# Summary of Changes for Revision 1

<table>
<thead>
<tr>
<th>Paragraph</th>
<th>Description of Change</th>
<th>Reason for Change</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>1. (3)</td>
<td>Changed “4 inches or less” to “less than 4 inches”</td>
<td>ASME Code defines small diameter piping as less than 4 inches NPS</td>
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<tr>
<td>2.0</td>
<td>Added “less than 4 inches” and deleted following sentence that addresses piping greater than or equal to 4 inches.</td>
<td>ASME Code defines small diameter piping as less than 4 inches NPS</td>
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<tr>
<td>3.10</td>
<td>Added definition of tangent beam angle</td>
<td>Not defined in procedure</td>
<td></td>
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<tr>
<td>4.0</td>
<td>Added references for MRP-23, R1; MRP-36, R2; MRP-146, R1; and MRP-192, R2</td>
<td>Updated revisions</td>
<td></td>
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<tr>
<td>5.1</td>
<td>Changed “cognizant” to “responsible”</td>
<td>Clarification</td>
<td></td>
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<tr>
<td>6.1</td>
<td>Deleted ASNT TC-1A and added “employer’s certification practice”</td>
<td>Revised from specific to generic requirement</td>
<td></td>
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<tr>
<td>6.2</td>
<td>Deleted reference to “EPRI NDE Center Training” and added “MRP-36, R2 CBT”</td>
<td>Update</td>
<td></td>
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<tr>
<td>6.2.1</td>
<td>Added ASME Section XI Appendix VIII qualification</td>
<td>MRP-146, Revision 1</td>
<td></td>
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<tr>
<td>6.2.2</td>
<td>Redefined required training as the MRP-36, Revision 2 CBT module</td>
<td>MRP-146, Revision 1, and MRP-192, Revision 2</td>
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<tr>
<td>6.3.1</td>
<td>Revised paragraph to be similar to PDI-UT-2</td>
<td>Generic procedure</td>
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<tr>
<td>6.4.2</td>
<td>Changed “cognizant” to “responsible”</td>
<td>Clarification</td>
<td></td>
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<tr>
<td>6.5 (2)</td>
<td>Defined tangent beam angle in note</td>
<td>Inquiry to MRP</td>
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<tr>
<td>6.5 (3)</td>
<td>Defined contouring minimum</td>
<td>Inquiry to MRP</td>
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<tr>
<td>6.5 (5)</td>
<td>Redefined beam angle tolerance</td>
<td>PDI defines the refracted beam angle tolerance as +/- 3° Interim Guidance Letter (6/3/2010) says (+0°) and (-) 2°</td>
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<tr>
<td>7.1.(4)</td>
<td>Deleted “adjusted” and added “performed”</td>
<td>Clarification</td>
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<tr>
<td>8.1.2</td>
<td>Added “(e.g. elbows, piping, and base material adjacent to socket welds) and replaced “examination area” with “piping examination zones”</td>
<td>Clarification</td>
<td></td>
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<tr>
<td>Section</td>
<td>Changes</td>
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<tr>
<td>8.3 (4)</td>
<td>1) Added “or skewed” 2) Added “at least”</td>
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<td></td>
<td>1) Clarify oscillation 2) Clarify that 20° is the maximum required oscillation</td>
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<tr>
<td>8.4.1</td>
<td>Added “Parallel to Circumferential Welds and Perpendicular to Longitudinal Welds”, added “For circumferential welds”, and added “For longitudinal welds”</td>
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<tr>
<td></td>
<td>Clarification</td>
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<tr>
<td>8.4.2</td>
<td>1) Added “Perpendicular to Circumferential Welds and Parallel to Longitudinal Welds” 2) Added “within minus three degrees”</td>
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<td></td>
<td>1) Clarification 2) PDI defines the beam angle tolerance as +/- 3° 2) Interim Guidance Letter (6/3/2012) says (-) 2°</td>
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<tr>
<td>8.5</td>
<td>1) Added “and Circumferential” 2) Added “(within minus three degrees)”</td>
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<tr>
<td></td>
<td>1) Clarification 2) PDI defines the beam angle tolerance as +/- 3° Interim Guidance Letter (6/3/2012) says (-) 2°</td>
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<tr>
<td>9.4. (c)</td>
<td>crazing</td>
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<td></td>
<td>Added recording of crazing regardless of signal amplitude</td>
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<td></td>
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<td></td>
<td>Inquiry to MRP</td>
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<tr>
<td>9.4.(c)</td>
<td>cracking</td>
<td></td>
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<tr>
<td></td>
<td>Added requirement for distinguishing crazing from cracking for recordable indications</td>
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<td></td>
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<tr>
<td></td>
<td>Inquiry to MRP</td>
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</table>
ULTRASONIC EXAMINATION OF SMALL-DIAMETER PIPING BUTT WELDS AND COMPONENTS FOR THERMAL FATIGUE DAMAGE

