PERFORMANCE DEMONSTRATION INITIATIVE

(PDI)

PROGRAM DESCRIPTION

RÉVISION 1, CHANGE 1

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PDI Program Description

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Appendix B

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Appendix C PDI Program Qualification Sample Size Ranges

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ASME SECTION XI, APPENDIX VIII PERFORMANCE DEMONSTRATION FOR ULTRASONIC EXAMINATION SYSTEMS

ARTICLE VIII-1000 SCOPE

REQUIREMENT

VIII-1100 GENERAL:

- (a) This Appendix provides requirements for performance demonstration for ultrasonic examination procedures, equipment, and personnel used to detect and size flaws.
- (b) Each organization (e.g., Owner or vendor) shall have a written program that insures compliance with this Appendix.

Each organization that performs ultrasonic examinations shall qualify its procedures, equipment, and personnel in accordance with this Appendix.

The organization may contract implementation of the program.

- (c) Performance demonstration requirements apply to personnel who detect, record, or interpret indications or size flaws in welds or components.
- (d) The performance demonstration requirements specified in this Appendix do not apply to personnel whose involvement is limited to mounting a scanner device, marking pipe, or other situations where knowledge of ultrasonics is not important.
- (e) Any procedure qualified in accordance with this Appendix is acceptable.
- (f) Instrument characterization described in Supplement 1 to this Appendix, is optional.

When Supplement 1 is selected, both the original and substituted equipment shall be characterized.

PDI IMPLEMENTATION

- (a) PDI has developed a written practice (<u>Protocol</u>) that prescribes a method for implementation of these requirements.
- (b) PDI has developed a program that provides a vehicle to meet all Appendix VIII requirements. Member utilities may adopt the PDI program as their written program to satisfy ASME Appendix VIII requirements.

- (c) The PDI Program is designed to qualify personnel for the scope of examination task being performed (i.e., detection, recording, or interpretation). See Appendix A and the *Protocol* for further information.
- (d) Appendix-A and the *Protocol* provides further details on this subject.
- (e) PDI monitors qualification of procedures and documents results. The qualification documentation is available to member utilities upon request.
- (f) PDI Program Instruction PDP-I-012.1, provides for Supplement 1 characterization. Some characterizations have been performed by PDI. PDI also maintains a list of equipment utilized during qualifications of manual piping procedures as an aid to owners and vendors who may substitute equipment in the future (Ref. Procedure Nos. PDI-UT-1, 2 & 3).

ARTICLE VIII-2000 GENERAL EXAMINATION SYSTEM REQUIREMENTS

REOUIREMENT

VIII-2100 PROCEDURE REQUIREMENTS:

(a) The examination procedure shall contain a statement of scope that specifically defines the limits of procedure applicability (e.g. materials, thickness, diameter, product form).

(b) The examination procedure shall specify a single value or a range of values for the variables listed in VIII-2100(d).

(c) Any calibration method may be used provided it is described and complies with VIII-2100(d)(5).

(d) The examination procedure shall specify the following essential variables:

- PDI IMPLEMENTATION
- (a) The PDI Program requires that procedures specify the limits of applicability in the Scope section.

The PDI Program uses the Scope section of the Candidate Registration Form to assemble test sets required to demonstrate the limits of the specific procedure.

PDI generic procedures (PDI-UT-1, 2 & 3) contain scope statements which specifically define the limits of each procedure's applicability including such items as materials, thickness, diameter, and product form.

(b) PDI has developed an instruction (PDP-I-009.1) which contains a checklist that specifically addresses all essential variables. The instruction and checklist are used during the procedure review process to assure that procedures specify a single value or range of values for each essential variable.

The checklist will be used to verify suitability of procedures to be demonstrated for qualification.

(c) PDI has developed an instruction (PDP-I-009.1) which contains a checklist that specifically addresses essential elements of calibration. The checklist is used during the procedure review process to assure that procedures contain the required elements for repeatable calibrations.

The candidate fills out calibration forms which are used during the surveillance process of the demonstration.

(d) PDI has developed an instruction (PDP-I-009.1) which contains a checklist that specifically addresses all essential variables [(d)(1) through (d)(10)]. The instruction and checklist are used during the procedure review process to assure that procedures specify a single value or range of values for each essential variable.

The checklist will be used to verify suitability of procedures to be demonstrated for qualification.

- instrument or system, including manufacturer and model or series of pulser, receiver, and amplifier;
- (2) search units, including:

ARTICLE VIII-2000 GENERAL EXAMINATION SYSTEM REQUIREMENTS

REQUIREMENT

PDI IMPLEMENTATION

- (a) center frequency and either bandwidth or waveform duration as defined in VIII-4000;
- (b) mode of propagation and nominal inspection angles;
- number, size, shape, and configuration of active elements and wedges or shoes;
- (3) search unit cable, including:
 - (a) type;
 - (b) maximum length;
 - (c) maximum number of connectors
- (4) detection and sizing techniques, including:
 - (a) scan pattern and beam directions;
 - (b) maximum scan speed;
 - (c) minimum and maximum pulse repetition rate;
 - (d) minimum sampling rate (automatic recording systems);
 - (e) extent of scanning and action to be taken for access restrictions;
- (5) methods of calibration for detection and sizing (e.g., actions required to insure that the sensitivity and accuracy of the signal amplitude and time outputs of the examination system, whether displayed, recorded, or automatically processed, are repeated from examination to examination); are repeated from examination to examination);
- (6) inspection and calibration data to be recorded;
- (7) method of data recording;

ARTICLE VIII-2000 GENERAL EXAMINATION SYSTEM REQUIREMENTS

- (8) recording equipment (e.g., strip chart, analog tape, digitizing) when used;
- (9) method and criteria for the discrimination of indications (e.g., geometric versus flaw indications and for length and depth sizing of flaws);
- (10) surface preparation requirements

ARTICLE VIII-3000 QUALIFICATION REQUIREMENTS

REQUIREMENT

PDI IMPLEMENTATION

VIII-2200 PERSONNEL REQUIREMENTS

Personnel shall meet the requirements of Appendix VII and shall be qualified in accordance with VIII-3000.

It is the owners responsibility to comply with this requirement. The PDI Program requires candidates to provide documentation that they have been rified to at least Level II in UT per their employers wn practice. PDI will not review the employers written practice.

VIII-3100 QUALIFICATION TEST REQUIREMENTS:

VIII-3110 DETECTION:

(a) Qualification test specimens shall meet the requirements of the appropriate Supplement listed in Table VIII-3110-1.

- (b) The examination procedure, equipment, and personnel are qualified for detecting flaws upon successful completion of the performance demonstration specified in the appropriate Supplement listed in Table VIII-3110-1.
- (c) For piping welds whose requirements are in course of preparation, the requirements of Appendix III, as supplemented by Table I-2000-1, shall be met.

(a) PDI has fabricated samples that meet all of the requirements of Supplements 2 through 8 and 12 identified in Table VIII-3110-1 (below).

PDI is not addressing cast austenitic piping welds because the requirements are in the course of preparation. Supplement 10 "Dissimilar Metal" and Supplement 11 "Overlay," are not included in the scope of the PDI Program at this time.

- (b) PDI Procedures PDP-Q-009.1 and PDP-Q-018.3, require that surveillances be conducted by qualified personnel to determine that combinations of procedures, equipment, and personnel can detect the prescribed number and type of test set flaws during the qualification demonstration.
- (c) PDI is not addressing implementation of Appendix III.

ARTICLE VIII-3000 QUALIFICATION REQUIREMENTS

REQUIREMENT

PDI IMPLEMENTATION

VIII-3110 DETECTION: (Continued)

Component Type	Applicable Supplement	
Piping Wolds		-
Wannahi Anataritia		
Wrought Austenitic	2	
Femuc	3	
Cast Austenitic	[Note (1)]	
Dissimilar Metal	10	
Overlay	11	
Vessels		
Clad/Base Metal Interface Region	4	
Nozzle Inside Radius Section	5	
Reactor Vessel Welds Other		
Than Clad/Base Metal Interface	6	
Nozzle-to-Vessel Weld	7	
	/	
Bolts and Studs	8	

TABLE VIII-3110-1 COMPONENT QUALIFICATION SUPPLEMENTS

NOTE:

(1) In course of preparation. The PDI Program meets Supplements 2, 3, 4, 5, 6, 7, 8 and 12 (12 inadvertently left out of the '93 Addenda to Appendix VIII).

ARTICLE VIII-3000 QUALIFICATION REQUIREMENTS

REQUIREMENT

VIII-3120 SIZING:

- (a) Qualification test specimens shall meet the requirements of the appropriate Supplement listed in Table VIII-3110-1.
- (b) The examination procedure, equipment, and personnel are qualified for sizing flaws upon successful completion of the performance demonstration specified in the appropriate Supplement listed in Table VIII-3110-1.
- (c) For piping welds whose requirements are in course of preparation, the requirements of Appendix III, as supplemented by Table I-2000-1, shall be met.

VIII-3130 ESSENTIAL VARIABLE RANGES:

- (a) Any two procedures with the same essential variables [VIII-2100(d)] are considered equivalent. Pulsers, search units, and receivers that vary within the tolerances specified in VIII-4100 are considered equivalent. When the pulsers, search units, and receivers vary beyond the tolerances of VIII-4100, or when the examination procedure allows more than one value or range for an essential variable, the qualification test shall be repeated at the minimum and maximum value for each essential variable with all other variables remaining at nominal values. Changing the essential variable may be accomplished during successive personnel performance demonstrations. Each examiner need not demonstrate qualification over the entire range of every essential variable.
- (b) When the procedure does not specify a range for essential variables and establishes criteria for selecting values, the criteria shall be demonstrated.

VIII-3140 REQUALIFICATION

When a change in an examination procedure causes an essential variable to exceed a qualified range, the examination procedure shall be requalified for the revised range.

PDI IMPLEMENTATION

(a) All PDI fabricated samples meet all of the requirements of the specific supplements identified in Table VIII -3110-1 above except Supplements 10 and 11.

Supplements 10 and 11 are not included in the current scope of the PDI effort.

- (b) The PDI Program provides for monitoring and determination of acceptable values of essential variables in accordance with Procedure PDP-Q-018.3 during the conduct of performance demonstrations.
- (c) PDI is not addressing implementation of Appendix III.

(a) The PDI program provides for monitoring of acceptable essential variables in accordance with Procedures PDP-Q-018.3 and PDP-Q-009.1. The Program also provides for documentation of Performance test results. It is the responsibility of the owner/vendor to determine equivalency of procedures.

The PDI program, in accordance with Instruction PDP-I-009.1, and procedures PDP-Q-009 and PDP-Q-009.1, provides measures whereby changes to essential variables may be accomplished during successive personnel performance demonstrations. Each examiner need not demonstrate qualification over the entire range of every essential variable.

(b) Procedures are reviewed in accordance with PDI Instruction PDP-I-009.1 to determine if it is criteria based. A successful demonstration by a candidate qualifies the procedure.

Procedures are requalified at the request of owner/vendors. PDI generic procedures are requalified when essential variable changes exceed the qualified range.

ARTICLE VIII-4000 ESSENTIAL VARIABLE TOLERANCES

REQUIREMENT

VIII-4100 PROCEDURE MODIFICATIONS

PDI IMPLEMENTATION

In lieu of the requirements specified in VIII-4110(a)-(h) PDI will qualify component substitutions in generic procedures by including any new components into personnel demonstrations.

Satisfactory personnel demonstrations using components different than originally specified will qualify the new component.

VIII-4110 PULSERS, RECEIVERS, AND SEARCH UNITS

The qualified procedure may be modified to substitute or replace pulsers, receivers, or search units without requalification when the following conditions are met.

- (a) Instruments with reject, damping, or pulse tuning controls, have discrete settings specified in the prr cedure.
- (b) Pulsers and receivers shall be evaluated using ASTM E 1324, Guide for Measuring Some Electronic Characteristics of Ultrasonic Instruments, with the following exceptions:
 - The lower (F_L) and upper (F_U) limits for receivers shall be determined between frequencies that are 6 dB below the peak frequency.
 - (2) The receiver center frequency (F_C) shall be determined by:

$$F_c = \frac{F_L + F_L}{2}$$

(3 The receiver band width (BW) shall be determined by:

$$BW = \frac{Fv - FL}{Fc} \times 100$$

- (c) Search units shall be evaluated using ASTM E 1065, Evaluation of the Characteristics of Ultrasonic Search Units.
- (d) Examination systems shall be evaluated using Supplement 1.

Owners or vendors may qualify equipment for substitution using PDI personnel demonstration or as described in VIII-4110 (a)-(h).

ARTICLE VIII-4000 ESSENTIAL VARIABLE TOLERANCES

REQUIREMENT

(e) Replacements of t = instrument or the pulser section of the instrument system shall be within the following tolerances of the original equipment as measured into a 50 ohm, noninductive, noncapacitive, resistive load:

- (1) pulse amplitude, ±10%;
- (2) pulse rise time, $\pm 10\%$;
- (3) pulse duration, $\pm 10\%$
- (f) Replacements of the instrument or the receiver section of the instrument system shall be within the following tolerances of the original equipment:
 - lower and upper frequency limits at the -6 dB point, ±0.2 MHz:
 - (2) center frequency for instrument receivers with bandwidths less than 30%, ±5%;
 - (3) center frequency for instrument receivers with bandwidths equal to or greater than 30%, ±10%.
- (g) Replacements of search units shall be within the following tolerances of the original search units:
 - (1) propagation mode is the same
 - (2) measured angle, $\pm 3 \deg$.
 - (3) center frequency for search units with bandwidths less than 30%, ±5%
 - (4) center frequency for search units with bandwidths equal to or greater than 30%, ± 10%
 - (5) waveform duration, ± ∀ cycle or 20%, whichever is greater (measured at -20 dB), or bandwidth, ±10
- (b) As an alternative to (e) through (g) above, equipment replacement is acceptable if the examination system is within the following tolerances of the original system:
 - system center frequency for examination systems with bandwidths less than 30%, ±5%
 - (2) system center frequency for examination systems with bandwidths equal to or greater than 30%, ±10%
 - (3) system bandwidth, ±10%

PDI IMPLEMENTATION

ARTICLE VIII-4000 ESSENTIAL VARIABLE TOLERANCES

REQUIREMENT

PDI IMPLEMENTATION

VIII-4120 SEARCH UNIT CHARACTERIZATION

Characterization measurements of the search unit shall be made using either a sinusoidal tone burst technique or shock excitation. When using shock excitation, the characterization pulser and UT instrument pulser shall be the same within the limits of VIII-4110(e).

ARTICLE VIII-5000 RECORD OF QUALIFICATION

REQUIREMENT

VIII-5100 GENERAL

The organization's performance demonstration program shall specify the documentation that shall be maintained as qualification records. Documentation shall include identification of personnel, NDE procedures, and equipment and specimens used during qualification, and results of the performance demonstration.

PDI IMPLEMENTATION

Each Owner/Vendor has the responsibility to describe in their performance demonstration program, the documentation to be maintained as qualification records. PDI Program documentation may be adopted by the Owner/Vendor, as applicable, to satisfy a portion of their program requirements.

PDI Program *Protocol* will generate the following as qualification records: identification of personnel, NDE procedures, and equipment and specimens used during qualification, and results of the performance demonstration. In accordance with Procedure PDP-Q-017 each qualification shall be documented on a performance demonstration qualification summary which meets the requirements of PDI Procedure PDP-Q-009.1.

APPENDIX VIII - SUPPLEMENTS

SUPPLEMENT 1 EVALUATING ELECTRONIC CHARACTERISTICS OF ULTRASONIC INSTRUMENTS

REQUIREMENT

PDI IMPLEMENTATION

1.0 PULSE RISE TIME, DURATION, AND AMPLITUDE

- 1.1 The pulser evaluation shall be performed with a 50 ohm noninductive resistive load. Additional loads, including search units, may be used. However, significant impedance mismatches may occur, which can cause variable results. A description of any additional loads shall be included in the report.
- 1.2 Connect the ultrasonic instrument, cables, attenuator, terminators, and oscilloscope as shown in Fig. VIII-S1-1.
- CAUTION: Pulser circuits can produce very high pulse voltages that may exceed attenuator maximum voltage limits. Choose an attenuator that can handle the peak pulser voltage.

Set the pulser module frequency control to the frequency of interest. (This is only necessary if the instrument has a tuned pulse shape. An example of a tuned and broadband pulse are shown in Fig. VIII-S1-2.) Set the pulse shape modification controls (e.g., pulse length, pulse tuning, damping) to obtain a minimum pulse length and adjust the oscilloscope to obtain a display as shown in Fig. VIII-S1-3 or Fig. VIII-S1-4.

- NOTE: In order to obtain a display that clearly shows the leading edge of the pulse, it may be necessary to trigger the oscilloscope externally from the clock logic signal or utilize an oscilloscope with built-in delay.
- 1.3 The interconnection between the ultrasonic instrument and the oscilloscope shall be made such that a characteristic impedance of 50 ohms is maintained. The cable length shall be kept as short as possible.
- CAUTION: Pulser circuit output pulses can exceed maximum oscilloscope input levels. Use protective probes where necessary.

1.1 PDI performed a few electronic characterizations in accordance with Instruction No. PDP-I-012.1 written to meet this supplement. It is the owner/vendor's responsibility to implement this supplement if they choose to do so. PDI will not use this supplement to substitute equipment listed in a PDI generated examination procedure.

1.2

1.3

REOUIREMENT

1.4 Pulse Rise

- (a) The pulse rise time T_R for a broadband pulse is the 1.4(a) time interval (in ns) between the 10% and 90% points (relative to the peak amplitude) on the leading edge of the pulse shape as shown in Fig. VIII-S1-3.
- (b) TR for a tuned pulse is the time interval between 1.4(b) the 10% and 90% points (relative to the peak amplitude) on the leading edge of the pulse shape as shown in Fig. VIII-S1-4.
- (c) The PULSE RISE TIME MIN for the 50 ohm load is the TR with the pulse shape modification controls set for the minimum pulse length. The PULSE RISE TIME - MAX for the 50 ohm load is the TR with the pulse shape modification controls set for the maximum pulse length. These values shall be recorded.

1.5 Pulse Amplitude

- (a) The pulse amplitude for a broadband pulse with a 1.5(a) specified pulse load is the peak amplitude of the pulse (in volts) as shown in Fig. VIII-S1-3.
- (b) For the tuned pulse, the pulse amplitude is 1.5(b) determined by measuring the peak amplitude of the positive and the negative portions of the pulse as shown in Fig. VIII-S1-4 and summing these two values. The amplitude of the positive and the negative peaks shall be reported separately.
- (c) The PULSE AMPLITUDE MIN for the 50 ohm 1.5(c) load is the pulse amplitude with the pulse shape modification controls set for minimum pulse length. The PULSE AMPLITUDE - MAX for the 50 ohm load is the pulse amplitude with the pulse shape modification controls set for maximum pulse length. These values shall be recorded.

1.6 Pulse Duration

(a) The pulse duration Tp for a broadband pulse with the 50 ohm pulse load is the time (in microseconds) corresponding to the time interval between the 10% point on the leading edge of the pulse shape and the 10% point on the tailing edge of the pulse shape (relative to the peak amplitude) as shown in Fig. VIII-S1-5.

PDI IMPLEMENTATION

1.4(c)

1.6(a)

1.6(b)

REQUIREMENT

PDI IMPLEMENTATION

- 1.6 Pulse Duration (Cont'd)
 - (b) For a tuned pulse, T_D is determined by super imposing curves representing the envelope of the pulse as shown in Fig. VIII-S1-6. The pulse duration is determined in the following manner:







FIG. VIII-S1-2 PULSE DISPLAY







Pulse amplitude = positive side amplitude + negative side amplitude









FIG. VIII 51-5 TUNED PULSE EVALUATION FOR PULSE DURATION

2.1

2.2

REQUIREMENT

PDI IMPLEMENTATION

1.6 Pulse Duration (Continued)

- STEP 1: Construct lines on the positive and negative sides of the zero voltage line at an amplitude equal to 10% of the respective peak amplitudes.
- STEP 2: TD is the maximum time interval between the points where the 10% lines from Step 1 intersect the pulse envelope as shown in Fig. VIII-S1-6.
 - (c) The PULSE DURATION MIN for this pulse load 1.6(c) is T_D with the pulse shape modification controls set for minimum length. The PULSE DURATION MAX for this pulse load is T_D with the pulse shape modification controls set for maximum pulse length. These values shall be recorded.

