 4 and 6 from uniform to representative. Supplements 4 and 6 require a uniform distribution of flaws in the test set. This provides the candidate with unintended information about the test sets. Additionally, it is impossible to obtain a uniform flaw distribution when incorporating four different flaw depths into a test set containing ten flaws. 10CFR50.55a requires the minimum flaw size to be 50% rather than 100% of the allowable, as currently specified by Supplement 4. Additionally, Supplement 4 contains qualification requirements for sizing off-axis flaws. All procedures qualified to date for single-side access have been able to satisfactorily length and depth size off-axis flaws. The additional requirements are, therefore, unwarranted and in excess of 10CFR50.55a, which only requires a detection demonstration.

BC04-1569 – IWA-2231, Phosphor Plate Radiography

This Code change allows radiography to be performed using phosphor imaging plates when requirements are published in Section V, Article 2. Originally, IWA-2231 stated in part: For radiographic examinations employing either X-ray equipment or radioactive isotopes and photographic films, the procedure shall be as specified in Article 2 of Section V.

Action is proceeding in ASME Section V, Article 2 (BC03-1548), and their Code Case 2476, and this Code revision provides for accelerated implementation in Section XI. Additionally, superfluous language was removed from paragraph IWA-2231 so it simply refers to Section V, Article 2, for examination requirements and matches the terminology used for other methods.

BC04-1561 – Appendix I, Ultrasonic Examinations

The current Appendix I-3000 does not define the coverage requirements for dissimilar and overlaid piping welds and the nozzle inside corner region. Additionally, many utilities are submitting for relief to use Appendix VIII qualified procedures for examination of the reactor pressure vessel (RPV) flange welds and other vessel welds, in lieu of Article 4, Section V. The proposed revision allows for the use of Appendix VIII qualified procedures without the need for relief and without the need for examinations from the flange face or seal surface. It also corrects a minor error as illustrated in many figures in ASME Sections XI and V. **T** refers to the thickness of the ultrasonic calibration block, and **t** refers to the thickness of the component's pressure retaining boundary.

BC04-1560 – Appendix VIII, Supplements 5 and 7

Examination of the nozzle inside corner region from the outside surface typically requires the use of curved compound angle search units. Determining the appropriate angles requires that the geometry be modeled using computer-based three-dimensional techniques. Code Case N-552 provides requirements for the modeling and is identified in RG 1.147 as an acceptable alternative to Appendix VIII, Supplement 5, for nozzle examinations, including the inner 15% of the nozzle-to-vessel weld. As a result, the PDI Program implements the rules of Code Case N-552, in lieu of the current Supplement 5. Furthermore, 10CFR50.55a requires the nozzle-to-vessel weld to be examined in accordance with Supplements 4 and 6 when examinations are conducted from the inside surface. When required to obtain coverage on an augmented basis, the rules of the current Supplement 7 are only applicable for the bore examination qualification. Therefore, much of Supplement 7 needs to be eliminated. Afterwards, because qualifications for the nozzle inside corner region and the nozzle bore are conducted on the same sample, it is logical to consolidate these qualification requirements into one supplement applicable to nozzles examined from the inside surface. Together, the proposed revisions align themselves with the current PDI program, Code Case N-552, 10CFR50.55a, requirements and result in one supplement for nozzle outside surface examinations and one for nozzle inside surface examinations.

BC04-1094 – Appendix VIII, Supplement 11

Utilities are currently implementing Appendix VIII, Supplement 11, through the PDI Program by submitting relief requests to the NRC. The initial NRC review process produced requests for additional information that subsequently resulted in enhancements to the terminology. Those enhancements are included in this revision and reflect the current PDI qualification program.

BC04-1093 – Figure IWB-2500-8c

Currently the examination requirements associated with the butter in Figure IWB-2500-8 can be interpreted several ways. One interpretation could be that the buttering is a separate weld and, if present, would require examination 1/4 in. (6.35 mm) beyond the toe of the butter to nozzle weld layer. Another interpretation is that the butter has been stress relieved along with the base material of the nozzle forging and should now be treated as base material and excluded from the examination volume. Recent experience indicates the buttering layer of dissimilar metal welds often extends more than 1/4 in. (6.35 mm) past the toe of the nozzle to safe end weld. The buttering layer, associated with a dissimilar metal weld, is also susceptible to cracking and should be included in the examination volume.

The line representing the right extremity of the examination volume was moved from the toe of the weld to the toe of the buttering. A thickness of 1/2 in. (12.7 mm) was assigned to the butter when the true thickness was unknown. The true thickness of the butter might be unknown due to field machining operations, for example, and the visible thickness might not be representative because the austenitic butter could wrap around the outside surface of the ferritic nozzle. Additional clarifications were included as notes.

2
ADDITIONAL PROJECTS

ASME Section XI, Appendix VIII, Supplement 1, Revision

As currently envisioned, this Code action replaces the existing Appendix VIII, Supplement 1, with a new supplement designed to address expanding the scope of qualified essential variables for both procedures and personnel and to redefine the essential variables. Although VIII-3140 contains requirements for expanding the range of qualified essential variables in the examination procedure, it does not address the requirements for personnel qualifications or define when a personnel re-qualification is required. Additionally, VIII-2100 does not provide for capturing essential variables associated with advanced ultrasonic systems and processes.

The existing Supplement 1 will be retained as a nonmandatory Appendix.

If you need interpretations, inquiries, or changes made to ASME Section XI, contact Mike Gothard at 704.595.2131 or mgothard@epri.com.

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