1. PURPOSE AND APPLICATION

   (1) This procedure provides the technical information and detailed steps necessary to perform ultrasonic examination of butt welds and component base material in stainless steel piping systems by means of manual, pulse-echo, contact techniques.

   (2) This procedure shall be applicable to piping butt welds, adjacent base material, and component base material in the nominal thickness range of greater than 0.10 to 0.90 inch.

   (3) This procedure shall be applicable to nominal pipe diameters in the range of 1.50 inches and greater through nominal pipe diameters less than 4.0 inches.

   (4) Welds to be examined shall be circumferential pipe-to-pipe and pipe-to-component welds, and longitudinal welds in piping and components.

1.1 General

   Ultrasonic examination shall be considered as a means of detecting thermal fatigue cracks. These cracks that originate in the internal surface of the pipe can be isolated, or may be present as a dense network of cracks called “craze.” The cracks can have an axial, circumferential, or skewed orientation. The isolated cracks may be a single defect, or may branch out into multiple cracks.

2. SCOPE /PURPOSE

   The purpose of this procedure is to establish the general requirements for the ultrasonic examination of thermal fatigue cracks in small diameter butt welded piping (less than 4 inches NPS). This work does not address depth-sizing techniques for thermal fatigue cracks or the examination of socket welds.

3. DEFINITIONS

3.1 Basic Calibration Block

   The basic calibration block is the ASME Section XI Code-defined block used to establish the distance amplitude correction curve. This block typically contains calibration reflectors, such as drilled holes or notches, of specific dimension in order to obtain uniformly sensitive calibrations.
3.2 Calibration Block
A calibration block is any block which may be used in order to perform some stage of the system calibration. This block may be either a basic calibration block or a reference calibration block.

3.3 Detection
Detection is the ability to present an indication of the desired reflector on the instrument cathode ray tube.

3.4 Discrimination
Discrimination is the act of determining the nature of an ultrasonic reflector, or distinguishing a crack indication from a geometric indication.

3.5 Investigation
Investigation is the process of determining the shape, identity, and location of a reflector.

3.6 May
The use of the word “may” implies that one is permitted to perform the indicated act.

3.7 Recalibration
Recalibration is the act of completely re-performing the steps involved in calibration.

3.8 Shall
The use of the word “shall” means that the act is mandatory.

3.9 Should
The use of the word “should” means that the act is desirable, but it is not mandatory.

3.10 Tangent ID Beam Angle
An impinging beam angle, dependent upon the inspected pipe size, where detection of inner diameter thermal fatigue flaws would be performed by the beam angle impinging on the face of a radial crack at a $90^\circ$ angle.

4. APPLICABLE DOCUMENTS

4.1 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, Applicable Edition.


5. RESPONSIBILITIES

(1) The responsible Level III shall be responsible for the application of this procedure.

(2) The examiner shall be responsible for the implementation of this procedure.

6. PERSONNEL AND EQUIPMENT

6.1 Personnel Certification

Personnel performing examinations shall be certified in accordance with the employer’s certification practice.

6.1.1 UT Level I personnel are permitted to calibrate the instrument, manipulate the search unit, and record data under the direct supervision of a UT Level II or III.

6.1.2 Only UT Level II or III personnel shall perform investigations and reporting of the indications.

6.2 Personnel Qualification

6.2.1 Personnel shall have been previously qualified for ultrasonic examination of austenitic piping in accordance with ASME Section XI Appendix VIII qualification administered by the Performance Demonstration Initiative (PDI) or another international standard (such as European Network for Inspection Qualification (ENIQ)) prior to performing examinations in accordance with this procedure.