2.0 RECEIVER SECTION FREQUENCY CHARACTERISTICS

- 2.1 Connect the ultrasonic instrument, protective circuit, variable delay gate generator, function generator, oscilloscope, step attenuator, and terminator, as shown in Fig. VIII-S1-7. The variable delay gate generator is used to provide a function generator trigger which is time delayed. The oscilloscope is used to monitor the function generator output, which is the unattenuated input signal to the ultrasonic instrument receiver section. the ultrasonic instrument CRT is used to monitor the receiver output. The impedance of each portion of this system shall be matched.
- 2.2 CAUTION: The ultrasonic instrument shall be in the through-transmission mode to isolate the pulser circuit from the receiver section. This is to avoid possible damage to the step attenuator and/or function generator. The protective circuit is a diode clamp or voltage divider that keeps the high pulse voltage from damaging the variable delay gate generator input.
 - (a) For instruments that have a substantial portion of the receiver located before the throughtransmission input, set the pulse length controls in their maximum position, disable the pulse output, and set the instrument in the pulse-echo mode.

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REQUIREMENT

2.2 CAUTION: (Continued)

- (b) If the receiver provides variable signal filtering, the signal filtering control shall be set for minimum or zero filtering. Set the receiver reject control to minimum or OFF. Set the receiver frequency control to the frequency range of interest and adjust the gate generator and function generator to provide a five-cycle sine wave whose frequency corresponds to the ultrasonic instrument frequency setting. However, if the ultrasonic instrument will amplify and detect a single-cycle burst instead of a five-cycle, this may be used. Set the calibrated attenuator to 0 dB attenuation and adjust the variable delay gate generator to provide a signal located midway across the CRT. (The ultrasonic instrument sweep rate is irrelevant to these measurements.) Adjust the receiver section gain controls and the function generator output amplitude to 80% full scale. (A preliminary scan of the frequency range may be desirable to determine the frequency of maximum response.)
- (c) Repeat the above measurements, varying the function generator frequency in 0.5 MHz increments above and below the receiver module frequency control setting until the CRT indication decreases to 10% of its maximum value. At each frequency increment, the function generator output amplitude shall be adjusted as required to maintain a constant amplitude input to the receiver Section. At each frequency increment, record the CRT amplitude (in present full scale) versus frequency measured with the oscilloscope. Plot the results as shown in Fig. VIII-S1-8.
- NOTE: The 0.25 MHz and 20 MHz points shall normally be the extent of measurement necessary to determine the frequency characteristics of the receiver. These limits may be reached before the CRT indication decreases to 10% of its maximum value.
 - (d) If the ultrasonic instrument is to be operated with filtering, the measurements described shall be repeated at the corresponding filtering levels.

PDI IMPLEMENTATION

2.2(b)

2.2(c)

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REQUIREMENT

PDI IMPLEMENTATION

2.3 Receiver Frequency Results

- (a) Lower Frequency Limit FL. The lower 2.3(a) frequency limit (in MHz) at a specific frequency control setting is the lowest frequency at which the instrument CRT indication is 6 dB below the maximum amplitude as shown in Fig. VIII-S1-8.
- (b) Center Frequency FC. The center frequency (in MHz) at a specific frequency control setting is the frequency at which the instrument CRT indication is maximum, as shown in Fig. VIII-S1-8. The center frequency shall be determine within ±0.1 MHz by decreasing the increment of frequency change in the region near the center frequency.
- (c) Upper Frequency Limit FU. The upper 2.3(c)
 frequency limit (in MHz) at a specific frequency control setting is the highest frequency at which the instrument CRT indication is 6 dB below the maximum amplitude as shown in Fig. VIII-S1-8.
- (d) The measurements described in 2.3(a) through 2.3(c) shall be repeated for each receiver module frequency control setting to determine the LOWER FREQUENCY LIMIT (in MHz) for each setting. These values shall be recorded.

2.3(b)

2.3(d)

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FIG. VIII-S1-1B TEST CONFIGURATION

1



FIG. VIII-S1-2A FREQUENCY RESPONSE CURVE

REQUIREMENT

1.0 SPECIMEN REQUIREMENTS

Qualification test specimens shall meet the requirements listed herein, unless a set of specimens is designed to accommodate specific limitations stated in the scope of the examination procedure (e.g., pipe size and access limitations). The same specimens may be used to demonstrate both detection and sizing qualification.

- General. The specimen set shall conform to the following requirements.
 - (a) Specimens shall have sufficient volume to minimize spurious reflections that may interfere with the interpretation process.
 - (b) The specimen set shall consist of at least four specimens having different nominal pipe diameters and thicknesses. They shall include the minimum and maximum pipe diameters and thicknesses for which the examination procedure is applicable. If the procedure is applicable to pipe diameters of 24 in. or larger, the specimen set must include at least one specimen 24 in. or larger in diameter with the maximum thickness covered by the procedure, but need not include the maximum diameter.
 - (c) The specimen set shall include examples of the following fabrication condition:
 - (1) unground weld reinforcement (crowns);
 - wide crowns, such that the total crown width is 1 1/2 to 2 times the nominal pipe wall thickness;

PDI IMPLEMENTATION

- 1.0 The PDI Program test specimens have been designed to meet all requirements of Supplement 2 as delineated below. A wide range of specimen sizes and geometric configurations is available to demonstrate owner/vendor procedures.
- 1.1(a) Specimens have been designed and fabricated with sufficient volume to minimize spurious reflections that may interfere with the interpretation process.
- 1.1(b) PDI performed an industry-wide survey on the range of sizes and geometric conditions and sizes that exist within the industry. (i.e.: counter bore, weld crown widths and weld roots.) For list of sizes see Appendix -C.

The PDI Program has provided an adequate quantity of samples to address piping ranges found in member utility facilities.

PDI will allow a .1 inch tolerance on minimum thickness, a .5 inch tolerance for maximum thickness on austenitic piping, and a 1.0 inch tolerance for the maximum thickness qualified on ferritic piping during the demonstration. (See PDI Position 94-001).

- 1.1(c) PDI performed an industry-wide survey on the range of sizes and geometric conditions that exist within the industry. (i.e.: counter bore, weld crown widths and weld roots.) For list of sizes see Appendix - C. PDI samples encompass a range of fabrication conditions which fully meet (c)(1) through (c)(4) requirements.
- 1.1(c)(1) PDI has developed general and specific design requirements that provide for samples with flat-topped reinforcement. Weld crowns will be masked if the procedure requires examination through unground crowns.
- 1.1(c)(2) PDI has developed general and specific design requirements that provide for samples with wide crowns.

1.1 General. (Continued)

- (3) geometric conditions that normally require discrimination from flaws (e.g., counterbore, weld root conditions such as excessive I.D. reinforcement);
- (4) typical limited scanning surface conditions,
 (e.g., diametrical shrink, single-side access due to safe ends or fittings).
- 1.1(c)(3) PDI has developed general and specific design requirements that provide for samples having various internal geometric conditions.
- 1.1(c)(4) PDI has developed general and specific design requirements that provide for samples having scan limitations.

REQUIREMENT

- 1.1 General. (Continued)
 - (d) All flaws in the specimen set shall be cracks.
 - Mechanical fatigue cracks and either IGSCC or thermal fatigue cracks shall be used. At least 75% of the cracks shall be either IGSCC or thermal fatigue cracks
 - (2) At least 50% of the cracks shall be coincident with areas described in 1.0(c) above
- 1.2 Detection Specimens The specimen set shall include detection specimens that meet the following requirements:
 - (a) Specimens shall be divided into grading units. Each grading unit shall include at least 3 in. of weld length. If a grading unit is designed to be unflawed, at least 1 in. of unflawed material shall exist on either side of the grading unit. The segment of weld length used in one grading unit shall not be used in another grading unit. Grading units need not be uniformly spaced around the pipe specimen.

PDI IMPLEMENTATION

- 1.1(d) All flaws in the PDI specimen sets are cracks.
- 1.1(d)(1) All flaws are cracks. Field removed IGSCC specimens are being used in the performance demonstration process. Non-IGSCC test sets include the required amount of mechanical and thermal cracks.
- 1.1(d)(2) PDI's test administration instruction (PDP-I-009.4.1) ensures that these conditions are addressed and documented.
- The PDI detection specimens meet the following requirements.
- 1.2(a) The PDI Program designed and fabricated specimens which contain flawed and unflawed areas (grading units) which fully comply with the requirements of 1.2(a). In addition, PDI applied a Quality Assurance program to verify compliance with specimen design and fabrication requirements.

TABLE VIII-S2-1 PERFORMANCE DEMONSTRATION DETECTION TEST ACCEPTANCE CRITERÍA

Detection Test Acceptance Criteria		False Call Test Acceptance Criteria		
No. of Flawed Grading Units	Minimum Detection Criteria	No. of Unflawed Grading Units	Maximum Number of False Calls	
5	5	10	0	
6	6	12	1	
7	6	14	1	
8	7	16	2	
9	7	18	2	
10	8	20	3	
11	9	22	3	
12	9	24	3	
13	10	26	4	
14	10	28	5	
15	11	30	5	
16	12	32	6	
17	12	34	6	
18	13	36	7	
19	13	3.8	7	

REQUIREMENT

1.2 Detection Specimens (Continued)

- (b) Detection sets shall be selected from Table VIII-S2-1. The number of unflawed grading units shall be at least twice the number of flawed grading units.
- (c) Flawed grading units shall meet the following criteria for flaw depth, orientation, and type.
 - (1) A minimum of 1/3 of the flaws, rounded to the nex. higher whole number, shall have depths between 5% and 30% of the nominal pipe wall thickness. At least 1/3 of the flaws, rounded to the next higher whole number, shall have depths greater than 30% of the nominal pipe wall thickness.

- (2) At least one and a maximum of 10% of the flaws rounded to the next higher whole number, shall be oriented axially. The remainder of the flaws shall be oriented circumferentially.
- (3) Service-induced flaws shall be included when available.

PDI IMPLEMENTATION

- 1.2(b) PDI protocol requires a minimum of 5 flawed grading units and 10 unflawed grading units to be included in a test for procedure qualification. For personnel qualifications, a minimum of 10 flawed and 20 unflawed grading units shall be included in a test set. Detection test sets are selected from Table VIII-S2-1.
- 1.2(c) Flawed and unflawed grading units are randomly placed through the specimen(s) circumference.
- 1.2(c)(1) A PDI computer software program was especially developed to aid the administrator in selecting specimens which meet the requirements of paragraphs 1.1, 1.2, and 1.3 in assembling test sets. The exceptions to this rule are IGSCC specimens and independently administered length sizing test.

Due to the fact that the IGSCC flaws in the piping test specimens are service induced and were removed from operating power plants, compliance with the through wall sizing distribution requirements are not mandatory.

Also paragraph 3.8.1.C of Instruction PDP-I-009.4.1 states, "When length sizing tests are administered independently the flaw through wall depth requirements do not apply."

(See PDI Position 95-001)

- 1.2(c)(2) PDI Specimen Test Sets assure that at least one and a maximum of 10% of the flaws are oriented axially. Inprocess verification and receipt inspections were performed to ensure that flawed and unflawed areas were fabricated in accordance with the requirements of ASME Section XI, Appendix VIII, and PDI specification requirements for flaw orientation.
- 1.2(c)(3) PDI samples include piping welds with flaws that were removed from operating nuclear power plants.

REQUIREMENT

- 1.3 Sizing Specimens The specimen set shall contain sizing specimens that meet the following requirements:
 - (a) The minimum number of flaws shall be ten.
 - (b) Flaws in the sample set shall be distributed as follows:

PDI IMPLEMENTATION

- 1.3 The PDI sizing specimens meet the following requirements.
- 1.3(a) The PDI Program provided for a minimum of ten flaws which are used for both depth and length sizing.
- 1.3(b) PDI Program depth sizing flaws are distributed in accordance with the Table in Section 1.3(b). See Section 1.2(c)(1) for length sizing specimens when length sizing is performed with detection examinations.

Flaw Depth	Miraimum	
(% Wall Thickness)	Number of Flaws	
5 - 30%	20%	
31 - 60%	20%	
61 - 100%	20%	

The remaining flaws shall be in any of the above categories.

2.0 CONDUCT OF PERFORMANCE DEMONSTRATIONS

The specimen inside surface and identification shall be concealed from the candidate. All examinations shall be completed prior to grading the results and presenting the results to the candidate. Divulgence of particular specimen results or candidate viewing of unmasked specimens after the performance demonstration is prohibited.

 Detection Test. Flawed and unflawed grading units shall be randomly mixed.

2.2 Length and Depth Sizing Test.

(a) For the length sizing test, the regions of each specimen containing a flaw to be sized shall be identified to the candiate. The candidate shall determine the length of the flaw in each region. All specimens are mounted or capped to conceal the inside surface. All specimens are constantly under direct monitoring, video surveillance, or in locked storage. PDI has developed a security program to safeguard and hold in confidence the specimens, the manufacturing data and the results of the performance demonstration qualifications. Grading results are presented to the candidate after the examination is completed.

- 2.1 In-process verification and receipt inspections were performed in accordance with the PDI Q.A. Prog., to ensure that flawed and unflawed grading units were fabricated in accordance with the requirements of ASME Section XI, Appendix VIII, and PDI specifications
- 2.2(a) The length sizing test is administered in conjunction with the detection test. See comment 1.2.(c)(1). When retest are performed for length sizing only, the flawed regions are identified to the candidate, except for IGSCC flawed specimens.

Due to the security of the IGSCC specimens, flawed regions are never identified to the candidates. The candidate must detect and length size the flaw as in the detection demonstration.

(See PDI Position 95-002)

REQUIREMENT

(b) For the depth sizing test, 80% of the flaws shall be sized at a specific location on the surface of the specimen identified to the candidate. For the remaining flaws, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region.

3.0 ACCEPTANCE CRITERIA

- 3.1 Detection Acceptance Criteria. Examination procedures, equipment, and personnel are qualified for detection when the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for both detection and false calls.
- 3.2 Sizing Acceptance Criteria. Examination procedures, equipment, and personne! are qualified for sizing if the results of the performance demonstration satisfy the following criteria:
 - (a) flaw lengths estimated by ultrasonics are within 1 in. of the true length;
 - (b) The RMS error of the flaw depths estimated by ultrasonics, as compared with the true depths, is less than 0.125 in. RMS error shall be calculated as follows:



where

 $m_1 = measured flaw depth$

n = number of flaws measured

PDI IMPLEMENTATION

- 2.2(b) Depth sizing flaws are identified to the candidate. All depth sizing is performed in a two inch window. This is done to ensure that depth sizing is performed in the region where the true flaw depth is known most accurately (see PDI Position 94-006).
- 3.1 All of the requirements of paragraph 3.1 and 3.2 are being met. Additionally, during the demonstration process, the candidate's ability to discriminate between flaw and geometric responses in accordance with the procedure essential variables, is verified during the surveillance activities.
- 3.2 UT Systems are qualified for sizing when the following requirements are met:
- 3.2(a) The ± 1 inch error tolerance is replaced by a .75 inch Root Mean Square (RMS) error from flaw true sizes. PDI considers the RMS error to be a more fair and truer evaluation of examiner capability. Justification for this Code variance is provided in PDI Position 94-002, and 94-005 contained in Appendix B to this program description.
- 3.2(b) The formula in paragraph 3.2(b) is used to calculate the RMS error. Sizing results are acceptable when the RMS error is equal to or less than .125 inch. This change is necessary so that Supplement 12, 2.0(c) and this paragraph agree.

SUPPLEMENT 3 QUALIFICATION REQUIREMENTS FOR FERRITIC PIPING WELDS

REQUIREMENT

Qualification of examination procedures, equipment, and personnel for ferritic pipe examination shall be accomplished by satisfying the requirements of Supplement 2, except that the sample material shall be ferritic and 75% of the sample set defects [Supplement 2, para. 1.0(c)(2)] shall be mechanically or thermally induced fatigue cracks.

PDI IMPLEMENTATION

PDI procedure PDP-I-009.4.2 requires that qualification for ferritic pipe only shall be accomplished by satisfying the requirements of Supplement 2 except that the sample material shall be ferritic and 75% of the sample set defects shall be mechanical or thermal fatigue cracks. (See PDI Positions 94-004 and 94-007 in Appendix-B to this document). LINE A. Linear regression line, y = a + bx, giving the best fit of n data points $(x_1, y_1), \dots, (x_n, y_n)$ obtained by the least-square method where,

$$e = y$$
 intercept = $\frac{\Sigma Y_i}{N} - b \frac{\Sigma x_i}{N}$



 $\frac{N\Sigma x_j Y_j - (\Sigma x_j) (\Sigma Y_j)}{N\Sigma x_j^2 - (\Sigma x_j)^2}$

· number of dete points

n



LINE B: Ideal line, y = x (perfect UT measurements).

.

CORRELATION COEFFICIENT: Correlation coefficient, defined as

$$r = \sqrt{[n\Sigma x_{j}^{2} - (\Sigma x_{j})^{2}] [n\Sigma y_{j}^{2} - (\Sigma y_{j})^{2}]}$$

is a measure of "how well" the least-equare regression line its the data with respect to the ideal of y = x.

MEAN DEVIATION: Meen deviation is an indicator of accuracy of the measurements defined as

Mean Deviation =
$$\frac{|d_1| + |d_2| + \dots + |d_n|}{n}$$

NOTES:

 Standard Methematical Tables, 25th ed., William H. Beyer, Ph. D., Ed., CRC Press, Inc., Boca Reton, FL, 1978.

(2) Percent through-well units apply to Supplements 2 and 3. Flaw depth units apply to Supplements 4 through 7.

FIG. VIII-S4-1 DEFINITION OF STATISTICAL PARAMETERS

SUPPLEMENT 4 QUALIFICATION REQUIREMENTS FOR THE CLAD / BASE METAL INTERFACE OF REACTOR VESSEL

REQUIREMENT

1.0 SPECIMEN REQUIREMENTS:

Qualification test specimens shall meet the requirements listed herein unless a set of specimens is designed to accommodate specific limitations stated in the scope of the examination procedure. The same specimens may be used to demonstrate both detection and sizing qualifications.

- 1.1 Detection Specimens Detection specimens, which may be full-scale mock ups, shall conform to the following requirements:
 - (a) Specimens shall have sufficient volume to minimize spurious reflections. Specimen length and width shall be at least 12 in. There shall be at least 10 square feet of clad surface in the specimen set.
 - (b) (1) When the examination procedure requires the examination to be performed from the vessel I.D. (clad surface), the specimen minimum thickness shall be 3 m. or the maximum thickness of the vessel (whichever is less).
 - (2) When the examination procedure requires the examination to be performed from the vessel O.D. surface, the specimen shall be at least 90% of the maximum thickness to be examined.
 - (c) The performance demonstration shall be on the same type cladding as that to be examined, with the following exceptions:
 - demonstration on shielded metal arc weld (SWAW) single-wire cladding is transferable to multiple-wire or strip-clad processes;
 - (2) demonstration of multiple-wire or strip-clad are considered equivalent but is not transferable to SMAW-type clad.

PDI IMPLEMENTATION

1.0

PDI Test specimens meet all of the requirements of Appendix VIII. Supplement 4, as described hereafter and will be used to demonstrate both detection and sizing qualifications

- 1.1 PDI Program detection specimens are full scale mockups manufactured from material removed from cancelled BWR and PWR Reactor Pressure Vessels.
- (a) Spurious reflections are minimized by the use of full size mockups. The minimum specimen length and minimum width is greater than the 12 in. minimum required.

PDI Program Implementing Instruction No. PDP-I-009.4.3, requires that each specimen set used for performance demonstration will include a minimum of 10 sq. ft. of clad surface.

- (b)(1) Demonstration of examination procedures applied from the vessel ID (clad surface) will be performed from the clad surface of the PDI specimens. The PDI minimum specimen size is 6.75 in. nominal thickness, and will be used to satisfy the minimum thickness requirement.
- (b)(2) The PDI Program requires via Instruction No. PDP-I-009.4.3, that demonstrations of examination procedures from the OD be performed from the OD surface. The test specimens used for performance demonstration will be a minimum of 90% of the maximum thickness to be examined in accordance with Instruction No. PDP-I-009.4.3.
- (c) The performance demonstration examination volume of PDI Program test specimens has been clad using a shielded metal arc weld (SMAW) single wire procedure, which is transferable to cladding applied by other methods per Code paragraph 1.1(c)(1).
- (c)(1) The demonstration will be on SMAW and is transferable to multiple-wire or strip clad components.
- (c)(2) Demonstrations of multiple-wire or strip clad are not possible using PDI specimens.

SUPPLEMENT 4 QUALIFICATION REQUIREMENTS FOR THE CLAD/BASE METAL INTERFACE OF REACTOR VESSEL

REQUIREMENT

- 1.1 Detection Specimens: (Continued)
 - (d) The surface condition of the test specimens shall be representative of the general condition of the vessel scanning surface.
 - (e) The detection test matrix shall include flaws with the following description.
 - (1) Flaw Type. At least 50% of the flaws shall be cracks. The balance of flaws may be cracks, fabrication defects (e.g., slag inclusions), or machined notches. Machined notches shall meet the following requirements:
 - (a) notches shall be perpendicular to the surface within ± 2 deg.;
 - (b) notches shall have a maximum width of 0.010 in. and shall be plugged to their full depth with an insert of the parent material prior to cladding.
 - (2) All flaws shall emanate from the clad base metal interface and shall propagate predominately into the base metal. A minimum of 40% of the flaws shall be oriented parallel to the clad direction (within ± 10 deg.) and a minimum of 40% shall be oriented perpendicular to the clad direction (within ± 10 deg.).

PDI IMPLEMENTATION

- (d) The surface condition of the test specimens is considered by the PDI to be generally representative of the surface conditions found in the majority of United States operating nuclear reactor pressure vessels.
- (e) The PDI Program detection test matrix contains flaws of the following description.
- (e)(1) Greater than 50% of the PDI Program flaws in the Supplement 4 examination volume of the test specimens are cracks. Within any individual test set at least 50% of the flaws shall be cracks. By PDI Program Instruction No. PDP-I-009.4.3, the balance of flaws may be a combination of cracks, fabrication defects such as slag inclusions or machined notches.
- (e)(1)(a) where notches are used they are perpendicular to the surface within +/-2 deg.;
- (e)(1)(b) notches in PDI test specimens have been manufactured using procedures that have repeatedly shown the notch tip dimension to be less than 0.010 in. The actual width of the notch at the clad to base metal interface may be greater than 0.010 in. All notches were plugged to their full depth prior to cladding. Justification for this deviation is provided in PDI Position 94-003.
- (e)(2) All flaws in the Supplement 4 examination volume emanate from the clad base metal interface and propagate into the base material.

50% of the flaws in the Supplement 4 examination volume of PDI test specimens are oriented parallel to the clad direction (within +/- 5 degrees). The remaining 50% are oriented perpendicular to the clad direction (within +/-5 degrees). Each Procedure demonstration test set will have a minimum of 40% of flaws oriented Parallel and a minimum of 40% presented perpendicular to the clad direction. <u>Each personnel demonstration test</u> set will contain c representative distribution of flaw orientations, sizes and locations.

(See PDI Position 9:-011) (See also PDI Positions 95-004 and 95-005)

SUPPLEMENT 4 QUALIFICATION REQUIREMENTS FOR THE CLAD / BASE METAL INTERFACE OF REACTOR VESSEL

REQUIREMENT

PDI IMPLEMENTATION

1.1 Detection Specimens: (Continued)

Detection Test Acceptance Criteria				
No. of Flaws		Minimum Detection Criteria		
 7		7		
8		8		
9		9		
10		10		
11		11		
12		11		
13		12		
14		13		
15		14		
16		14		

TABLE VIII-S4-1 PERFORMANCE DEMONSTRATION DETECTION TEST ACCEPTANCE CRITERIA

(3) The flaw sizes shall be uniformly distributed in through-wall depths (inches) among the ranges:

17

18

19

20

- (a) 0.075-0.200
 (b) 0.201-0.350
 (c) 0.351-0.550
- (d) 0.551-0.750

No flaw shall have an aspect ratio (depth/length) less than 0.1.

(f) The number of flaws in the detection test matrix shall be selected from Table VIII-S4-1. The rules of IWA-3000 shall be used for determining whether closely spaced flaws should be treated as separate flaws. (e)(3) Flaws selected for detection test will be from the four categories (a, b, c, d) as specified, except that:

15

16

17

18

a. Flaws smaller than the 50% of allowable flaw size, as defined in IWB-3510-1, will not be included as detection flaws. For procedures applied from the inside surface, use the minimum thickness specified in the Scope of the procedure, to calculate a/t. For procedures applied from the outside surface, the actual thickness of the test specimen is used to calculate a/t.

PDI Program test specimen flaws do not have aspect ratios (depth/length) less than 0.1

(See PDI Position 95-003)

(f) The number of flaws used for grading of the detection test set will be a minimum of 7 for procedure qualification. For personnel qualification, the total of supplement 4 and 6 flaws shall be at least 10, and at least 50% of these shall be Supplement 4 flaws. Other flaws may be present in the examination area.

The rules of IWA-3000 shall be used for determining whether closely spaced flaws should be treated as separate flaws.

(See PDI Position 95-004)

SUPPLEMENT 4 QUALIFICATION REQUIREMENTS FOR THE CLAD/BASE METAL INTERFACE OF REACTOR VESSEL

REQUIREMENT

1.2 Sizing Specimens

(a) The sizing test matrix shall contain a minimum of ten flaws, at least half of which shall be cracks. 1.2

(a) For procedure qualification, PDI Program Implementing Instruction PDP-I-009.4.3 requires that the sizing test matrix will be selected to contain a minimum of ten flaws. For personnel qualification, the total of supplement 4 and 6 sizing flaws shall be at least 10, and that at least 50% of these shall be Supplement 4 flaws. At least half of the flaws in any sizing test matrix will be cracks.

(See PDI Position 95-005)

- (b) Sizing specimens shall conform with the requirements of 1.1(b), 1.1(c), 1.1(d), and 1.1(e).
- (b) The detection specimens meet the specified requirements of Supplement 4 Code paragraphs 1.1(b), 1.1(c), 1.1(d), and 1.1(e). The detection specimens will also be used for sizing.

2.0 CONDUCT OF PERFORMANCE DEMONSTRATIONS:

2.1 Detection Test

(a) Specimen identification and flaw locations shall be obscured so as to maintain a "blind test." All examinations shall be completed prior to grading the results and presenting the results to the candidate. Divulgence of particular specimen results or candidate viewing of unmasked specimens is prohibited. 2.1

(a) A specimen identification will be provided to the candidate. The flaw locations within the test specimens are obscured providing a "blind test."

PDI procedures require that all detection examinations (analysis of data) will be completed prior to grading the results. The individual flaw results will not be divulged; however, information on the type of errors made, for example, *Missed Detection*, *False Calls etc.* will be provided. Candidates will be able to view specimens since all flaw locations are disguised. (See PDI Position 94-007).

PDI IMPLEMENTATION
SUPPLEMENT 4 QUALIFICATION REQUIREMENTS FOR THE CLAD/BASE METAL INTERFACE OF REACTOR VESSEL

REQUIREMENT

2.1 Detection Test (Continued)

(b) When a flaw is reported within 1/2 in. of it true location (x and y) it shall be considered detected. All other reported flaws shall be considered false calls.

2.2 Length and Depth Sizing Test

- (a) For the length sizing test, the inside surface and specimen identification shall be obscured. The regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the length of the flaw in each region.
- (b) For the depth sizing test, 80% of the flaws shall be sized at a specific location on the surface of the specimen identified to the candidate. For the remaining flaws, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region.

PDI IMPLEMENTATION

2.1

(b) <u>A flaw will be considered detected when reported within</u> <u>1.0 inch</u> of the true X, Y and Z location or the error allowed by Code Case N-545 <u>whichever is larger</u>

Location accuracy is for grading purposes only. Mathematical errors, systematic location errors, and other errors which exceed the allowable detection criteria, may be accepted by the PDA, provided:

- 1. There is no doubt that the reported indication is related to the actual flaw.
- 2. The error did not result from misinterpretation of the ultrasonic signals
- 3. The results of the investigation is documented and justified.

(See PDI Position 95-004)

2.2

- (a) Access for sizing will be based on the exam technique (i.e. ID or OD.) Since flaws are buried, inside surfaces are obscured with cladding. A specimen identification will be provided. The candidate will be required to size the length of each intended flaw reported during the detection test. If required, scan areas containing additional flaws for length sizing will be identified to the candidate.
- (b) For depth sizing, the candidate will be required to size the depth (thru-wall) of each intended flaw reported during the detection test. If required, scan areas containing additional flaws for depth sizing will be identified to the candidate. The candidate shall determine the maximum depth.

SUPPLEMENT 4 QUALIFICATION REQUIREMENTS FOR THE CLAD / BASE METAL INTERFACE OF REACTOR VESSEL

REQUIREMENT

3.0 ACCEPTANCE CRITERIA

3.1 Detection Acceptance Criteria

Examination procedures, equipment and are qualified for detection if the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S4-1.

Additionally, the number of false calls shall not exceed A/10

rounded to the next whole number where A is the total scan

area of specimens in the test measured in square feet.

3.1

Examination procedures, equipment, and personnel are qualified for detection if the combined results of the performance demonstration satisfy the acceptance criteria of Table VIII-S4-1 or <u>VIII-S6-2 where combined Supplement 4</u> <u>& 6 demonstrations are performed</u>. Additionally, during the demonstration process, the candidate's ability to discriminate between flaw and geometric responses in accordance with the procedure essential variables is verified during the surveillance activities, using instruction PDP-Q-018.3.

(See PDI Position 95-004)

The acceptable number of false calls is determined by the surface area scanned in the performance demonstration sample set. A false call is defined as reporting a non-flawed area as flawed. False calls in excess of the allowed number will result in an unsuccessful performance demonstration.

False Calls \leq A/10 (Rounded to the next Larger Whole Number)

A = Total Area Scanned (Square Feet)

The total area scanned "A" is defined as the cumulative scan area for the examination volume (total x-scan axis length X total y-scan axis length) for scans performed perpendicular to the area of interest and scans performed parallel to the area of interest.

3.2 Sizing Acceptance Criteria

Examination procedures, equipment and personnel are qualified for sizing if the results of the performance demonstration satisfy the following criteria:

- (a) no flaw is undersized for depth by more than 0.2 in.;
- (b) flaw lengths estimated by ultrasonics shall be the true length -1/4 in., + 1 in.;

It has become necessary for PDI to adopt sizing acceptance criteria which differ from those specified in the Code. Refer to PDI Position 94-005 and 94-010.

- (a) Critical miscall requirements have been removed from PDI Sizing Acceptance Criteria, see PDI Position 94-010.
- (b) An RMS method of grading will be used. The RMS error of the ultrasonic flaw length measurements, compared to the true flaw length, must be equal to or less than 0.750in. Refer to PDI Position 94-605 for justification for this deviation.

PDI IMPLEMENTATION

SUPPLEMENT 4 QUALIFICATION REQUIREMENTS FOR THE CLAD / BASE METAL INTERFACE OF REACTOR VESSEL

REQUIREMENT

3.0 ACCEPTANCE CRITERIA (Continued)

3.2 Sizing Acceptance Criteria (Continued)

(c) performance demonstration results reported by the candidate, when plotted on a two-dimensional plot (Fig. VIII-S2-1) with the depth estimated by ultrasonics plotted along the ordinate and the true depth plotted along the abscirsa, satisfy the following statistical parameters:

PDI IMPLEMENTATION

3.2

(c) The criteria of 3.2(c) (1)-(3), are replaced by an equivalent RMS criteria. The measured flaw depth, as compared to the true depth shall be equal to or less than an error of 0.15 inch RMS. Refer to PDI Position 94-010 for justification of this deviation.

For combined Supplement 4 and 6, personnel gualification, the acceptance criteria for Supplement 4 will be applied to Supplement 4 flaws and Supplement 6 for Supplement 6 flaws

(See PDI Position 95-005)

- slope of the linear regression line is not less than 0.7;
- (2) the mean deviation of flaw depth is less than 0.25 in.;
- (3) correlation coefficient is not less than 0.70.

SUPPLEMENT 5 QUALIFICATION REQUIREMENTS FOR NOZZLE INSIDE RADIUS SECTION

REQUIREMENT

Demonstrations on clad/base metal interface of reactor vessel plate specimens (Supplement 4) qualifies examination procedures, equipment and personnel for nozzle inside radius section examination when the following requirements are met.

(a) For detection, a minimum of three additional flaws at the inside radius section in one or more full scale nozzle mock-ups (supplement 7) shall be added to the test set. PDI IMPLEMENTATION

The PDI Program is designed to qualify examination procedures, equipment and personnel for nozzle inside radius section examination when the following requirements are met:

- (a) PDI has fabricated two full size PWR nozzle mockups, simulating both inlet and outlet configurations. Five BWR mockups are available if they are needed to expand the scope of a procedure performed from the inside surface. For procedure qualifications, applicable to PWR RPVs, a minimum of three flaws will be included in both the inlet and outlet nozzles. For "analysis only" personnel qualifications, the following shall apply:
 - 1. Where the analysis equipment and the ultrasonic technique are basically the same as the Supplement 4 application, no further demonstrations will be required.
 - Where the techniques differ substantially, a demonstration set of a minimum of three flaws will be provided. These will be distributed in either the inlet or outlet configuration or both as appropriate.

(See PDI Position 95-008)

The specimens comply with Supplement 4, 1.1. Flaw types will generally be cracks. However, some notches may be used.

All flaws are located within the radial axial plane of the nozzle inside radius section as illustrated by Fig.IWB-2500-7.

The PDI BWR nozzle specimens have been designed to facilitate OD examination surface procedures. The dimensions of the specimens were developed to include dimensions suitable that these requirements can be met for most BWR RPV's.

The specimens shall comply with Supplement 4, 1.1, but flaws may be either notches or cracks.

Flaws shall be located in the radial axial plane of the nozzle inside radius section shown in Fig. IWB-2500-7.

If the examination procedure requires the examination to be performed from the vessel OD surface, at least one notice in the specimen set shall be at least 90% of the maximum thickness t_{n2} in Fig IWB-2500-7, to be examined and the ratio of the nozzle thickness to shell thickness shall be within $\pm 30\%$ of that ratio for the vessel nozzles to be examined.

SUPPLEMENT 5 QUALIFICATION REQUIREMENTS FOR NOZZLE INSIDE RADIUS SECTION

REQUIREMENT

(a) (Continued)

If the examination procedure requires the examination be performed from the inside surface, the specimen shall have the minimum nozzle diameter covered by the procedure.

Each of the flaws presented for demonstration shall be correctly identified in accordance with Supplement 4, 2.1 with no false calls. Demonstrations on Clad nozzle mockups may be used for examination of unclad nozzles. Demonstrations performed on unclad nozzle mockups shall not be used for examinations of clad nozzles.

- (b) For length sizing, a minimum of three additional flaws as in (a) above shall be added to the test set. All flaws shall be sized to the acceptance standards of Supplement 4.
- (c) For depth sizing, a minimum of three additional flaws as in (a) above shall be added to the test set. Their depths shall be evenly distributed over the ranges of Supplement 4, 1.1(e)(3)(a), 1.1(e)(3)(b), and 1.1(e)(3)(c). The sizing results from these flaws shall be combined with the sizing results from the clad/base metal interface qualification, and combined results shall meet the acceptance criteris of Supplement 4, 3.2.

PDI IMPLEMENTATION

(a) (Continued)

The PDI PWR inlet nozzle specimen has an internal diameter of 28 inches, which is sufficient for demonstrations for PWR inlet and outlet nozzles. BWR mockups are available for smaller nozzles.

Due to the limited sample base it is not possible to provide the same test set diversity as is done for Supplement 4 and 6. As a minimum the PDA will do the following to insure the integrity of the demonstrations:

- Require procedures definitively specify criteria for detection and sizing,
- Require that candidates provide specific evidence that their decisions followed the procedure directions, without apriori information,
- No information as to the true size, location or orientation will be divulged to the candidates, and
- To the extent possible candidates will be assigned separate areas of the test specimens or different specimens.

Candidates for personnel demonstrations will be provided a sampling of the essential variables qualified by the procedure.

Each of the flaws in the examination test set shall be correctly identified. <u>False calls shall not exceed the</u> value established by paragraph 4.1(a) of Code Case N-552.

- (b) PDI will not implement this requirement, see Code Case N-542.
- (c) For depth sizing a minimum of three flaws will be added to the test set. The depth range of these flaws will be <u>distributed</u> over the range required by Supplement 4. The sizing results will be combined with the clad/base metal interface qualification. The acceptance criteria shall be the same as is applied for Supplement 4.

REQUIREMENT

Code Case N-552 ALTERNATIVE METHODS - QUALIFICATION FOR NOZZLE INSIDE RADIUS SECTION FROM THE OUTSIDE SURFACE Section XI, Division 1

1.0 PROCEDURE REQUIREMENTS

The examination procedure shall include or provide for the following

- (a) A computational model that calculates misorientation angles and the maximum metal path distance to the required inspection volume. Misorientation angle is shown in Figure N552-1.
- (b) A scope statement that specifies the maximum acceptable misorientation angle and metal path for the examinations.
- (c) Division of the surface of the required examination volume into grids of 1.0 inch or less in the nozzle axis direction and 10 degrees or less of azimuth.
- (d) Documenting the misorientation angle and metal path distance in each grid cell location for each search unit or scan.
- (e) Documenting the search unit or scan that produces the minimum misorientation angle when multiple search units are used.

2.0 SPECIMEN REQUIREMENTS

Demonstration specimens shall meet the requirements of Supplement 4, except as permitted by (a) through (d) below.

- (a) One or more full size nozzle mockups or sections of full size nozzle mockups shall be used.
- (b) Nozzle mockup material and configurations shall be representative of nozzles installed in operating reactor vessels, but need not match exact thickness, diameter, or radius.

PDI IMPLEMENTATION

PDI WILL ADOPT THIS CODE CASE FOR THE DEMONSTRATION OF NOZZLE INSIDE RADIUS EXAMINATIONS FROM THE OUTSIDE SURFACE.

1.0 PROCEDURE REQUIREMENTS

The examination procedure shall include or provide of the following:

- (a) The capabilities of the proposed model are verified as a part of the initial procedure review and are validated during the demonstration process. Models which have previously been validated will be used for comparison.
- (b) The Scope statement is verified as a part of the procedure review and must be accepted before proceeding with the demonstration.
- (c) Operation of the model will be verified as part of the demonstration.
- (d) The capability of the model will be compared to previously validated models.
- (e) Operation of the model will be verified during the procedure review and modeling phase of the demonstration. The results will be compared to those from previously validated models.

2.0 SPECIMEN REQUIREMENTS

Demonstration specimens shall meet the requirements of Supplement 4, except as permitted by (a) through (d) below.