6.2.2 Personnel shall receive focused training to familiarize themselves with the unique aspects of UT examination for thermal fatigue damage, including geometric considerations specific to small diameter piping. As an option
to meet this requirement, personnel may complete the MRP-36, Revision 2 Computer-Based Training Module (or the previous revision) for detection of thermal fatigue cracks or other alternate training methods prior to performing examinations in accordance with this procedure.

6.3 Reference Blocks

(1) Reference blocks (i.e. IIW, DSC, Rompas, etc.) used for establishing linear screen ranges, determining actual refracted angles, exit point information, establishing reference sensitivity, and performing calibration verifications shall be made of austenitic material.

6.4 Basic Calibration Blocks

NOTE: A distance amplitude correction (DAC) curve is not necessary to establish examination sensitivity. However if in addition to the method of determining sensitivity described in this procedure, a DAC curve is used the following shall apply.

(1) The calibration block shall be of austenitic stainless steel and shall conform to the requirements of the applicable edition of ASME Section XI.

(2) Other calibration blocks may be used as determined by the responsible Level III.

6.5 Search Units

(1) The primary search unit frequency shall be either a nominal 2.25 MHz for wall thickness greater than 0.45 inch, or 5 MHz for wall thickness equal or less than 0.45 inch.

(2) The search unit size, mode, and beam angle shall be selected from the following:

<table>
<thead>
<tr>
<th>Scan Direction</th>
<th>Beam Angle at the ID</th>
<th>Mode</th>
<th>Search Unit Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>Circ</td>
<td>*Tangent</td>
<td>Shear</td>
</tr>
<tr>
<td>Confirmation</td>
<td>Circ</td>
<td>45</td>
<td>Shear</td>
</tr>
<tr>
<td>Primary</td>
<td>Axial</td>
<td>45</td>
<td>Shear</td>
</tr>
<tr>
<td>Confirmation</td>
<td>Axial</td>
<td>60</td>
<td>Shear</td>
</tr>
</tbody>
</table>

*The tangent beam angle is the optimum angle for detection of axially oriented flaws; however, a range of angles, especially in the minus (-)
direction within the allowable refracted beam angle tolerance are acceptable.

(3) For detection of axial oriented flaws adjacent to the weld or in the component base material, the wedge shall be contoured to a range of 1.5 to 2 times the nominal pipe diameter. (For a nominal pipe diameter of 3.0 inches, the wedge shall have a maximum contour diameter of 6.0 inches.) A wedge contoured to less than 1.5 times the pipe diameter may not detect skewed flaws due to the smaller skew angle.

(4) For detection of circumferential or skewed oriented flaws adjacent to the weld or in the component base material, the wedge shall be flat.

(5) For flat wedges, the exit point of the sound beam and the actual refracted angle of the search unit shall be determined on an IIW or Rompas block and marked on the search unit wedge. The refracted beam angle shall be within +/- 3° of the nominal angle of the wedge.

(6) Other search unit sizes, angles, modes, and frequencies may be used for supplemental evaluations if equal or better sensitivity can be demonstrated and documented.

6.6 Ultrasonic Instrument

The ultrasonic instrument shall provide, as a minimum, a digital or analog A-scan presentation.

6.7 Couplant

Couplant materials shall comply with site-specific requirements. The couplant used for the calibration shall be the same as that used for during the examination.

7. CALIBRATION METHOD

(1) The FREQ MHz control shall be turned to the closest setting that corresponds to the applicable search unit frequency.

(2) The REJECT control shall be maintained in the 0 or off position during the calibration and the examination.
7.1 Angle-Beam Distance Calibration

(1) The screen distance calibration shall be the shortest distance that includes at least 1/8 V-path past the anticipated examination range.

(2) The screen distance can be either in depth or metal path.

(3) Observing the radii echoes from the applicable reference block, obtain the necessary sound path distance along the instrument display baseline.

(4) When using curved wedges, curved reference blocks may be used. Alternatively, the calibration may be performed by observing the inside surface reflections from the edge of the calibration block or mockup.