- (a) Five nozzles, covering the typical range of BWR applications, are available for demonstrations.
- (b) Nozzle(s) most appropriate to demonstrate the stated scope of the procedure will be selected. Others may be used to perform personnel demonstrations.

REQUIREMENT

2.0 SPECIMEN REQUIREMENTS (Continued)

- (c) Flaws shall be uniformly distributed in examination zones A and B of Figure N552-2. At least half of the flaws shall be located within ±45 degrees of nozzle azimuth angles 90 or 270.
- (d) All flaws shall be located in the required inspection volume and shall be oriented in the radial axial plane of the nozzle inside radius section as shown in Fig. IWB-2500-7.
- (e) Flaw depths shall be distributed over the range of depths required by Supplement 4.

3.0 CONDUCT OF PERFORMANCE DEMONSTRATIONS

3.1 Procedure Qualification Demonstrations

Procedure qualification demonstrations shall be conducted according to the following:

- (a) The qualification shall demonstrate the following:
 - Examination surfaces to be used, i.e. vessel plate, outer blend radius, and nozzle boss;
 - (2) Maximum metal path length; and
 - (3) Maximum misorientation angles.
- (b) The demonstration shall include a minimum of 10 flaws for detection and sizing, in one or more mockups.

PDI IMPLEMENTATION

2.0 SPECIMEN REQUIREMENTS (Continued)

- (c) The required distribution will be verified for each procedure demonstration. Personnel demonstrations will employ a selection of these flaws.
- (d) Flaws within the mockups meet this requirement.
- (e) Flaw depths shall be distributed over the range of depths required by Supplement 4, for procedure demonstrations. For personnel demonstrations, a selection of flaws will be selected.

3.0 CONDUCT OF PERFORMANCE DEMONSTRATIONS

- 3.1 Procedure Qualification Demonstrations
- (a) The qualification shall demonstrate the following:
- (a)(1) Examination surfaces to be used, i.e. vessel plate, outer blend radius, and nozzle boss;
- (a)(2) Maximum metal path length; and
- (a)(3) Maximum misorientation angles.
- (b) The demonstration shall include a minimum of 10 flaws for detection and sizing, in one or more mockups. A portion of these will be distributed among the examination to be demonstrated.

REQUIREMENT

3.1 Procedure Qualification Demonstrations (Continued)

(c) The initial demonstration shall be a blind test.

PDI IMPLEMENTATION

3.1 Procedure Qualification Demonstrations (Continued)

(c) The initial demonstration shall be a blind test.

Due to the limited sample base it is not possible to provide the same test set diversity as is done for Supplements 4 and 6. As a minimum the PDA will do the following to insure the integrity of the demonstrations:

- Require procedures definitively specify criteria for detection and sizing,
- Require that candidates provide specific evidence that their decisions followed the procedure directions, without the aid of apriori information.
- No information as to the true size, location or orientation will be divulged to the candidates and
- To the extent possible candidates will be assigned separate areas of the test specimens or different specimens
- (d) After a successful initial demonstration, the scope of the procedure may be extended by (1) additional demonstrations on additional mockups, or (2) non blind demonstrations on at least one flaw using scan parameters calculated to provide the desired maximum path length or misorientation angles. Detection will be demonstrated to specific criteria listed in the examination procedures for any extension of procedure scope, beyond that demonstrated in the initial blind demonstration.

3.2 Procedure Qualification Documentation

The examination procedure, modeling program and methods, and the qualification results shall be documented to the extent necessary to determine that examinations, performed on reactor vessel nozzles, produce equivalent or smaller misorientation angles, than the procedures which were demonstrated.

 (d) After a successful initial demonstration, the scope of the procedure may be extended by (1) additional demonstrations on additional mockups, or (2) non blind demonstrations on at least one flaw using scan parameters calculated to provide the desired maximum path length or misorientation angles. Detection shall be demonstrated to specific criteria listed in the examination procedure for any extension of procedure scope.

3.2 Procedure Qualification Documentation

The examination procedure, modeling program and methods, and the qualification results shall be documented to the extent necessary to determine that examinations, performed on reactor vessel nozzles, produce equivalent or smaller misorientation angles, than the procedures demonstrated.

REQUIREMENT

3.3 Personnel Qualification

- (a) Individuals previously qualified to the requirements of Appendix VIII Supplement 4, for the same type of procedure (manual vs. automated), from the outside surface, using the same type of instrument and data recording and analysis equipment, shall be qualified as follows:
 - Successful demonstration shall include at least three additional flaws.
 - (2) Examinations shall be conducted from each of the scan surfaces covered by the procedure.
 - (3) The candidate shall demonstrate a selection of essential variables covered by the procedure, but need not demonstrate the full range.
- (b) Individuals not previously qualified to the requirements of Supplement 4 shall be qualified as follows:
 - The candidate shall demonstrate the procedure on one or more mockups.
 - (2) The demonstration shall contain at least the minimum number of detection and depth sizing flaws specified in Supplement 4.
 - (3) The demonstration shall include examinations from each of the scan surfaces described in the procedure.
 - (4) The demonstration need not cover the full range of all the essential variables.

PDI IMPLEMENTATION

3.3 Personnel Qualification

- (a) Individuals previously qualified to the requirements of Appendix VIII Supplement 4, for the same type of procedure (manual vs. automated), from the outside surface, using the same type of instrument and data recording and analysis equipment, shall be qualified as follows:
 - (1) Successful demonstration shall include at least three additional flaws.
 - (2) Examinations shall be conducted from each of the scan surfaces covered by the procedure.
 - (3) The candidate will demonstrate a selection of essential variables covered by the procedure, but need not demonstrate the full range. The demonstrations may be performed on mockups different than those used to qualify the procedure or other personnel.
- (b) Individuals not previously qualified to the requirements of Supplement 4 shall be qualified as follows:
- The candidate shall demonstrate the procedure on one or more mockups.
- (2) The demonstration shall contain at least the minimum number of detection and depth sizing flaws specified in Supplement 4.
- (3) The demonstration shall include examinations from each of the scan surfaces described in the procedure.
- (4) The demonstration need not cover the full range of all the essential variables. The demonstrations may be performed on mockups different than those used to qualify the procedure or other personnel.

REQUIREMENT

4.0 ACCEPTANCE CRITERIA

4.1 Detection Acceptance Criteria

- (a) Examination procedures and equipment are qualified when each flaw is detected and identified. The number of false calls shall not exceed D/10 rounded up to the next whole number, where D is the nominal nozzle inside diameter, in. If only a portion of a nozzle is examined, proportional credit for false calls shall be allowed.
- (b) Personnel previously qualified to Supplement 4, as described in 3.3(a) above, are qualified if each of the flaws presented are detected and identified with no false calls.
- (c) Personnel not previously qualified to Supplement 4 are qualified for detection if the results of the demonstration meet the requirements of Table VIII-S4-1. Additionally, the number of false calls shall not exceed the number specified in 4.1(a) above.

4.2 Depth Sizing Acceptance Criteria

(a) Examination procedures and equipment are qualified for depth sizing if the results of the sizing demonstration meet the requirements of Appendix VIII Supplement 4, paragraph 3.2.

PDI IMPLEMENTATION

4.1 Detection Acceptance Criteria

- (a) Examination procedures and equipment are qualified when each flaw is detected and identified. The number of false calls shall not exceed D/10 rounded up to the next whole number, where D is the nominal nozzle inside diameter, in. If only a portion of a nozzle is examined, proportional credit for false calls shall be allowed.
- (b) Personnel previously gualified to Supplement 4, as described in 3.3(a) above, are gualified if each of the flaws presented are detected and identified. The number of false calls allowed shall be the same as in 4.1(a) above.

(See PDI Position 95-011)

(c) Personnel not previously qualified to Supplement 4 are qualified for detection if the results of the demonstration meet the requirements of Table VIII-S4-1. Additionally, the number of false calls shall not exceed the number specified in 4.1(a) above.

4.2 Depth Sizing Acceptance Criteria

(a) Examination procedures and equipment are qualified for depth sizing if the results of the sizing demonstration meet the requirements of Appendix VIII Supplement 4, paragraph 3.2.

REQUIREMENT

4.2 Depth Sizing Acceptance Criteria (Continued)

- (b) Personnel previously qualified to Supplement 4, as described in 3.3 (a) above, are qualified if the results from the sizing tests, when added to the candidate's results from Supplement 4, meet the acceptance criteria of Supplement 4, paragraph 3.2.
- (c) Personnel not previously qualified to Supplement 4, are qualified for depth sizing if the results of the sizing demonstration meet the sizing acceptance requirements of Supplement 4.

5.0 FIELD EXAMINATIONS

The computational model shall be applied in conjunction with each field examination, to demonstrate that the proposed examination variables are within the bounds of the qualification demonstration.

- (a) Documentation showing coverage and misorientation angle shall be provided for each nozzle examination application performed. The documentation shall be used to demonstrate that the examination performed will achieve misorientation angles that do not exceed the misorientation angles for which the procedure was qualified.
- (b) Modeling need not be applied for repeated examination of the same or identical nozzles. Nozzle geometry changes that do not result in an increase in the misorientation angles or loss of coverage area need not be calculated.
- (c) If the misorientation angle or metal path of the field examination exceeds that of the qualification, additional probe angles and directions may be applied to examine these areas without need for requalification, provided the demonstrated misorientation angle or path length can be achieved.
- (d) If an area can be examined by addition of new search unit angles, orientations, or scan areas that produce misorientation angles or path length in excess of the qualified values, a new procedure qualification shall be performed.

PDI IMPLEMENTATION

4.2 Depth Sizing Acceptance Criteria (Continued)

- (b) Personnel previously qualified to Supplement 4, as described in 3.3 (a) above, are qualified if the results from the sizing tests, when added to the candidate's results from Supplement 4, meet the acceptance criteria of Supplement 4, paragraph 3.2.
- (c) Personnel not previously qualified to Supplement 4, are qualified for depth sizing if the results of the sizing demonstration meet the sizing acceptance requirements of Supplement 4.

5.0 FIELD EXAMINATIONS

The computational model shall be applied in conjunction with each field examination, to demonstrate that $t^{\nu} \sim \text{proposed}$ examination variables are within the bounds of the qualification demonstration. This statement will be included in the procedure PDQS.

- (a) This item is beyond the Scope of the PDI Program. It will be the responsibility of the utility, the Inspector, regulatory authorities to assure these requirements are fulfilled.
- (b) The PDA can provide assistance in performing scoping studies to assist in these determinations.
- (c) This item is beyond the Scope of the PDI Program. It will be the responsibility of the utility, the Inspector, regulatory authorities to assure these requirements are fulfilled.
- (d) This item is beyond the Scope of the I/DI Program. It will be the responsibility of the utility, the Inspector, regulatory authorities to assure these requirements are fulfilled.

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REQUIREMENT

5.0 FIELD EXAMINATIONS (Continued)

(e) If neither 5.0(c) nor (d) can be met, the area shall be declared an area of no coverage.

PDI IMPLEMENTATION

5.0 FIELD EXAMINATIONS (Continued)

(e) This item is beyond the Scope of the PDI Program. It will be the responsibility of the utility, the Inspector, regulatory authorities to assure these requirements are fulfilled.

SUPPLEMENT 5 QUALIFICATION REQUIREMENTS FOR NOZZLE INSIDE RADIUS SECTION

REQUIREMENT

Demonstrations on clad/base metal interface of reactor vessel plate specimens (Supplement 4) qualifies examination procedures, equipment and personnel for nozzle inside radius section examination when the following requirements are met.

(a) For detection, a minimum of three additional flaws at the inside radius section in one or more full scale nozzle mock-ups (supplement 7) shall be added to the test set.

The specimens shall comply with Supplement 4, 1.1, but flaws may be either notches or cracks.

Flaws shall be located in the radial axial plane of the nozzle inside radius section shown in Fig. IWB-2500-7.

If the examination procedure requires the examination to be performed from the vessel OD surface, at least one nozzle in the specimen set shall be at least 90% of the maximum thickness t_{n2} in Fig IWB-2500-7, to be examined and the ratio of the nozzle thickness to shell thickness shall be within $\pm 30\%$ of that ratio for the vessel nozzles to be examined.

PDI IMPLEMENTATION

The PDI Program is designed to qualify e: _mination procedures, equipment and personnel for nozzle inside radius section examination when the following requirements are met:

- (a) PDI has fabricated two full size PWR nozzle mockups, simulating both inlet and outlet configurations. Five BWR mockups are available if they are needed to expand the scope of a procedure performed from the inside surface. For procedure qualifications, applicable to PWR RPVs, a minimum of three flaws will be included in both the inlet and outlet nozzles. For "analysis only" personnel qualifications, the following shall apply:
 - 1. Where the analysis equipment and the ultrasonic technique are basically the same as the Supplement 4 application, no further demonstrations will be required.
 - Where the techniques differ substantially, a demonstration set of a minimum of three flaws will be provided. These will be distributed in either the inlet or outlet configuration or both as appropriate.

(See PDI Position 95-008)

The specimens comply with Supplement 4, 1.1. Flaw types will generally be cracks. However, some notches may be used.

All flaws are located within the radial axial plane of the nozzle inside radius section as illustrated by Fig.IWB-2500-7.

The PDI BWR nozzle specimens have been designed to facilitate OD examination surface procedures. The dimensions of the specimens were developed to include dimensions suitable that these requirements can be met for most BWR RPV's.

SUPPLEMENT 5 QUALIFICATION REQUIREMENTS FOR NOZZLE INSIDE RADIUS SECTION

REOUIREMENT

(a) (Continued)

If the examination procedure requires the examination be performed from the inside surface, the specimen shall have the minimum nozzle diameter covered by the procedure.

Each of the flaws presented for demonstration shall be correctly identified in accordance with Supplement 4, 2.1 with no false calls. Demonstrations on Clad nozzle mockups may be used for examination of unclad nozzles. Demonstrations performed on unclad nozzle mockups shall not be used for examinations of clad nozzles.

- (b) For length sizing, a minimum of three additional flaws as in (a) above shall be added to the test set. All flaws shall be sized to the acceptance standards of Supplement 4.
- (c) For depth sizing, a minimum of three additional flaws as in (a) above shall be added to the test set. Their depths shall be evenly distributed over the ranges of Supplement 4, 1.1(e)(3)(a), 1.1(e)(3)(b), and 1.1(e)(3)(c). The sizing results from these flaws shall be combined with the sizing results from the clad/base metal interface qualification, and combined results shall meet the acceptance criteria of Supplement 4, 3.2.

PDI IMPLEMENTATION

(a) (Continued)

The PDI PWR inlet nozzle specimen has an internal diameter of 28 inches, which is sufficient for demonstrations for PWR inlet and outlet nozzles. BWR mockups are available for smaller nozzles.

Due to the limited sample base it is not possible to provide the same test set diversity as is done for Supplement 4 and 6. As a minimum the PDA will do the following to insure the integrity of the demonstrations:

- Require procedures definitively specify criteria for detection and sizing,
- Require that candidates provide specific evidence that their decisions followed the procedure directions, without apriori information,
- No information as to the true size, location or orientation will be divulged to the candidates, and
- To the extent possible candidates will be assigned separate areas of the test specimens or different specimens.

Candidates for personnel demonstrations will be provided a sampling of the essential variables qualified by the procedure.

Each of the flaws in the examination test set shall be correctly identified. <u>False calls shall not exceed the</u> value established by parcgraph 4.1(a) of Code Case N-552.

- (b) PDI will not implement this requirement, see Code Case N-542.
- (c) For depth sizing a minimum of three flaws will be added to the test set. The depth range of these flaws will be <u>distributed</u> over the range required by Supplement 4. The sizing results will be combined with the clad/base metal interface qualification. The acceptance criteria shall be the same as is applied for Supplement 4.

REQUIREMENT

PDI IMPLEMENTATION

1.0 SPECIMEN REQUIREMENTS

Qualification test specimens shall meet the requirements listed herein unless a set of specimens is designed to accommodate specific limitations stated in the scope of the examination procedure. The same specimens may be used to demonstrate both detection and sizing qualifications. 1.0 PDI Test specimens meet the requirements of Appendix VIII as described hereafter and will be used to demonstrate both detection and sizing qualifications.

Flaw Location	Flaw Through-Wall dimension, in.					
	0.075-0.200	0.201-0.350	0.351-0.550	0.551-0.750	0.751-2.00	
Inner 10% [Note (1)]	X	X	S	S		
Outer 10%	Х	X	S	S		
11-30% T			X	X	S	
31-60% T			Х	Х	S	
61-89% T			X	Х	S	

TABLE VIII-S6-1 DETECTION AND SIZING TEST FLAWS AND LOCATIONS

NOTE:

(1) Does not apply to clad vessels(see Supplement 4)

LEGEND:

X Applies to detection and sizing flaws.

S Applies only to sizing flaws.

T Thickness of the thickest specimen in the specimen set.

- 1.1 Detection Specimens. Detection specimens, which may be full-scale mock ups, shall conform to the following requirements:
 - (a) Specimens shall have sufficient volume to minimize spurious reflections. Specimen length and width shall be at least 12 in.

There shall be at least 10 sq ft of scan surface in the specimen set.

(b) The specimen set shall contain at least one sample that is at least 90% of the maximum thickness to be examined.

The specimen set shall contain one or more flaws in each of the locations and size ranges shown in table VIII-S6-1.

- 1.1 Detection specimens are full scale mock-ups manufactured from material removed from canceled BWR and PWR Reactor Pressure Vessels.
- (a) Spurious reflections are minimized by the use of full size mockups. The minimum specimen length and minimum width is greater than 12 in.

Instruction PDP-I-009.4.3 requires that the examination surface area of each specimen set used for performance demonstration will be a minimum of 10 sq. ft.

(b) Instruction PDP-I-009.4.3 requires that the specimen set will contain at least one sample that is at least 90% of the maximum thickness to be examined.

The flaws in the supplement 6 examination volume are positioned at depths within the locations shown in table VIII-S6-1. The size of the flaws has also been selected from the same table.

REQUIREMENT

1.1 Detection Specimens (Continued)

- (c) When the examination procedure requires the examination to be performed from the vessel I.D. (clad surface), the cladding on the mockup shall be of the same type as the cladding on the component to be examined, with the following exceptions:
 - Demonstration on shielded metal arc weld (SMAW) single wire cladding is transferable to multiple-wire or strip clad processes;
 - (2) Demonstration on multiple-wire or strip clad are considered equivalent but is not transferable to SMAW-type clad.
- (d) The surface condition of the test specimens shall be representative of the general condition of the vessel scanning surface.
- (e) The detection test matrix shall include flaws with the following description.
 - Flaw Type. At least 50% of the flaws shall be cracks. The balance of flaws may be cracks, fabrication defects (e.g., slag inclusions), or machined notches. Machined notches shall meet the following requirements:
 - (a) Notches shall be perpendicular to the surface within ± 2 deg.;
 - (b) Notches shall have a minimum width of 0.010 in. and shall be plugged to their full depth with an insert of the parent material prior to cladding.
 - (2) No more than 10% of the flaws shall emanate from the outer (unclad) surface.

A weld direction shall be established whether or not the specimen contains a weld.

PDI IMPLEMENTATION

- (c) The performance demonstration examination volume of PDI test specimens has been clad using a shielded metal arc weld (SMAW) single wire procedure, which is transferable to cladding applied by other methods.
- (c)(1) ID (clad surface)demonstration will be on SMAW cladding and is transferable to multi-wire or strip clad components.
- (c)(2) Demonstrations of multiple-wire or strip clad are not possible using PDI specimens.
- (d) The surface condition of the test specimens is considered by the PDI to be generally representative of the surface conditions found in most United States operating nuclear reactor pressure vessels.
- (e) The detection test matrix will include flaws of the following description.
- (e)(1) Flaws in supplement 6 test specimens are a combination of cracks and fabrication defects such as slag/lack of fusion. PDI procedures require that within any individual test set at least 50% of the flaws will be cracks.
- (e)(1)(a) Notches have not been used in manufacturing the supplement 6 specimens.
- (e)(1)(b) Not applicable
- (e)(2) PDI Instruction PDP-I-009.4.3 specifies that the test set will include no more than 10% of flaws, rounded to the next higher whole number, which are OD connected for procedure qualifications test sets.

PDI specimens do not include a weld and the weld direction will be considered circumferential which will be described as the "X" axis.

REQUIREMENT

1.1 Detection Specimens (Continued)

A minimum of 40% of the flaws shall be oriented parallel to the weld direction (within ± 10 deg.) and a minimum of 40% shall be oriented perpendicular to the weld direction (within ± 10 deg.).

(3) Flaws for the detection test matrix shall be selected from the detection test flaws included in Table VIII-S6-1.

The flaws selected shall provide a demonstration of the minimum and maximum metal path ranges to be demonstrated.

as well as a uniform distribution of flaw sizes and locations.

(4) The number of flaws in the detection test matrix shall be selected from Table VIII-S6-2.

The rules of IWA-3000 shall be used for determining whether closely spaced flaws should be treated as separate flaws.

PDI IMPLEMENTATION

Flaws are evenly distributed between being parallel and perpendicular to the stipulated weld direction within ± 5 degrees. Each Procedure demonstration test set will have a minimum of 40% of flaws oriented Parallel and a minimum of 40% presented perpendicular to the clad direction. Each personnel demonstration test set will contain a representative distribution of flaw orientations, sizes and locations.

(See PDI Position 95-011) (See also PDI Positions 95-004 & 95-005)

- (e)(3) Flaws selected for the detection test will be as shown in Table VIII-S6-1 except that:
 - a. <u>Flaws smaller than the 50% of allowable flaw size</u>, <u>as defined in IWB-35:0-1</u>, will not be included as <u>detection flaws</u>.
 - b. <u>Flaws equal to or less than the allowable flaw size</u> will be counted as detection flaws, without regard to their position in Table VIII-S6-1.
 - c. <u>The thickness of the demonstration test specimen will</u> be used to determine the a/t ratios in IWB-3510-1.

(See PDI Position 95-003)

The test set will include at least one flaw in the outer 10% of the flaw location volume and at least one flaw within the 11-30% T location volume of Table VIII-S6-1.

At least one of the specified flaw sizes in Table VIII-S6-1 will be included in the test set. These flaws will be distributed throughout the specified flaw locations of Table VIII-S6-1.

(e)(4) The number of flaws used for grading of the detection test set will be a minimum of 7 for procedure qualification. For personnel qualification, the total of supplement 4 and 6 sizing flaws shall be at least 10, and at least 50% of these shall be Supplement 4 flaws. Other flaws may be present in the examination area.

(See PDI Position 95-004)

The rules of IWA-3000 shall be used of determining whether closely spaced flaws should be treated as separate flaws.

REQUIREMENT

1.2 Sizing Specimens

(a) The sizing test matrix shall contain a minimum of ten flaws, at least half of which shall be cracks.

PDI IMPLEMENTATION

1.2 Sizing Specimens

 (a) For procedure qualification, PDI Program Implementing Instruction PDP-I-009.4.3 requires that the sizing test matrix will be selected to contain a minimum of ten flaws. For personnel qualification, the total of supplement 4 and 6 sizing flaws shall be at least 10, and that at least 50% of these shall be Supplement 4 flaws. At least half of the flaws in any sizing test matrix will be cracks.

(See PDI Position 95-005)

- (b) Sizing specimens shall conform with the requirements of 1.1(b), 1.1(c), 1.1(d) and 1.1(e), except that the test matrix shall be selected from the sizing and detection flaws included in Table VIII-S6-1.
- (b) The detection specimens which meet the specified Appendix VIII requirements will also be used for sizing. The flaws will be selected form the sizing and detection flaws included in Table VIII-S6-1

Detection Test				
No. of Flaws	Minimum De(sction Criteria			
7	7			
8	8			
9	9			
10	10			
11	11			
12	11			
13	12			
14	13			
15	14			
16	14			
17	15			
18	16			
19	17			
20	18			

TABLE VIII-S6-2 PERFORMANCE DEMONSTRATION DETECTION TEST ACCEPTANCE CRITERIA

REQUIREMENT

2.0 CONDUCT OF PERFORMANCE DEMONSTRATIONS

2.1 Detection Test

(a) Specimen identification and flaw locations shall be obscuied so as to maintain a "blind test."...

All examinations shall be completed prior to grading the results and presenting the results to the candidate. Divulgence of particular specimen results or candidate viewing of unmasked specimens is prohibited.

(b) When a flaw is reported within 1/2 in. of its true location (x and y) it shall be considered detected. All other reported flaws shall be considered false calls.

2.2 Length and Depth Sizing Test

(a) For the length sizing test, the inside surface and specimen identification shall be obscured. The regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the length of the flaw in each region.

PDI IMPLEMENTATION

2.0 CONDUCT OF PERFORMANCE DEMONSTRATIONS

2.1 Detection Test.

(a) A specimen identification will be provided to the candidate. The flaw locations within the test specimens are obscured providing a "blind test."

PDI procedures require that all detection examinations (analysis of data) will be completed prior to grading the results. The individual flaw results will not be divulged; however, information on the type of errors made, for example, *Missed Detection*, *False Calls etc.* will be provided. Candidates will be able to view specimens since all flaw locations are disguised. (See PDI Position 94-007).

(b) A flaw will be considered detected when reported <u>within</u> <u>1.0</u> inch of the true X, Y and Z location or the error allowed by Code Case N-545 <u>whichever is larger</u>.

Location accuracy is for grading purposes only. Mathematical errors, systematic location errors, and other errors which exceed the allowable detection criteria, may be accepted by the PDA, provided:

- 1. <u>There is no doubt that the reported indication is</u> related to the actual flaw.
- 2. <u>The error did not result from misinterpretation of the</u> <u>ultrasonic signals.</u>
- 3. The results of the investigation is documented and iustified.

(See PDI Position 95-006)

2.2

(a) Access for scanning will be based on the examination technique. (i.e. ID or OD) since flaws are buried, specimen surfaces need not be obscured. A specimen identification will be provided. The candidate will be required to size the length of each intended flaw reported during the detection test. If required, scan areas containing additional flaws for length sizing will be identified to the candidate.

REQUIREMENT

2.2 Length and Depth Sizing Test (Continued)

(b) For the depth sizing test, 80% of the flaws shall be sized at a specific location on the surface of the specimen identified to the candidate. For the remaining flaws, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region.

3.0 ACCEPTANCE CRITERIA

3.1 Detection Acceptance Criteria. Examination procedures, equipment, and personnel are qualified for detection if the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S6-2.

Additionally the number of false calls shall not exceed A/10 rounded to the next whole number where A is the total scan area of specimens in the test measured in square feet.

3.2 Sizing Acceptance Criteria.

Examination procedures, equipment and personnel are qualified for sizing if the results of the performance demonstration satisfy the following criteria:

- (a) No flaw is undersized for depth by more than 0.2 in.;
- (b) Flaw lengths estimated by ultrasonics shall be the true length -1/4in.,+1 in.;
- (c) Performance demonstration results reported by the candidate, when plotted on a two dimensional plot (Fig. VIII-S4-1) with the depth estimated by ultrasonics plotted along the ordinate and the true depth plotted along the abscissa, satisfy the following statistical parameters:
 - (1) Slope of the linear regression line is not less than 0.7
 - The mean deviation of flaw depth is less than 0.25 in.;

PDI IMPLEMENTATION

(b) For depth sizing, the candidate will be required to size the depth (through-wall) of each intended flaw reported during the detection test. If required scan areas containing additional flaws for depth sizing will be identified to the candidate. The candidate will determine the maximum depth of the flaw in each region.

3.0 ACCEPTANCE CRITERIA

3.1 The criteria of Table VIII-S6-2 will be used to evaluate the performance demonstration detection results.

The number of false calls will not exceed A/10 rounded to the next whole number where area A is calculated using the maximum Y surface dimension scanned by the ultrasonic transducer multiplied by the X surface dimension scanned by the ultrasonic transducer.

- 3.2 It has become necessary for PDI to adopt sizing acceptance criteria which differ from those specified in the Code. Refer to PDI Position 94-005 and 94-010-R1.
- (a) Critical miscall requirements have been removed from PDI Sizing Acceptance criteria, see PDI Position 94-010-R1.
- (b) An RMS method of grading will be used. The RMS error of the ultrasonic flaw length measurements, compared to the true flaw length, must be equal to or less than O.750in. Refer to PDI Position 94-005 for justification for this deviation.
- (c) The criteria of 3.2(c)(2) and (3), are replaced by an equivalent RMS criteria. Refer to PDI Position 94-010-R1 for justification for this deviation.
- (1) Will not be utilized by the PDI Program.

(See PDI-Position 94-010-R1)

(2) The measured flaw depth, as compared to the true depth, shall be equal to or less than an error of 0.25 inch RMS.

REQUIREMENT

PDI IMPLEMENTATION

3.2 Sizing Acceptance Criteria. (Continued)

- (3) Correlation coefficient is not less than 0.70.
- (3) Will not be utilized by the PDI Program.

(See PDI-Position 94-010-R1)

(4) For combined Supplement 4 and 6. personnel qualification, the acceptance criteria for Supplement 4 will be applied to Supplement 4 flaws and Supplement 6 for Supplement 6 flaws.

(See PDI Position 95-005)

SUPPLEMENT 7 QUALIFICATION REQUIREMENTS FOR NOZZLE-TO-VESSEL WELD

REQUIREMENT

PDI IMPLEMENTATION

TABLE VIII-S7-1

	Parallel to Weld	Perpendicular to Weld	
ID Surface	X	X	
OD Surface	х	x	
Subsurface	x	x	

Demonstration on reactor vessel plate specimens (Supplement 6) qualifies examination procedures, equipment, and personnel for nozzle-to-vessel weld examination when the following requirements are met.

(a) For detection, a minimum of three additional flaws in one or more full-scale nozzle mock-ups shall be added to the test set. The protocol to demonstrate the ultrasonic examination of nozzle-to-vessel weld sections is in the process of preparation. For information the following is provided.

(a) PDI has fabricated three full-size nozzle-to-shell mockups. One represents a BWR application from the outside surface. The remaining two represent a PWR and a small injection or core flood nozzle. <u>PDI will</u> <u>implement the requirements of Supplement 7 for inside</u> <u>surface, clad-to-base metal interface, only.</u>

Due to limited sample base it is not possible to provide the same test set diversity as is done for Supplements 4 and 6. As a minimum the PDA will do the following to insure the integrity of the demonstrations:

- Require procedures definitively specify criteria for detection and sizing,
- Require that candidates provide specific evidence that their decisions followed the procedure directions, without apriori information,
- No information as to the true size, location or orientation will be divulged to the candidates, and
- To the extent possible candidates will be assigned separate areas of the test specimens or different specimens.

SUPPLEMENT 7 QUALIFICATION REQUIREMENTS FOR NOZZLE-TO-VESSEL WELD

REQUIREMENT

PDI IMPLEMENTATION

(a) (Continued)

For "analysis only" personnel qualifications, the following shall apply:

1. Where the analysis equipment and the ultrasonic technique are basically the same as the Supplement 4 application, no further demonstrations will be required.

 Where the techniques differ substantially, a demonstration set of a minimum of three flaws will be provided. These will be distributed in either the inlet or outlet configuration or both as appropriate.

For manual personnel qualification and all procedure qualifications, the rules listed below shall apply.

(See PDI Position 95-009)

The flaws comply with the requirements of Supplement 4, 1.1. The flaws are predominantly cracks.

A combination of flaws parallel and perpendicular to the weld will be used. <u>These flaws will include only inside</u> surface flaws of this demonstration.

- (a)(1) Demonstrations performed from the outside surface, will use test specimens which are at least 90% of the maximum thickness to be examined, as indicated in the Scope of the procedure.
- (a)(2) Nozzle bore demonstrations are not included. The flaws comply with the requirements of Supplement 4, 1.1. The flaws are predominantly cracks.
- (a)(3) Each of the flaws presented for demonstration shall be correctly identified, in accordance with the requirements of Supplement 4. <u>False calls shall not</u> <u>exceed the value established by paragraph 4.1(a) of</u> <u>Code Case N-552.</u>
- (b) A minimum of three additional flaws as in (a) above will be added to the test set. The depth range of these flaws will be distributed over the range required by <u>Supplement 4</u>. The sizing results will be combined with the clad/base metal interface gualification results. The acceptance criteria, for the combination shall meet the requirements of Supplement 4.

The specimens shall comply with Supplement 6, 1.1, but flaws may be either notches or cracks.

Flaw locations and orientations shall be selected from the choices shown in Table VIII-S7-1. At least one subsurface flaw shall be included and there shall be no more than one flaw from each category.

- For de a variations performed from the vessel shell, a specimen shall be at least 90% of the maximum thickness to be examined.
- (2) For examinations performed from the bore of the nozzle, at least one flaw parallel to the weld shall provide a metal path distance within 10% of the equivalent path length to the weld centerline of the thickest component to be examined.
- (3) Each of the flaws presented for demonstration shall be correctly identified, in accordance with supplement 6, 2.1, with no false calls.
- (b) For length sizing, a minimum of three additional flaws as in (a) above shall be added to the test set. All flaws shall be sized to the acceptance standards of Supplement 6.

SUPPLEMENT 7 QUALIFICATION REQUIREMENTS FOR NOZZLE-TO-VESSEL WELD

REQUIREMENT

(c) For depth sizing a minimum of three additional flaws as in (a) above shall be added to the test set. Their depths shall be evenly distributed over the ranges of Supplement 6, 1.1. The sizing results from these flaws shall be combined with the sizing results from the rector vessel weld qualification and the combined results shall meet the acceptance criteria of Supplement 6, 3.2.

PDI IMPLEMENTATION

(c) For depth sizing a minimum of three flaws will be added. The depth range of these flaws will be distributed over the range required by <u>Supplement 4</u>. The sizing results will be combined with the clad/base metal interface qualification results. The acceptance criteria, for the combination shall meet the requirements of Supplement 4.

SUPPLEMENT 8 QUALIFICATION REQUIREMENTS FOR BOLTS AND STUDS

REQUIREMENT

PDI IMPLEMENTATION

1.0 SPECIMEN REQUIREMENTS:

Qualification test shall meet the requirements listed herein, unless a set of specimens is designed to accommodate specific limitations stated in the scope of the examination procedure

1.1 Specimens shall conform to the following requirements:

(b) The qualification specimen shall be of similar

bolt or stud to be examined.

chemical composition, tensile properties, and

metallurgical structure as the bolt or stud to be

examined. The scan surface of the qualification

specimen shall have a configuration similar to the

(a) The qualification process shall be performed with a full-scale section bolt or stud that is sufficient to contain the beam path and demonstrate the scanning technique Specimens met the requirements listed below. Owner/vendors will provide specimens if their procedures contain specific limitations.

(a) Qualification will be performed on full scale bolts or studs. A bolt/stud test set shall contain at least (3) different diameters and lengths, with sufficient beam path to demonstrate the scanning technique requested by the candidate. A survey of the utilities provided the information regarding the appropriate bolts and studs.

(See PDI Position 95-010)

(b) The test specimens used in the performance demonstration process are actual full scale bolts / studs which were purchased from canceled units or spare parts vendors.

(See PDI Position 95-010)

Depth, in. Reflective Area, sq. in. Bolt or Stud Size [Note(1)] sq. in. Greater than 4 inches diameter 0.157 0.059 2 in. diameter and greater, but not over 4 in diameter 0.107 0.027

TABLE VIII-S8-1

NOTE:

(1) For threaded surfaces, depth is meassured from the bottom of the thread root to bottom of notch.

- (c) Circumferentially oriented notches shall be located in the qualification specimen at the minimum and maximum qualified metal paths. These notches are required on the outside threaded surface and the inner bore hole surface of bored studs with maximum depths and reflective areas as specified in Table VIII-S8-1.
- (c) Circumferential notches are located at the minimum and maximum metal paths (within one diameter of each end for personnel gualifications and within one diameter of the opposite end for procedure qualifications) which a candidate request to demonstrate. They are located on the outside threaded surface, outer shaft, and the inner bore hole surface of bored studs as specified in Table VIII-S8-1. The minimum number of notches in a test set shall be five. PDI's design review (PDI-Q-002) verified that the size and location of the notches meet Table VIII-S8-1.

SUPPLEMENT 8 QUALIFICATION REQUIREMENTS FOR BOLTS AND STUDS

REQUIREMENT

PDI IMPLEMENTATION

(c) (Continued)

Specimen identification and notch locations are obscured. The detection performance demonstration acceptance criteria consist of 2 parts; detection test and a false call test. A successful detection performance demonstration is achieved if the acceptance criteria of both parts are satisfied.

(See Code Case N-457)

Detection Test - The minimum detection criteria, or minimum number of notches which must be detected, is determined by the number of notches included in the performance demonstration sample set.

- (d) Additional notches may be located between the notches in (c) which do not interfere with the detection of other notches. Some bolts and studs may be unflawed.
- (d) Additional notches may be located within the range specified in (c) above, provided they do not interfere with the detection of other notches.

2.0 CONDUCT OF PERFORMANCE DEMONSTRATIONS:

2.1 Detection Test

- (a) Specimen identification and notch locations shall be obscured so as to maintain a "blind test." A flaw shall be considered detected when the notch, as defined in 1.1, is found. The notch axial location correlation shall be ± 1/2 in. or ±5% of the bolt or stud length, whichever is greater.
- (a) To receive credit for detecting a notch, it must be recorded correctly relative to the following criteria;

Number of	Minimum	Number of	
otches in Set	Detection	False Calls	
5	4	0	
6	5	1	
7	6	1	
8	7	2	
9	8	2	
10	8	2	

False Call Test - The acceptable number of false calls is determined by the number of flaws in the test and in accordance with the table above.

A false call is defined as exceeding the following limits:

The notch axial location correlation shall be $\pm 1/2$ " or $\pm 5\%$ of the bolt/stud length, whichever is greater.

Notch circumferential position must be within \pm 60 degrees of notch centerline location (within the appropriate third of the bolt/stud).

These requirements meet or exceed the requirements of Supplement 8.

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SUPPLEMENT 8 QUALIFICATION REQUIREMENTS FOR BOLTS AND STUDS

REQUIREMENT

PDI IMPLEMENTATION

3.0 Acceptance Criteria

- 3.1 Examination procedures, equipment, and personnel are qualified for detection when each qualification notch (as described in 1.1) has been detected and its response equals or exceeds the reporting criteria specified in the procedure. The notch response shall have a minimum peak signal to peak noise ratio of 2:1.
- 3.1 Examination systems are qualified for detection when each notch has been detected and its response equals or exceeds the reporting criteria of the procedure. The surveillance of the demonstration will verify detections and that notch responses have a minimum peak signal to peak noise ratio of 2:1.

SUPPLEMENT 9 QUALIFICATION REQUIREMENTS FOR CAST AUSTENITIC PIPING WELDS

REQUIREMENT

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PDI IMPLEMENTATION

(In the course of preparation)

Supplement 9, Cast Austentic, is "In Course of Preparation" so PDI cannot implement.

SUPPLEMENT 10 QUALIFICATION REQUIREMENTS FOR DISSIMILAR METAL PIPING WELDS

REQUIREMENT

PDI IMPLEMENTATION

1.0 SPECIMEN REQUIREMENTS

Qualification test specimens shall meet the requirements listed herein, unless a set of specimens is designed to accommodate specific limitations stated in the scope of the examinaiton procedure (e.g., pipe size, weld joint configuration, access limitations). The same specimens may be used to demonstrate both detection and sizing qualifications.