7.2 Angle-Beam Sensitivity Calibration

Reference level sensitivity shall be established in the examination area for each examination. Place the search unit on the examination surface and observe the material noise signals at the inside surface. Adjust the instrument gain settings to place the material noise at the inside surface in the range of 5 to 10% of full screen height. This will be the reference level sensitivity.

7.3 Calibration Verification

7.3.1 Sweep Range and Sensitivity Verification

(1) The initial and final sweep range calibrations shall be verified on the appropriate reference block and the reference sensitivity on the examination surface when any of the following occurs:

   (a) With any substitution of the same type and length of search unit cable,
   (b) With any substitution of the same type of power source; for example, a change of batteries, or
   (c) Whenever the validity of the calibration is in doubt.

(2) Intermediate calibration verification may be performed on the appropriate reference block or examination surface. These verifications shall be performed at least every 4 hours.
7.3.2 Calibration Changes

(1) Perform the following if the sensitivity has decreased more than 20% or 2 dB in amplitude, or any point has moved on the sweep line more than 10% of the sweep division reading or 5% of full sweep, whichever is greater:

(a) Void all examinations referring to the calibration in question and performed after the last valid calibration verification.
(b) Conduct a new calibration.
(c) Reexamine the areas for which examinations have been voided.

(2) Perform the following if the reference sensitivity has increased more than 20% of full screen height or 2 dB in amplitude:

(a) Correct the calibration.
(b) Reexamine all indications recorded since the last valid calibration verification.
(c) Enter proper values on a new examination record.

7.3.3 Recalibration

Substitution of any of the following shall be cause for recalibration:

(1) Search unit wedge or transducer
(2) Search unit cable
(3) Ultrasonic instrument
(4) Examination personnel
(5) Couplant
(6) Change in type of power source; for example, change from direct to alternating current.

8. EXAMINATION

8.1 Examination Volume

8.1.1 Weld Profile

(1) If necessary to determine the required examination volume for pipe weld examinations, inside surface and outside surface profiles shall be taken on each weld at the L₀ location as a minimum.
(1) Profiles shall consist of thickness measurements and outside surface contours using a contour gauge. Thickness measurements shall be taken at a maximum interval of 1/4 inch and shall cover the material volume for a distance of 2t from the weld fusion line on each side of the weld. The "t" dimension shall be the nominal pipe wall thickness.

Outside surface profiles shall cover the same distance as the thickness measurements. Weld profiles shall be documented on the appropriate data record.

8.1.2 Component Base Material
Scanning on the base material of components (e.g. elbows, piping, and base material adjacent to socket welds) shall be adequate to ensure complete two directional coverage, when practicable. The customer shall determine the piping examination zones.

8.2 Surface Condition
The contact surfaces shall be free from weld spatter, roughness, or other conditions that interfere with free movement of the search unit or impair the transmission of ultrasound.

8.3 Scanning
(1) When practicable, scanning may be performed at a gain setting of two times the reference level sensitivity.

(2) The search unit movement rate for scanning shall not exceed three inches per second.

(3) Scanning overlap shall be a minimum of 10% of the search unit piezoelectric element dimension perpendicular to the direction of scan.

(4) When scanning with a flat wedge, the search unit shall be oscillated or skewed at least 20 degrees in each direction. When scanning with a contoured wedge, the search unit shall be oscillated the maximum allowable by the wedge while maintaining good contact in each direction.

8.4 Examination of Circumferential and Longitudinal Butt Welds
8.4.1 Examination for Indications Parallel to Circumferential Welds and Perpendicular to Longitudinal Welds
An examination using a 45 degree conventional search unit shall be accomplished from both sides of the weld. For circumferential welds, the sound beam shall be directed perpendicularly into the weld to detect indications oriented parallel with the weld. For longitudinal welds, the sound beam shall be directed parallel to the weld to detect indications oriented perpendicularly to the weld.

8.4.2 Examination for Indications Perpendicular to Circumferential Welds and Parallel to Longitudinal Welds

The examination shall be conducted on each weld (if possible) and adjacent base material for the entire examination volume. Place the search unit producing an incident angle tangent (within minus three degrees) to the inside surface on the weld crown with the sound beam directed into and parallel with the weld. Scanning shall be performed on the weld and adjacent base material from two opposing directions to ensure two-directional coverage of the entire examination volume.