1.1 General

- (a) Specimens shall have sufficient volume to minimize spurious reflections that may interfere with the interpretation process.
- (b) The specimen set shall include the minimum and maximum pipe diameters and thicknesses for which the examinaiton procedure is applicable. Pipe diameters within a range of 0.9 to 1.5 times a nominal diametershall be considered equivalent. Pipe diameters larger than 24 in. shall be considered to be flat. When a range of thicknesses is to be examined, a thickness tolerance of ±25% is acceptable.
- (c) The specimen set shall include examples of the following fabrication condition:
 - geometric conditions that normally require discrimination from flaws (e.g., counterbore or weld root conditions, cladding, weld buttering, remnants of previous welds, adjacent welds in close proximity);
 - (2) typical limited scanning surface conditions (e.g., diametrical shrink, single-side access due to nozzle and safe end external tapers).
- (d) All flaws in the specimen set shall be cracks.
 - (1) At least 50% of the cracks shall be in austenitic material. At least 50% of the cracks in austenitic material shall be contained wholly in weld or buttering material. At least 10% of the cracks shall be in ferritic material. The remainder of the cracks may be in either austenitic or ferritic material.

Supplement 10, Dissimilar Metal, is not being implemented by PDI at this time.

SUPPLEMENT 10

QUALIFICATION REQUIREMENTS FOR DISSIMILAR METAL PIPING WELDS

REQUIREMENT

PDI IMPLEMENTATION

- (2) At least 50% of the cracks in austenitic base material shall be either IGSCC or thermal fatigue cracks. At least 50% of the cracks in ferritic material shall be mechanically or thermally induced fatigue cracks.
- (3) At least 50% of the cracks shall be coincident with areas described in (c) above.

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REQUIREMENT

PDI IMPLEMENTATION

1.0 SPECIMEN REQUIREMENTS

Qualification test specimens shall meet the requirements listed herein, unless a set of specimens is designed to accommodate specific limitations stated in the scope of the examination procedure (e.g., pipe size, weld joint configuration, access limitations). The same specimens may be used to demonstrate both detection and sizing qualification.

1.1 General

The specimen set shall conform to the following requirements.

- (a) Specimens shall have sufficient volume to minimize spurious reflections that may interfere with the interpretation process.
- (b) The specimen set shall consist of at least three specimens having different nominal pipe diameters and overlay thicknesses. They shall include the minimum and maximum nominal pipe diameters for which the examination procedure is applicable. Pipe diameters within a range of 0.9 to 1.5 times a nominal diameter shall be considered equivalent. If the procedure is applicable to pipe diameters of 24 in. or larger, the specimen set must include at least one specimen 24 in. or larger but need not include the maximum diameter. The specimen set must include at least one specimen with overlay thickness within -0.1 in. to +0.25 in. of the maximum nominal overlay thickness for which the procedure is applicable.
- (c) The surface condition of at least two specimens shall approximate the roughest surface condition for which the examination procedure is applicable.
- (d) Flaw Conditions
 - (1) Base metal flaws. All flaws must be cracks in or near the butt weld heat-affected zone, open to the inside surface, and extending at least 75% through the base metal wall. Flaws may extend 100% through the base metal and into the overlay material; in this case, intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the cracking. Specimens containing IGSCC shall be used when available.

1.0

<u>Specimens currently being used for the BWROG - IGSCC</u> <u>Overlay Examination will be used for this demonstration</u>.

REQUIREMENT

PDI IMPLEMENTATION

1.1 General (Continued)

- (2) Overlay fabrication flaws. At least 40% of the flaws shall be non-crack fabrication flaws (e.g., side-wall lack of fusion or laminar lack of bond) in the overlay or the pipe-to-overlay interface. At least 20% of the flaws shall be cracks. The balance of the flaws shall be of either type.
- (e) Detection Specimens
 - (1) At least 20% but less than 40% of the flaws shall be oriented within ±20 deg. of the pipe axial direction. The remainder shall be oriented circumferentially. Flaws shall not be open to any surface to which the candidate has physical or visual access. The rules of IWA-3300 shall be used to determine whether closely spaced flaws should be treated as single or multiple flaws.
 - (2) Specimens shall be divided into base and overlay grading units. Each specimen shall contain one or both types of grading units.
 - (a)(1) A base grading unit shall include at least 3 in. of the length of the overlaid weld. The base grading unit includes the outer 25% of the overlaid weld and base metal on both sides. The base grading unit shall not include the inner 75% of the overlaid weld and base metal overlay material, or base metal-to-overlay interface.
 - (2) When base metal cracking penetrates into the overlay material, the base grading unit shall include the overlay metal within 1 in. of the crack location. This portion of the overlay material shall not be used as part of any overlay grading unit.

REQUIREMENT

- (3) When a base grading unit is design to be unflawed, at least 1 in. of unflawed overlaid weld and base metal shall exist on either side of the base grading unit. The segment of weld length used in one base grading unit shall not be used in another base grading unit. Base grading units need not be uniformly spaced around the specimen.
- (b)(1) An overlay grading unit shall include the overlay material and the base metal-to-overlay interface of at least 6 sq. in. The overlay grading unit shall be rectangular, with minimum dimensions of 2 in. *
 - (2) An overlay grading unit designed to be unflawed shall be surrounded by unflawed overlay material and unflawed base metal-to-overlay interface for at least 1 in. around its entire perimeter. The specific area used in one overlay grading unit shall not be used in another overlay grading unit. Overlay grading units need not be spaced uniformly about the specimen.
 - (3) Detection sets shall be selected from Table VIII-S2-1. The minimum detection sample set is five flawed base grading units, ten unflawed base grading units, five flawed overlay grading units, and ten unflawed overlay grading units. For each type of grading unit, the set shall contain at least twice as many unflawed as flawed grading units.
- (f) Sizing Specimen
 - (1) The minimum number of flaws shall be ten. At least 30% of the flaws shall be overlay fabrication flaws. At least 40% of the flaws shall be cracks open to the inside surface.
 - (2) At least 20% but less than 40% of the flaws shall be oriented axially. The remainder shall be oriented circumferentially. Flaws shall not be open to any surface to which the candidate has physical or visual access.

PDI IMPLEMENTATION

REQUIREMENT

(f) Sizing Specimen (Continued)

- (3) Base metal cracking used for length sizing demonstrations shall be oriented circumferentially.
- (4) Depth sizing specimen sets shall include at least two distinct locations where cracking in the base metal extends into the overlay material by at least 0.1 in. in the through-wall direction.

2.0 CONDUCT OF PERFORMANCE DEMONSTRATIONS

The specimen inside surface and identification shall be concealed from the candidate. All examinations shall be completed prior to grading the results and presenting the results to the candidate. Divulgence of particular specimen results or candidate viewing of unmasked specimens after the performance demonstration is prohibited.

2.0

The specimen inside surface and identification shall be concealed from the candidate. All examinations shall be completed prior to grading the results and presenting the results to the candidate. Divulgence of particular specimen results or candidate viewing of unmasked specimens after the performance demonstration is prohibited. <u>Performance demonstrations will be conducted to the requirements of the existing program, with the additional requirements of essential variable recording and monitoring, which is required by Appendix VIII and the PDI Protocol. Extension of procedure Scope and essential variables, not demonstrated by the existing samples, will be demonstrated on site specific calibration blocks, during examinations.</u>

2.1 Detection Test

Flawed and unflawed grading units shall be randomly mixed. Although the boundaries of specific grading units shall not be revealed to the candidate, the candidate shall be made aware of the type or types of grading units (base or overlay) that are present for each specimen.

2.2 Length Sizing Test

- (a) The length sizing test may be conducted separately or in conjunction with the detection test.
- (b) When the length sizing test is conducted in conjunction with the detection test and the detected flaws do not satisfy the requirements of para. 1.1(f), additional specimens shall be provided to the candidate. The regions containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the length of the flaw in each region.

2.1

<u>The detection, length sizing and depth sizing tests will be</u> <u>conducted according to the protocol of the existing BWROG</u> - <u>IGSCC Overlay Program.</u> (See PDI Position 95-014)

2.2

The detection, length sizing and depth sizing tests will be conducted according to the protocol of the existing BWROG - IGSCC Overlay Program. (See PDI Position 95-014)

PDI IMPLEMENTATION

REQUIREMENT

2.2 Length Sizing Test (Continued)

- (c) For a separate length sizing test, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the length of the flaw in each region.
- (d) For flaws in base grading units, the candidate shall estimate the length of that part of the flaw that is in the outer 25% of the base wall thickness.

2.3 Depth Sizing Test.

For the depth sizing test, 80% of the flaws shall be sized at a specific location on the surface of the specimen identified to the candidate. For the remaining flaws, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region.

3.0 ACCEPTANCE CRITERIA

3.0

2.3

<u>Theacceptance criteria of the existing BWROG - IGSCC</u> <u>Overlay Program.</u> (See PDI Position 95-014)

The detection, length sizing and depth sizing tests will be

IGSCC Overlay Program. (See PDI Position 95-014)

conducted according to the protocol of the existing BWROG

3.1 Detection Acceptance Criteria

Examination procedures, equipment, and personnel are qualified for detection when the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for both detection and false calls. The criteria shall be satisfied separately by the demonstration results for base grading units and for overlay grading units.

3.2 Sizing Acceptance Criteria

Examination procedures, equipment, and personnel are qualified for sizing when the results of the performance demonstration satisfy the following criteria.

- (a) Flaw lengths are estimated within 1 in. of the true length (the length of base metal cracking is measured at the 75% through-base-metal position).
- (b) All extensions of base metal cracking into the overlay material by at least 0.1 in. are reported as being intrusions into the overlay material.

PDI IMPLEMENTATION

Revision 1, Change 1

REQUIREMENT

PDI IMPLEMENTATION

3.2 Sizing Acceptance Criteria (Continued)

(c) The RMS error of the flaw depth measurements, as compared to the true flaw depths, is less than or equal to 0.125 in. RMS error shall be calculated as follows:

RMS =
$$\left[\frac{\sum_{i=1}^{n} (m_i - t_i)^2}{n}\right]^{1/2}$$
.

where

- $m_1 = \text{measured flaw depth}$
- 11 = true flaw depth
- n = number of flaws measured
SUPPLEMENT 12 QUALIFICATION REQUIREMENTS FOR COORDINATED IMPLEMENTATION OF SELECTED ASPECTS OF SUPPLEMENTS 2, 3, 10, AND 11

REQUIREMENT

PDI IMPLEMENTATION

1.0 DETECTION AND LENGTH SIZING

- (a) Ferritic Piping
 - The requirements of Supplement 3 are satisfied by asmonstration on wrought austenitic piping when the following requirements are met.
 - (a) For detection qualification, at least three additional flawed grading units and six additional unflawed units in ferritic piping shall be added to the test set. A grading unit shall include at least 3 in. continuous weld length. All 9 ferritic grading units shall be correctly identified.
 - (b) For length sizing qualification, at least three additional flaws in ferritic piping shall be added to the test set. All flaws shall be sized within the length criteria of Supplement 2, para 3.2.
 - (2) Examinations of specimens during a successful detection or length sizing demonstration on dissimilar metal welded piping may be applied toward a Supplement 3 demonstration when the following requirements are met.
 - (a) Grading units shall include at least 6 in. continuous weld length. The grading unit shall contain only the ferritic-side base metal and inside surface clad. The austenitic base metal, butt weld, and weld preparation buttering shall not be a part of the grading unit.
 - (b) The examinations performed on the ferritic (a)(2)(b) side of the dissimilar metal weld specimens shall use the same ultrasonic procedure essential variable values, or, when appropriate, the same criteria for selecting values, as the examinations performed on the ferritic specimens.

- (a) PDI qualifies ferritic piping detection by adding at least three flawed ferritic grading units and six unflawed ferritic grading units to an austenitic test set. The grading unit includes at least 3 in. of continuous weld length. Surveillance verifies that all 9 grading units are correctly identified.
- (a)(1) PDI satisfies Supplement 3 requirements by adding ferritic piping specimens to wrought austenitic sample sets of Supplement 2.
- (a)(1)(a) PDI qualifies ferritic piping detection by adding at least three flawed ferritic grading units and six unflawed ferritic grading units to an austenitic test set. The grading unit includes at least 3 in. of continuous weld length. Surveillance verifies that all ferritic grading units are correctly identified.
- (a)(1)(b) For length sizing, PDI includes at least three and no more than four flaws in ferritic piping to the flaws in Supplement 2. Ferritic sizing results are graded with the Supplement 2 results. The RMS error must be equal to or less than .75" for the combined test sets.
- (a)(2) PDI is not currently implementing dissimilar metal requirements.

(a)(2)(e)

SUPPLEMENT 12 QUALIFICATION REQUIREMENTS FOR COORDINATED IMPLEMENTATION OF SELECTED ASPECTS OF SUPPLEMENTS 2, 3, 10, AND 11

REQUIREMENT

- (b) Austenitic Piping Examinations of specimens during a successful detection or length sizing demonstration on dissimilar metal welded piping may be applied toward a Supplement 2 demonstration when the following requirements are met.
 - Grading units shall be defined as at least 6 in. (1) continuous weld length. The grading unit shall contain only the austenitic-side base metal. The ferritic base metal, butt weld, and weld preparation buttering shall not be a part of the grading unit.
 - (2) The examinations performed on the austenitic side of the dissimilar metal weld specimens shall use the same ultrasonic procedure essential variable values, or, when appropriate, the same criteria for selecting values, as the examinations performed on the austenitic specimens.

2.0 DEPTH SIZING

Examination personnel, equipment, and procedure qualification requirements for depth sizing for more than one of Supplements 2, 3, 10, and 11 are met by the following demonstration.

- (a) Specimens
 - (1) The minimum number of flaws shall be ten.
 - (2) The specimen set shall include at least four flaws from specimens specific to each of the Supplements addressed by the demonstration. If Supplement 3 is being addressed, the specimen set shall include no more than five Supplement 3 flaws.
 - (3) The overall flaw depth distribution shall meet the requirements of Supplement 2, para. 1.0(e)(2).
 - (4) Of the flaws specific to each of an Supplements addressed by the demonstration, no more than half, rounded to the next higher whole number, may be in any one of the depth categories of Supplement 2, para. 1.0(e)(2).

PDI IMPLEMENTATION

(b) PDI is not currently implementing dissimilar metal requirements.

(b)(1)

(b)(2)

2.0 PDI coordinates the qualification of examinations for Supplements 2 and 3 only at this time.

- (a)(1) The minimum number of flaws is ten.
- (a)(2) PDI uses 4 or 5 ferritic flaws for Supplement 3 in coordination with at least 5 austenetic flaws (for a minimum total of 10 flaws) from Supplement 2.
- (a)(3) The surveillance and computer program for making tests verify that overall flaw distribution meets the requirements of Supplement 2, para. 1.3 ('93 Addenda)
- (a)(4) PDI surveillance and instructions ensure that no more than half of the flaws in any one depth category come from supplement 2 or 3 flaws.

SUPPLEMENT 12 QUALIFICATION REQUIREMENTS FOR COORDINATED IMPLEMENTATION OF SELECTED ASPECTS OF SUPPLEMENTS 2, 3, 10, AND 11

REQUIREMENT

PDI IMPLEMENTATION

2.0 DEPTH SIZING (Continued)

(b) The demonstration shall be conducted in accordance with the requirements of Supplement 2, para. 2.2.(b). PDI conducts the depth sizing demonstration by providing a region on the specimen where the maximum depth is measured. This is because the Code assumed that the IGSC Planar Sizing Program was measuring depths at a specific location 20% of the time. This has not been true for several years and the Code hasn't revised this paragraph until recently.

PDI qualifies examination systems for depth sizing by combining the results of Supplement 2 and 3 flaws and determining the RMS error. Acceptable performance is when the RMS error is less than or equal to .125 in. (See FDI s, Position 94-002).

(c) The examination procedure, equipment, and personnel are qualified for depth sizing under each of the Supplements addressed by the demonstration when the FMS error of the flaw depth

measurements, as compared to the true flaw depths, is less than or equal to 0.125 in. RMS error shall be calculated as follows:



where

- $m_1 = \text{measured flaw depth}$
- $t_1 = true flaw depth$
- n = number of flaws measured

"APPENDIX A"

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PROGRAM IMPLEMENTING

PROCEDURES

Specimen Fabrication

Quality Assurance Program

NUMBER	TITLE	STATUS
SFQAR	PDI Specimen Fabrication Quality Assurance Requirements	Proprietary
SFQAP	PDI Specimen Fabrication Quality Assurance Program	Proprietary
PDI-Q-002	Design Control	Proprietary
PDI-Q-003	PDI Test Specimen Procurement	Proprietary
PDI-Q-004	PDI Document Control	Proprietary
PDI-Q-005	Material Control and Identification for PDI Specimen Fabrication	Proprietary
PDI-Q-006	Qualification of Inspection, Examination and Test Personnel for PDI Specimen Fabrication	Proprietary
IA-301	Qualification and Certification of NDE Personnel	Proprietary
ADM-217	Calibration and Control of NDE Center Measurement and Test Equipment	Proprietary
PDI-Q-010	PDI Test Specimen and Information Security	Proprietary
PDI-Q-012	PDI Control of Nonconforming Items	Proprietary
PDI-Q-013	PDI Specimen Manufacturing and Examination Records Indexing	Proprietary
PDI-I-013	PDI Test Specimen Quality Records Review Instruction	Proprietary
PDI-Q-014	Quality Assurance Monitoring	Proprietary
PDI-G-001	Preparation, Use and Control of Process Control Sheets	Proprietary

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PDP-I-009	PDP Prerequisites Instruction	Proprietary
PDP-I-009.1	Procedure Review Instruction	Proprietary
PDP-I-009.2	Dispute Resolution Instruction	Proprietary
PDP-I-009.3	Candidate Registration and Scheduling Instruction	Proprietary
PDP-I-009.4	General Test Specimen Selection Instruction	Proprietary
PDP-I-009.4.1	Test Specimen Selection Instruction - Manual or Semi-Automated Austenitic Piping Examinations for Detection, Length and Depth Sizing (Supplement 3 & 12)	Proprietary
PDP-I-009.4.2	Test Specimen Selection Instruction - For Detection, Length, and Depth Sizing of RPV Clad/Base Material Interface examinations (Supplement 4) and RPV Welds other than Clad/Base Material Interface (Supplement 6)	Proprietary
PDP-I-009.5	Grading Instruciton for Piping and Bolting	Proprietary
PDP-I-009.5.1	Grading Instruciton for Reactor Pressure Vessel (Supplements 4 & 6)	Proprietary
PDP-I-009.6	PDQS Expansion Instruction	Proprietary
PDP-I-009.7	Piping Qualification Retest Instruction	Proprietary
PDP-I-009.7.1	RPV Qualification Retest Instruction (Supplements 4 & 6)	Proprietary
PDP-I-012.1	Instrument and Search Unit Characterization	Proprietary
PDP-I-018	Piping Surveillance Instruction	Proprietary
PDP-I-018.1	Automated Surveillance Instruction	Proprietary

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PDPQAR	Performance Demonstration Process Quality Assurance Requirements	Proprietary
PDPQAP	Performance Demonstration Process Quality Assurance Program	Proprietary
PDP-Q-001	Organization	Proprietary
PDP-Q-005	Procedures and Instructions	Proprietary
PDP-Q-006	Document Control	Proprietary
PDP-Q-008	Security of Test Specimen Information	Proprietary
PDP-Q-008.1	Control and Security of Test Specimen	Proprietary
PDP-Q-009	Performance Demonstration Control	Proprietary
PDP-Q-009.1	Test Administration	Proprietary
IA-301	Qualification and Certification of NDE Personnel	Proprietary
ADM-217	Calibration and Control of NDE Center Measurement and Tests Equipment	Proprietary
PDP-Q-013	Handling, Storage, and Shipping	Proprietary
PDP-Q-015	Control of Nonconformances	Proprietary
PDP-I-015.1	10CFR21 Evaluation and Reporting	Proprietary
PDP-Q-016	Corrective Action and Root Cause Analysis	Proprietary
PDI-Q-017	QA Records	Proprietary
PDP-Q-018	Audits	Proprietary
PDP-Q-018.1	Qualification & Certification of Lead Auditors	Proprietary
PDP-Q-018.2	Qualification & Certification of Auditors	Proprietary
PDP-Q-018.3	Surveillances	Proprietary

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PDI PROGRAM POSITIONS

"APPENDIX B"

PDI POSITION NO. 94-001R1

I. CODE REFERENCE/REQUIREMENT -

ASME Section XI, Appendix VIII Supplement 2 - "Qualification Requirements for Wrought Austenitic Piping Welds" Paragraph 1.1(b)

"The specimen set shall consist of at least four specimens having different nominal pipe diameters and thicknesses. They shall include the minimum and maximum pipe diameters and thicknesses for which the examination procedure is applicable. If the procedure is applicable to pipe diameters of 24 in. or larger, the specimen set must include at least one specimen 24 in. or larger in diameter with the maximum thickness covered by the procedure, but need not include the maximum diameter."

II. PDI POSITION AND PROPOSED CODE CHANGE -

The specimen set shall consist of at least four specimens having different nominal pipe diameters and thicknesses. The set shall include pipe specimens not thicker than 0.1 inch more than the minimum thickness, nor thinner than 0.5 inch less than the maximum thickness for which the examination procedure is applicable. It shall include the minimum and maximum pipe diameters and thicknesses for which the examination procedure is applicable. It shall include the minimum and maximum pipe diameters and thicknesses for which the examination procedure is applicable. If the procedure is applicable to pipe diameters of 24 inch or larger, the specimen set must include at least one specimen 24 inch or larger in diameter but need not include the maximum diameter.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

These changes were incorporated by the 95 Addenda. See also, PDI Position 95-013, which describes additional changes to Supplement 12.

{94-001 and 94-004 should be combined}

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PDI POSITION NO. 94-002R1

I. CODE REFERENCE/REQUIREMENT -

ASME Section XI, Appendix VIII Supplement 2 - "Qualification Requirements for Wrought Austenitic Piping Welds"

> "Sizing Acceptance Criteria. Examination procedures, equipment, and personnel are qualified for sizing if the results of the performance demonstration satisfy the following criteria:

 (a) flaw lengths estimated by ultrasonics are within 1 in. of the true length;"

II. PDI POSITION AND PROPOSED CODE CHANGE -

PDI will allow a Root Mean Square (RMS) error of .75 inch instead of the specified 1 inch tolerance. The Section XI Code Committee is currently evaluating changes to this paragraph (Reference ISI 94-39). A change has been proposed to the ASME Section XI Code Committee which reflects this position.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

The RMS Calculation is more fair to the examiner since it does not consider a single "critical miscall" error. The RMS Calculation provides a truer indication of an examiners actual ability. The use of the RMS value may also reduce any tendency to intentionally oversize to avoid a "critical miscall" error. Additionally, the overall capability for accuracy, when averaged over all measurements, will be better than the 1 inch tolerance could allow.

Code Case N-538 and a Code revision incorporating these changes have been accepted by the ASME Code, but have not yet been published as of February 1996.

I. CODE REFERENCE/REQUIREMENT

ASME Section XI, Appendix VIII (92 Edition w/93 Addenda) Supplement 4 -"Qualification Requirements for the Clad/Base Metal Interface of Reactor Vessel" Paragraph 1.1(e) (1) (b).

> "Notches shall have a maximum width of 0.010 in. and shall be plugged to their full depth with an insert of the parent material prior to cladding."

II. PDI POSITION AND PROPOSED CODE CHANGE

Notches in PDI test specimens have been manufactured using procedures that have repeatedly shown the notch tip dimension to be less than 0.010 in. The actual width of the notch at the clad to base metal interface may be greater than 0.010 in. All notches were plugged to their full depth prior to cladding.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE

It is important to make the notch tip less than 0.010 in. to control the notch radius which has an effect on flaw response. The flaw manufacturers were required to demonstrate that they could meet the notch width requirement and it was demonstrated that they could not reliably make the notch opening width less than 0.010 in. However, they could control the notch tip width to less than 0.010 in. The notches required by the Code are beyond current fabrication capabilities and are not technically feasible.

PDI POSITION NO. 94-004R1

I. CODE REFERENCE REQUIREMENT -

ASME Section XI, Appendix VIII (92 Edition w/93 Addenda) Supplement 2 -"Qualification Requirements for Wrought Austenitic Piping Welds" Paragraph 1.1(b).

> "The specimen set shall consist of at least four specimens having different nominal pipe diameters and thicknesses. They shall include the minimum and maximum pipe diameters and thicknesses for which the examination procedure is applicable. If the procedure is applicable to pipe diameters of 24 in. or larger, the specimen set must include at least one specimen 24 in. or larger in diameter with the maximum thickness covered by the procedure, but need not include the maximum diameter."

Supplement 3 - "Qualification Requirements for Ferritic Piping Welds"

"Qualification of examination procedures, equipment, and personnel for ferritic pipe examination shall be accomplished by satisfying the requirements of Supplement 2, except that the sample material shall be ferritic and 75% of the sample set defects (Supplement 2, para. 1.0(c)(2) shall be mechanically or thermally induced fatigue cracks."

Supplement 12 - "Requirements for Coordinated Implementation of Selected Aspects of Supplements 2, 3, 10, and 11"

Refer to requirements of Supplements 2 and 3.

PDI POSITION NO. 94-004R1 (Continued)

II. PDI POSITION AND PROPOSED CODE CHANGE -

Supplement 2, 1.1, (b) The specimen set shall consist of at least four specimens having different nominal pipe diameters and thicknesses. The set shall include pipe specimens not thicker than 0.1 inch more than the minimum thickness, nor thinner than 0.5 inch less than the maximum thickness for which the examination procedure is applicable. It shall include the minimum and maximum pipe diameters and thicknesses for which the examination procedure is applicable to pipe diameters of 24 inch or larger, the specimen set must include at least one specimen 24 inch or larger in diameter but need not include the maximum diameter.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

In developing a program for meeting the requirements of Appendix VIII, we find that there is a large diversity of needs by the various utilities which must meet these requirements. We find disagreements over the significance of 0.030 inch differences in wall thickness. Among the realm of things which are significant in regard to examination effectiveness, this is of minor importance. At the larger end of the pipe wall thickness spectrum we find that the maximums are approximately 3.0 inches for wrought austenitic piping and 3.75 inches for ferritic piping. Material at these extreme sizes is extremely rare. We propose that there is no fundamental difference within the proposed ranges, 0.5 for wrought austenitic and 1.0 inch for ferritic material. Methods of compensating for metal path range and attenuation are a requirement of the demonstrations.

The last sentence of 1.1(b) is unnecessarily complicated. What the Code implies is 24 inches is big enough, after that it doesn't matter. The requirement that the largest thickness is in the largest diameter, is also not necessary The most difficult case is where the maximum thickness is in the smaller diameter pipe.

These changes were incorporated by the 95 Addenda. See also, PDI Position 95-013, which describes additional changes to Supplement 12.

I. CODE REFERENCE REQUIREMENT

ASME Section XI, Appendix VIII (92 Edition W/93 Addenda) Supplement 4 -"Qualification Requirements for the Clad/Base Metal Interface of Reactor Vessel" Paragraph 3.2 Sizing Acceptance Criteria (b)

> "Flaw lengths estimated by ultrasonics shall be the true length -1/4 in. + 1 in."

II. PDI POSITION AND PROPOSED CODE CHANGE

PDI will allow a Root Mean Square (RMS) error of 0.75 inch RMS.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE.

It is the position of the PDI that this requirement is arbitrary and not based on need or a demonstrated capability to perform at this level. The following facts should be considered.

These requirements are in effect, critical miscall conditions, i.e., one error invalidates the entire examination. Where examination demonstrations are requiring 80 to 120 hours or more this is just not acceptable, particularly in light of the relative importance of the length measurement. Critical miscall conditions tend to encourage testmanship (i.e., candidates will tend toward over sizing rather than correctly sizing the indication). The results are therefore less descriptive of the technique or what will actually be performed in the field. An acceptance criteria based on the overall or average performance is much more meaningful. The RMS criteria now accepted for through wall sizing in piping is an example of such a criteria.

There have been three documented studies which have looked at the question of flaw length sizing in RPV test specimens. These include the PISC II Round Robin Test Trials (1), the Sizewell B Validations at the IVC (2) and a demonstration performed by TVA in the spirit of Appendix VIII (3).

The PISC II trials were the largest of the three demonstration trials. This large international trial was conducted in 1982 - 84 time frame and included manual and automated systems as well as "advanced or alternative systems." The PISC trial results have been the subject of a large number of studies which have been widely accepted. Of

PDI POSITION NO. 94-005 (Continued)

the specimens included in PISC II, Plate No. 2 is most appropriate to Supplements 4 and 6. PISC Plate No. 2 is a flat plate clad on one side and approximately 5 X 5 feet and 10 inches thick. The plate contained flaws which would be included in both Supplements 4 and 6. The error in sizing the length of these flaws, ESY, is shown in Figure 10, for 20% ASME DAC procedures. The reported mean was 14 mm width and the standard deviation was 33.1. This is a very large error. It indicates that only 65% of the measurements were within 33 mm or 1.3 inches of the mean which is off by more than .5 inch.

The PISC data was collected up to 12 years ago. Considerable advances in training and equipment have been made since that time. In addition, the overall data is skewed considering that there were some teams with mean errors in length of up to 2 inches, with very large standard deviations. There were at least 8 teams which examined Plate No. 2, achieving standard deviations of less than 19 mm for the length measurements.

The IVC trials for Sizewell B, were directed primarily at the RPV. However, other components of the steam generator, pressurizer and flywheel were also included. These trials included both manual and automated systems. Mr. Conroy, program administrator, concludes that many individuals with high capability would have failed to pass the - 1/4 inch criteria. Reported length sizing accuracy's in this trial ranged from 3.9 to 10.2 mm (0.15 to 0.4 inch) RMS. In terms of mean and standard deviation these were -1.9 ± .3.4 mm for the low and 4.2 ± 9.3 mm for the high. These are extraordinary accuracy's. However, many of these individuals would fail Appendix VIII due to the -1/4 inch requirement.

The TVA "Demonstration In the Spirit of Appendix VIII" (3) was led by Frank Leonard of TVA and assisted by NDE Center personnel. The demonstration contained both Supplement 4 & 6 test blocks. The demonstration used automated data collection systems. Four data analysis candidates took part in the demonstration. One prominent difference between Appendix VIII requirements and the test results was a failure to stay with the - I/4 inch length sizing tolerance. Overall the length sizing performance was very good. The mean deviation for all length measurements including retests was +0.155 inch with a standard deviation of ± 0.325 inch. The measurement data base included 102 measurements. The RMS Error for these same measurements was 0.359 inch. In one case the measurement exceeded the + 1.0 inch requirement when the error was 1.028 inch.

Adoption of a length sizing criteria of 0.75 inch RMS would provide a workable and achievable standard for this measurement. Examples of this criteria can be seen in the proposal for revising the length sizing criteria for piping. It is actually more descriptive of the sizing process, as opposed to ± 1.0 inch. Candidates who can demonstrate highly accurate sizing should be given credit for this achievement. The - 1/4 inch has been shown to be impractical.

PDI POSITION NO. 94-006R1

I. CODE REFERENCE REQUIREMENT -

ASME Section XI, Appendix VIII (92 Edition w/93 Addenda) Supplement 2 -"Qualification Requirements For Wrought Austenitic Piping Welds" Paragraph 2.2 (b)

> "For the depth sizing test, 80% of the flaws shall be sized at a specific location on the surface of the specimen identified to the candidate. For the remaining flaws, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region."

Supplement 4 - "Qualification Requirements for the Clad/Base Metal Interface of Reactor Vessel" Paragraph 2.2(b)

"For the depth sizing test, 80% of the flaws shall be sized at a specific location on the surface of the specimen identified to the candidate. For the remaining flaws, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region."

Supplement 6 "Qualification Requirements for Reactor Vessel Welds Other Than Clad/Base Metal Interface" Paragraph 2.2(b)

"For the depth sizing test, 80% of the flaws shall be sized at a specific location on the surface of the specimen identified to the candidate. For the remaining flaws, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region."

Revision 1, Change 0

PDI POSITION NO. 94-006R1 (Continued)

II. PDI POSITION AND PROPOSED CODE CHANGE -

For depth sizing tests the region of the specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in the region.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

This requirement originated during the early days of IGSC. It was found to be impractical and was dropped. It is not always possible to achieve the required signal responses at any specified location. The new requirement is: more conservative, needed to maintain security, and more similar to what is done in actual field practice.

Code Case N-537, published in the 95 Supplement, is applicable to this situation.

PDI POSITION NO. 94-007R1

I. CODE REFERENCE REQUIREMENT -

ASME Section XI, Appendix VIII (92 Edition w/93 Addenda) Supplements 4 "Qualification Requirements For The Clad/Base Metal Interface Of Reactor Vessel" Paragraph 2.1(a), 2.2(a) and Supplement 6 "Qualification Requirements For Reactor Vessel Welds Other Than Clad/Base Metal Interface" Paragraph 2.1(a) and 2.2(a)

2.1a	"Specimen identification and
	flaw locations shall be
	obscured so as to maintain a
	"blind test".
2.2a	"For the length sizing test,
	the inside surface and the
	specimen identification shall
	be obscured."

II. PDI POSITION AND PROPOSED CODE CHANGE -

Supplements 4 and 6, paragraphs 2.1(a) and 2.2(a)

2.1 Detection Test

(a) Flaw locations shall be obscured so as to maintain a "blind test." All examinations shall be completed prior to grading and presenting the results to the candidate. Divulging particular specimen results or candidate viewing of unmasked specimens is prohibited.

2.2 Length sizing test

(a) For the length sizing test, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the length of the flaw in each region.

PDI POSITION NO. 94-007R1 (Continued)

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

Steps have been taken to obscure flaw locations on both the inside and outside surface. Flaws on the outside surface are even more difficult to conceal than the clad inside surface. It would not be possible to conduct a demonstration under the original requirements.

These changes have been incorporated in Code Case N-541, which was published in the 95 Supplement.

I. CODE REFERENCE/REQUIREMENT -

ASME Section XI, Appendix VIII (92 Edition W/93 Addenda) Supplement 6 -"Qualification Requirements for Reactor Vessel Welds Other Than Clad/Base Metal Interface" Paragraph 3.2 Sizing Acceptance Criteria (b).

> "Flaw lengths estimated by ultrasonics shall be the true length -1/4 in., + 1 in."

II. PDI POSITION AND PROPOSED CODE CHANGE -

PDI will allow a Root Means Square (RMS) error of 0.75 inch RMS.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

It is the position of the PDI that this requirement is arbitrary and not based on need or a demonstrated capability to perform at this level. The following facts should be considered.

These requirements are in effect, critical miscall conditions, i.e., one error invalidates the entire examination. Where examination demonstrations are requiring 80 to 120 hours or more this is just not acceptable, particularly in light of the relative importance of the length measurement. Critical miscall conditions tend to encourage testmanship (i.e., candidates will tend toward over sizing rather than correctly sizing the indication). The results are there fore less descriptive of the technique or what will actually be performed in the field. An acceptance criteria based on the overall or average performance is much more meaningful. The RMS criteria now accepted for through wall sizing in piping is an example of such a criteria.

There have been three documented studies which have looked at the question of flaw length sizing in RPV test specimens. These include the PISC II Round Robin Test Trials (1), the Sizewell B Validations at the IVC (2) and a demonstration performed by TVA in the spirit of Appendix VIII (3).

The PISC II trials were the largest of the three demonstration trials. This large international trial was conducted in 1982 - 84 time frame and included manual and automated systems as well as "advanced or alternative systems." The PISC trial results have been the subject of a large number of studies which have been widely accepted. Of

the specimens included in PISC II, Plate No. 2 is most appropriate to Supplements 4 and 6. PISC Plate No. 2 is a flat plate clad on one side and approximately 5 X 5 feet and 10 inches thick. The plate contained flaws which would be included in both Supplements 4 and 6. The error in sizing the length of these flaws, ESY, is shown in Figure 10, for 20% ASME DAC procedures. The reported mean was 14 mm width and the standard deviation was 33.1. This is a very large error. It indicates that only 65% of the measurements were within 33 mm or 1.3 inches of the mean which is off by more than .5 inch.

The PISC data was collected up to 12 years ago. Considerable advances in training and equipment have been made since that time. In addition, the overall data is skewed considering that there were some teams with mean errors in length of up to 2 inches, with very large standard deviations. There were at least 8 teams which examined Plate No. 2, achieving standard deviations of less than 19 mm for the length measurements.

The IVC trials for Sizewell B, were directed primarily at the RPV. However, other components of the steam generator, pressurizer and flywheel were also included. These trials included both manual and automated systems. Mr. Conroy, program administrator, concludes that many individuals with high capability would have failed to pass the - 1/4 inch criteria. Reported length sizing accuracy's in this trial ranged from 3.9 to 10.2 mm (0.15 to 0.4 inch) RMS. In terms of mean and standard deviation these were -1.9 ± 3.4 mm for the low and 4.2 ±9.3 mm for the high. These are extraordinary accuracy's. However, many of these individuals would fail Appendix VIII due to the -1/4 inch requirement.

The TVA "Demonstration In the Spirit of Appendix VIII" (3) was led by Frank Leonard of TVA and assisted by NDE Center personnel. The demonstration contained both Supplement 4 & 6 test blocks. The demonstration used automated data collection systems. Four data analysis candidates took part in the demonstration. One prominent difference between Appendix VIII requirements and the test results was a failure to stay with the - 1/4 inch length sizing tolerance. Overall the length sizing performance was very good. The mean deviation for all length measurements including retests was +0.155 inch with a standard deviation of ± 0.325 inch. The measurement data base included 102 measurements. The RMS Error for these same measurements was 0.359 inch. In one case the measurement exceeded the + 1.0 inch requirement when the error was 1.028 inch.

Adoption of a length sizing criteria of 0.75 inch RMS would provide a workable and achievable standard for this measurement. Examples of this criteria can be seen in the proposal for revising the length sizing criteria for piping. It is actually more descriptive of the sizing process, as opposed to ± 1.0 inch. Candidates who can demonstrate highly accurate sizing should be given credit for this achievement. The - 1/4 inch has been shown to be impractical.

PDI POSITION NO. 94-009R1

This position is deleted and replaced by PDI Position 95-001

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I. CODE REFERENCE/REQUIREMENT -

ASME Section XI, Appendix VIII (92 Edition w/93 Addenda) Supplement 4 "Qualification Requirements for the Clad / Base Metal Interface of Reactor Vessel" Paragraph 1.1(f)

> "The number of flaws in the detection test matrix shall be selected from Table VIII-S4-1. The rules of IWA-3000 shall be used for determining whether closely spaced flaws should be treated as separate flaws."

II. PDI POSITION AND PROPOSED CODE CHANGE -

1.1(f) The number of flaws used for grading of the detection test set will be a minimum of 7 for procedure qualification. For personnel qualification, the total of supplement 4 and 6 flaws shall be at least 10, and at least 50% of these shall be Supplement 4 flaws. Other flaws may be present in the examination area.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

PDI implementation experience has shown that, for personnel qualification demonstrations, many fewer flaws can be used to obtain reasonable assurance that the candidate can accurately apply the detection procedures. No change is recommended for procedure qualification. In automated RPV examination analyst qualification, the candidate is looking at the same information and following the same steps to arrive at the desired conclusion. These examinations have taken up to four weeks, for a test and a retest, according to the previous rules. This time and cost for these examinations are not justifiable based on the modest, if any gain in confidence one might achieve.