8.5 Examination for Axial and Circumferential Indications in Component Base Material

When component base material examinations are required, search for circumferential and axial flaws, as well as flaws oriented at a skew angle relative to the pipe axis. When searching for circumferentially oriented flaws, use a flat wedge and scan in both directions. Oscillate the search unit 20 degrees in each direction while performing the inspection. When searching for axially oriented flaws, use a search unit that produces an incident beam angle tangent to the inside surface on the component (within minus three degrees). Scanning shall be performed with the beam oriented circumferentially around the component from two opposing directions to ensure two-directional coverage of the examination volume, and oscillating the search unit to the maximum allowable by the wedge while maintaining good contact.

If oscillating the search unit results in poor transducer contact, scans at a fixed skew angle can be perform instead. These types of scans will follow a spiral path. Perform scans with a flat wedge at –20 and +20 degrees relative to the pipe axis, and at the minimum and maximum angles the contour wedge will allow in the circumferential direction. Perform the fixed skew angle scans in both directions.

9. RECORDING, RESOLUTION, AND REPORTING CRITERIA

(1) The following are the minimum data required to be recorded for each examination:
(a) Data sheet identification and time period of examination.

(b) Names and level of certification of examination personnel.

(c) Examination procedure and revision.

(d) Calibration sheet identification.

(e) Identification and location of weld or component volume scanned.

(f) Surface from which the examination is conducted.

(g) Examination results

(2) UT reflectors suspected to be cracks shall be recorded regardless of amplitude. All other reflectors producing a response 50% or greater of FSH shall be recorded.

(3) Recordable indications attributable to geometry shall be recorded only once, even if the amplitude of the indication drops below the required recording amplitude along the weld.

(4) Indications with the following attributes shall be considered thermal fatigue crazing, thermal fatigue cracking, or both;

Thermal Fatigue Crazing:

(a) A sudden increase in the amplitude of the inside surface noise.

(b) UT instrument presentation with multiple indications at the depth or metal path position of the inside surface. These indications will have an echo-dynamic presentation similar to a "clad roll." That is, the signal response will appear “walking” through the screen, starting at a low amplitude and long propagation time, progressing to a higher amplitude and intermediate propagation time, and ending at a low amplitude and short propagation time.

(c) Thermal fatigue crazing as described above shall be recorded regardless of signal amplitude.

Thermal Fatigue Cracking:

(a) A sharp, narrow based signal with at least 3:1 signal-to-noise ratio.

(b) A sharp, narrow based signal that walks through the craze crack signals and is at least twice the amplitude of the craze crack signals.

(c) Thermal fatigue recordable indications are to be distinguished as thermal fatigue crazing or cracking
Note: Thermal fatigue cracking and crazing can occur circumferentially, axially, and off axis, and without association to a weld. Oscillation of the search unit while scanning, or performing scans at a fixed skew angle is very important.

(5) Length sizing of thermal fatigue cracks shall be at the 1/4 max end points. Using the instrument gain controls set the peaked signal to 80% FSH. Move the search unit along the length of the indication in each direction until the signal response drops to 20% full screen height. The distance between these two end points shall be the recorded length.

(6) Length sizing for thermal fatigue crazing shall be baseline to baseline. Without adjusting the instrument gain, move the search unit laterally until the "clad roll" type presentation disappears. Move the search unit in the opposite direction until the signals disappear. This shall be the recorded length for crazing.

(7) Length sizing for all other indications shall be at the 50% full screen height end points.

(8) Indications not attributable to geometry shall be investigated by a level II or a level III examiner to determine the shape, identity, and location of the reflector.

10. EVALUATION

Initial evaluation of reportable indications shall be performed by the vendor, and shall be conducted in accordance with the applicable codes, standards, or specifications. Final evaluation and disposition of reportable indications shall be the responsibility of the customer.

11. DATA COMPARISON

Examination results shall be compared with recorded results from any previous examinations when such previous data are available. As a minimum, review prior data to determine the presence and location of flaws.

12. RECORDS

Records produced in accordance with this procedure shall be stored as specified by the customer.