I. CODE REFERENCE/REQUIREMENT -

ASME Section XI, Appendix VIII (92 Edition w/93 Addenda) Supplement 4 "Qualification Requirements for the Clad / Base Metal Interface of Reactor Vessel" Paragraph 1.1(e)(3)

> "The flaw sizes shall be uniformly distributed in through-wall depths (inches) among the ranges:

(a) 0.075-0.200
(b) 0.201-0.350
(c) 0.351-0.550
(d) 0.551-0.750

No flaw shall have an aspect ratio (depth/length) less than 0.1."

II. PDI POSITION AND PROPOSED CODE CHANGE -

Paragraph 1.1(e)(3) Flaws selected for detection test will be from the four categories (a, b, c, d) as specified, except that:

a. <u>Flaws smaller than the 50% of allowable flaw size, as defined in IWB-3510-1, will</u> not be included as detection flaws. For procedures applied from the inside surface, use the minimum thickness specified in the Scope of the procedure, to calculate a/t. For procedures applied from the outside surface, the actual thickness of the test specimen is used to calculate a/t.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

This requirement in some instances results in flaws which are a small fraction of the allowable flaw sizes listed in Table IWB-3512-1. This forces examination vendors to increase examination sensitivities beyond what is required to detect unacceptable flaws. This excessive sensitivity will require reporting and investigation of a large number of trivial indications. Including flaws of less than 50% of the IWB 3500 requirements are counterproductive to the development of effective procedures. It is expected that this revision will be recommended to the ASME Code.

I. CODE REFERENCE/REQUIREMENT -

ASME Section XI, Appendix VIII (92 Edition w/93 Addenda) Supplement 4 "Qualification Requirements for the Clad / Base Metal Interface of Reactor Vessel" Paragraph 2.1(b)

> "When a flaw is reported within 1/2 in. of it true location (x and y) it shall be considered detected. All other reported flaws shall be considered false calls."

II. PDI POSITION AND PROPOSED CODE CHANGE -

<u>A flaw will be considered detected when reported within 1.0 inch</u> of the true X, Y and Z location or the error allowed by Code Case N-545 <u>whichever is larger</u>

Location accuracy is for grading purposes only. Mathematical errors, systematic location errors, and other errors which exceed the allowable detection criteria, may be accepted by the PDA, provided:

1. There is no doubt that the reported indication is related to the actual flaw.

2. The error did not result from misinterpretation of the ultrasonic signals

3. The results of the investigation is documented and justified.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

It is the position of the PDI that the positioning error in the X and Y dimensions are required in the Code only for the purpose of Grading. We have found that there is little difficulty in deciding whether or not the candidate has detected the intended flaw. We also believe the candidate should not be penalized for errors of position resulting from plotting errors.

Code Case N-545, which has been accepted by the Main Committee of the ASME Code, allows a positioning error based on metal path distance. The PDI position incorporates this Code Case as well as using the description of the PDA which is subject to definitive rules and is open to audit at any time.

I. CODE REFERENCE/REQUIREMENT -

ASME Section XI, Appendix VIII (92 Edition w/93 Addenda) Supplement 4 "Qualification Requirements for the Clad / Base Metal Interface of Keactor Vessel" Paragraph 1.2(a)

> "The sizing test matrix shall contain a minimum of ten flaws, at least half of which shall be cracks."

II. PDI POSITION AND PROPOSED CODE CHANGE -

1.2(a) For procedure qualification, PDI Program Implementing Instruction PDP-I-009.4.3 requires that the sizing test matrix will be selected to contain a minimum of ten flaws. *For personnel qualification, the total of supplement 4 and 6 sizing flaws shall be at least 10, and that at least 50% of these shall be Supplement 4 flaws.* At least half of the flaws in any sizing test matrix will be cracks.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

PDI Performance Demonstration experience has shown that, for personnel qualification demonstrations, many fewer flaws can be used to obtain reasonable assurance the candidate can accurately apply the sizing procedure. No change is recommended for procedure qualification. In automated RPV examination analyst qualification, the candidate is looking at the same information and following the same steps to arrive at the desired conclusion. These examinations have taken up to four weeks, for a test and a retest, according to the previous rules. This time and cost for these examinations are not justifiable based on the modest, if any gain in confidence one might achieve. It is expected that this revision will be submitted to the ASME Code.

I. CODE REFERENCE/REQUIREMENT -

ASME Section XI, Appendix VIII Supplement 5 "Qualification Requirements for Nozzle Inside Radius Section" for demonstrations and examination from the <u>outside</u> <u>surface</u> Paragraph 4.1(b)

> "Personnel previously qualified to Supplement 4, as described in 3.3(a) above, are qualified if each of the flaws presented are detected and identified with no false calls."

II. PDI POSITION AND PROPOSED CODE CHANGE -

The requirements of the 93 edition of the Code, are replaced by Code Case N-552, for examination from the outside surface.

Supplement 5, Paragraph 4.1(b), Personnel previously qualified to Supplement 4, as described in 3.3(a) above, are qualified if each of the flaws presented are detected and identified. The number of false calls allowed shall be the same as in 4.1(a) above.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

The program to be implemented meets or exceeds the requirements of Code Case N-552. The demonstrations and examinations performed to this code Case are superior those which are described in the 93 Code. The failure to allow a proportional number of false calls was an oversight and will be corrected when the case is incorporated.

PDI POSITION NO. 95-008 (Continued)

The PDI BWR nozzle specimens have been designed to facilitate OD examination surface procedures. The dimensions of the specimens were developed to include dimensions suitable that these requirements can be met for most BWR RPV's.

The PDI PWR inlet nozzle specimen has an internal diameter of 28 inches, which is sufficient for demonstrations for PWR inlet and outlet nozzles. BWR mockups are available for smaller nozzles.

Due to the limited sample base it is not possible to provide the same test set diversity as is done for Supplement 4 and 6. As a minimum the PDA will do the following to insure the integrity of the demonstrations:

Require procedures definitively specify criteria for detection and sizing,

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- Require that candidates provide specific evidence that their decisions followed the procedure directions, without apriori information,
- No information as to the true size, location or orientation will be divulged to the cundidates, and
- To the extent possible candidates will be assigned separate areas of the test specimens or different specimens.

Candidates for personnel demonstrations will be provided a sampling of the essential variables q_{ω} slifted by the procedure.

Each of the flaws in the examination test set shall be correctly identified. <u>False calls</u> shall not exceed the value established by paragraph 4.1(a) of Code Case N-552.

(b) PDI will not implement this requirement, see Code Case N-542.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

The PDI implementation for the nozzle-inside-radius, from the <u>inside surface</u>, meets or exceeds Code requirements with the exception of personnel qualification. In addition, Code Cases N-542 and the false call calculations from Code Case N-552 are incorporated. All of these examinations, performed from the inside surface, are eccomplished using automated systems and techniques which are nearly identical to those performed for supplement 4, except for slight adaptation for the curvature. It is the opinion of the PDI that these minor changes do not warrant an additional personnel qualification. The procedure will be thoroughly qualified.

I. CODE REFERENCE/REQUIREMENT -

ASME Section XI, Appendix VIII Supplement 5 "Qualification Requirements for Nozzle Inside Radius Section" for applications applied from the inside surface, Paragraphs (a) and (b).

> "(a) For detection, a minimum of three additional flaws at the inside radius section in one or more full scale nozzle mock-ups (supplement 7) shall be added to the test set."

> "(b) For length sizing, a minimum of three additional flaws as in (a) above shall be added to **the** test set. All flaws shall be sized to the acceptance standards of Supplement 4."

II. PDI POSITION AND PROPOSED CODE CHANGE -

(a) PDI has fabricated two full size PWR nozzle mockups, simulating both inlet and outlet configurations. Five BWR mockups are available if they are needed to expand the scope of a procedure performed from the inside surface. For procedure qualifications, applicable to FWR RPVs, a minimum of three flaws will be included in both the inlet and outlet nozzles. *For "analysis only" personnel qualifications, the following shall apply:*

1. Where the analysis equipment and the ultrasonic technique are basically the same as the Supplement 4 application, no further demonstrations will be required.

2. Where the techniques differ substantially, a demonstration set of a minimum of three flaws will be provided. These will be distributed in either the inlet or outlet configuration or both as appropriate.

(See PDI Position 95-008)

The specimens comply with Supplement 4, 1.1. Flaw types will generally be cracks. However, some notches may be used.

All flaws are located within the radial axial plane of the nozzle inside radius section as illustrated by Fig.IWB-2500-7.

I. CODE REFERENCE/REQUIREMENT -

ASME Section XI, Appendix VIII (92 Edition w/93 Addenda) Supplement 8 Qualification Requirements For Bolts And Studs

II. PDI POSITION AND PROPOSED CODE CHANGE -

The PDI has developed a personnel qualification program which meets or exceeds the requirements of Supplement 8.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

This position satisfies the requirements of Appendix VIII Supplement 8. Additional flaws and false call requirements are in addition to the Code requirement for personnel qualifications. It is expected that exact ranges and essential variables specific to a particular plant will be qualified at the lime of calibration, at the site.

I. CODE REFERENCE/REQUIREMENT -

II. PDI POSITION AND PROPOSED CODE CHANGE -

Supplement 7, "Qualification Requirements For Nozzle-To-Vessel Weld," paragraphh (a)

PDI will implement the requirements of Supplement 7 for inside surface, clad-to-base metal interface, only.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

The technical basis for revising the scope of this qualification is under development. The cost/benefit of performing the examination to the existing requirements is very poor. It was estimated that performing a fully qualified Appendix VIII examination would extend PWR RPV examinations for up to 5 days. It is our position that there is no active flaw mechanism in these areas and that we would be spending an inordinate sum for re-detecting insignificant manufacturing flaws if any.

I. CODE REFERENCE/REQUIREMENT -

ASME Section XI, Appendix VIII (92 Edition w/93 Addenda) Supplement 8 Qualification Requirements For Bolts And Studs, paragraph 1.1(c)

> "Circumferentially oriented notches shall be located in the qualification specimen at the minimum and maximum qualified metal paths. These notches are required on the outside threaded surface and the inner bore hole surface of bored studs with maximum depths and reflective areas as specified in Table VIII-S8-1."

II. PDI POSITION AND PROPOSED CODE CHANGE -

Circumferential notches are located at the minimum and maximum metal paths (*within* one diameter of each end for personnel qualifications and within one diameter of the opposite end for procedure qualifications) which a candidate request to demonstrate. They are located on the outside threaded surface, outer shaft, and the inner bore hole surface of bored studs as specified in Table VIII-S8-1. The minimum number of notches in a test set shall be five. PDI's design review (PDI-Q-002) verified that the size and location of the notches meet Table VIII-S8-1.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

Code Case N-457 allowed location of the circumferential notches within one diameter from the end of the bolt or stud. N-457 was applicable to Appendix VI. It has now been incorporated into the Code by the 94 Addenda. For personnel qualification, it is necessary to place notches at various locations to provide a blind test. The procedure and the essential variables are qualified using site specific calibration studs before each examination.

I. CODE REFERENCE/REQUIREMENT -

ASME Section XI, Appendix VIII (92 Edition w/93 Addenda) Supplement 4 "Qualification Requirements for the Clad / Base Metal Interface of Reactor Vesse?" Paragraph 1.1(e) (2)

> "All flaws shall emanate from the clad base metal interface and shall propagate predominately into the base metal. A minimum of 40% of the flaws shall be oriented parallel to the clad direction (within \pm 10 deg.) and a minimum of 40% shall be oriented perpendicular to the clad direction (within \pm 10 deg.)."

II. PDI POSITION AND PROPOSED CODE CHANGE -

All flaws in the Supplement 4 examination volume emanate from the clad base metal interface and propagate into the base material.

50% of the flaws in the Supplement 4 examination volume of PDI test specimens are oriented parallel to the clad direction (within +/- 5 degrees). The remaining 50% are oriented perpendicular to the clad direction (within +/-5 degrees). Each Procedure demonstration test set will have a minimum of 40% of flaws oriented Parallel and a minimum of 40% presented perpendicular to the clad direction. <u>Each personnel</u> <u>demonstration test set will contain a representative distribution of flaw orientations, sizes</u> <u>and locations</u>.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

When administering a combined demonstration for personnel qualification it is not possible to meet all of the distribution requirements specified or implied by Appendix VIII. The PDI has concluded that these requirements should be considered as objectives for guidance and not necessarily as requirements for personnel qualifications. A sampling of conditions are considered to be adequate to qualify personnel, provided that the procedure has previously been fully demonstrated. This sampling would include flaw size, location, and crientation.

I. CODE REFERENCE/REQUIREMENT -

ASME Section XI, Appendix VIII Supplement 12, "Qualification Requirements for Coordinated Implementation of Selected Aspects of Supplements 2, 3, 10, and 11," paragraphs 1.3(b) & (c)

II. PDI POSITION AND PROPOSED CODE CHANGE -

1.0 (a) (1) (b) The demonstration shall meet the requirements of Supplement 2, except that for length sizing qualification, the minimum number of flaws shall be ten, and the specimen set shall include at least three, but not more than four, flaws in ferritic material.

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

This revision to Supplement 12 was incorporated into the Code by the 95 Addenda. This revises length sizing to the same basis as has been the case for depth sizing.

I. CODE REFERENCE/REQUIREMENT -

Supplement 11 Qualification Requirements for Overlaid Austenitic Piping Welds

II. PDI POSITION AND PROPOSED CODE CHANGE -

1.0 Specimen Requirements

Specimens currently being used for the BWROG - IGSCC Overlay Examination will be used for this demonstration.

2.0 Conduct of Perfromance Demonstrations

The specimen inside surface and identification shall be concealed form the candidate. All examinations shall be completed prior to grading the results and presenting the results to the candidate. Divulgence of particular specimen results or candidate viewing of unmasked specimens after the performance demonstration is prohibited. <u>Performance demonstrations will be conducted to the requirements of the existing program, with the additional requirements of essential variable recording and monitoring, which is required by Appendix VIII and the PDI Protocol. Extension of procedure Scope and essential variables, not demonstrated by the existing samples, will be demonstrated on site specific calibration blocks, during examinations.</u>

2.1 Detection Test

The detection, length sizing and depth sizing tests will be conducted according to the protocol of the existing BWROG -IGSCC Overlay Program.

2.2 Length Sizing Test

The detection, length sizing and depth sizing tests will be conducted according to the protocol of the existing BWROG -IGSCC Overlay Program.

2.3 Depth Sizing Test

The detection, length sizing and depth sizing tests will be conducted according to the protocol of the existing BWROG -IGSCC Overlay Program.

3.0 Acceptance Criteria

The acceptance criteria of the existing BWROG - IGSCC Overlay Program will be applied.

Underlined Italic text indicates a deviation from the Code requirements

Revision 1, Change 1

PDI POSITION NO. 96-001 (Continued)

III. TECHNICAL JUSTIFICATION FOR PDI POSITION AND PROPOSED CODE CHANGE -

PDI believes that the number of candidates and application justification the fabrication of a separate set of samples. The existing samples, used for the BWROG-IGSCC qualification program, differ from those required by Supplement 11 in the use of flawed and unflawed grading units, as well as the total number of grading units. The original program did not consider these factors and consequently many of the flaws and samples do not meet the requirements of Appendix VIII Supplement 11. PDI believes that the current samples coupled with the procedure and essential variables of Appendix VIII, are adequate to address the question of personnel and procedure qualification.
"Appendix C"

PDI PROGRAM QUALIFICATION

SAMPLE SIZE RANGES

APPENDIX C

Sample Identity		Pipe Sample Description	Pipe Nominal Thickness	Outside Diameter	_
SS Detection		an a			
301 302 303		SS 2" SCH 160 SS 4" SCH 40 S,S 4" SCH 80	0.344 0.237 0.337	2.375 4.500 4.500	
306 307 308 309 310	Existing	SS 12" SCH 80 SS 24" SS 29" BWROG SS 27.5" ID SS 30" + DIA	0.688 1.45 1.4 - 1.5 2.500 ≥3.000	12.750 14.000 28.000 27.500 30.0	
SS Sizing Set					
311 312 313	Existing	SS 4" SCH 80 SS 12" SCH 100 SS 14" SCH 160	0.337 0.844 1.406	4.500 12.750 14.000	
Ferritic Set					
421 423 424		FE 4" SCH 80 FE 12" SCH 80 FE 24"	0.337 0.688 ≥2.000	4.500 12.750 24.000	
525 CLAD 526 CLAD		30" ID 42" ID	3.125 3.750	36.25 49.5	

PDI PROGRAM QUALIFICATION SAMPLE SIZE RANGES

"Appendix D"

CODE CASES AND REVISIONS BEYOND ADDENDA 1993

"Appendix D"

CODE CASES AND REVISIONS BEYOND ADDENDA 1993

Code Case N-457 and Code Revision, Qualification Specimen Notch Location for Ultrasonic Examination of Bolts and Studs, Applicable to Supplement 8

This Code Case was incorporated in the 94 Addenda. The Code Case is only applicable to Appendix VI. The Code revision is applicable to Appendix VIII. See also PDI Position 95-012.

Code Revision Supplement 2, 95 Addenda, Paragraph 1.1(b) Thickness Tolerance for Piping Qualification Specimen Test Sets

This revision was incorporated into Supplement 2 of the Code by the 95 Addenda. This revision allows examination of piping components which are .1 inch thinner and .5 inch thicker than the specimens which were used in the qualification demonstration, for austenitic piping. For ferritic piping the upper limit is raised to 1.0 inches thicker than the demonstration sample set. This change is included in the PDI program and is justified in PDI Position 94-001R1 and 94-004R1.

Code Case N-537, Location of Ultrasonic Depth-Sizing Flaws, Supplements 2, 4, & 6 Paragraph 2.2

This Code Case was published in the 95 edition. The Case allows the test administrator to point out the region where a flaw is located as opposed to the exact location. This difference is needed to assure test set security. See PDI Position 94-006R1.

Code Case N-538, and Code Revision, Revise Pipe Length Sizing Acceptance Criteria

This Case and the Code revision have been accepted by the Main Committee of the Code, as of December 1995. These revisions establish a realistic length sizing acceptance criteria, which meets the needs of safety. See PDI Position 94-002R1.

Code Case N-541, and Code Revision, Clarification of Surface Access Conditions, Supplements 4, 5, 6, & 7

This Case has been published in the 95 Code Case Supplement. The Code revision was incorporated in the 95 Addenda. These changes allow access to the surface where flaws are located provided their locations are properly obscured. See PDI Position 94-007R1.

"Appendix D"

CODE CASES AND REVISIONS BEYOND ADDENDA 1993 (Continued)

Code Case N-542 and Code Revision, Deletion of Length Sizing Requirements, for the Nozzle Inner-Radius Examinations of Supplement 5

The Code Case was published in the 95 S-1 Supplement. The Code Revision was incorporated by the 95 Addenda. This revision deletes the requirements for length sizing inner-radius indications. The revision is based on the fact that flaw length is not used for determination of acceptability. See PDI Position 95-008.

Code Revision, Pipe Length Sizing Set Selection Rules for Supplements 2 Paragraph 1.3(b) & Supplement 12 Paragraph 1.0(a)(1)(b)

This revision has been incorporated in the 95 Addenda to the Code. This change provides a more appropriate description of the length sizing test set and allows length sizing tests to be performed on a combined test set, as is the case for depth sizing. See PDI Position 95-013 and 94-001R1.

Code Case N-545, Revise Location Tolerance Requirements, Supplements 4, 5, 6, &7

This Code Case has been accepted and will be published in the 95 S-2 supplement for Code Cases. This revision was needed to provide more realistic location tolerances. These location tolerances are only used to assist in the grading of the examination. See PDI Position 95-006.

Code Case N-552, Alternative Rules for Examination of the Nozzle Inner-Radius from the Outside Surface

This Code Case has been accepted by the Main Committee of the ASME Code. Publication is expected in 1996. This Code Case simplifies the demonstration and provides a technical basis for the demonstrations as well as examinations performed in the field. A copy of the Code Case is included in the Program Description. See PDI Position 95-007.