PB-1000

ULTRASONIC TESTING

REVISION A04

SEPTEMBER 12, 2018

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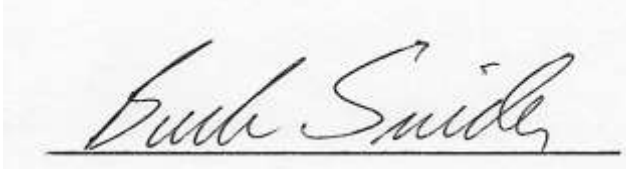
Buck Snider Quality Manager Date: September 12th, 2018	
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REVISION HISTORY

Revision	Date	Description of Changes	Revised by
A0	01/01/96	Original Issue	N/A
A01	12/30/99	Minor revision in various paragraphs as noted	Scott Powers
A02	08/18/08	Major revision	Scott Powers
A03	10/09/14	Removal of Back Reflection Tech.	Scott Powers
A04	09/13/18	• Reformatted and updated entire procedure • Correction of reference acceptance (10.1)	Scott Powers

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1.0 PURPOSE

1.1 To provide the general procedure to be used by P & B TESTING, INC. For the testing of contact longitudinal beam and/or shear wave examinations using the pulse-echo technique to evaluate forgings and bar.

2.0 REFERENCE SPECIFICATION

2.1 ASTM A388, "Standard Practice for Ultrasonic Testing and Inspection of Heavy Steel Forgings" (latest edition).

2.2 ASTM E428, "Standard Practice for Fabrication and Control of Steel Reference Blocks used in Ultrasonic Inspection" (latest edition).

2.3 ASTM E114, "Standard Practice for Ultrasonic Pulse Echo Straight Beam Testing by the Contact Method" (latest edition).

2.4 ASTM E317, "Standard Practice for Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing System Without the Use of Electronic Measurement Instruments" (latest edition).

2.5 SNT-TC-1A, "Recommended Practice for Personnel Qualification in Nondestructive Testing" (latest edition).

3.0 PERSONNEL

3.1 Personnel shall be qualified in accordance with P & B TESTING, INC. Procedure PB-4000, and ASNT SNT-TC-1A, to maintain a minimum of level II.

4.0 EQUIPMENT

4.1 A pulsed, reflection-type ultrasonic examination instrument shall be used.

4.2 The pulsed/receiver shall provide a dB attenuation having a +10%, or 1dB accuracy.

4.3 The vertical linearity of the instrument (receiver and display) shall be within +5% for at least 80% of the vertical limit.

4.4 Performance for the dB attenuation and vertical linearity shall be confirmed once every three months in accordance with ASTM E317.

4.5 The transducer shall be .5" to 1.0" square or have a diameter of .75 to 1.125 inches.

4.6 The nominal examination frequency shall be 2.25 MHz unless the grain size or microstructure of the material prevents adequate ultrasonic penetration, in which case the frequency shall be 1 MHz.

4.7 Shear wave (angle beam) examinations shall be performed using nominal angles of 45, 60, and/or 70 degrees as applicable to assure complete coverage.

4.8 Transducer size and frequency used for evaluation shall be selected to provide the most accurate evaluation of an indicator.

4.9 For the contact method water-cellulose gel, glycerin, 10 to 30 weight oil, or commercially prepared-type couplants may be used. The same mixed batch of couplant shall be used for calibration and examination specimen.

4.10 Scan rate shall not exceed 6" per. sec. and shall have an overlap of 10% min.

5.0 SURFACE CONDITIONS

5.1 The surface finish for contact testing shall be 250 RMS or finer.

5.2 In all cases, the test specimen(s) shall be free of loose scale, paint, dirt, or other foreign material, which might hinder the transmission of the ultrasonic energy into or out of the test specimen(s).

6.0 CALIBRATION BLOCKS

6.1 All calibration blocks, shall be in accordance with ASTM E127 and E428.

6.2 Contact calibration blocks shall be acoustically similar to the test specimen(s) to be examined.

6.3 Calibration blocks unable to comply with the perimeters of paragraph 6.2 above, may be used provided it is demonstrated to the satisfaction of the Level III that the sensitivity level of the calibration is transferred to the test specimen(s) under examinations.

7.0 CALIBRATION

7.1 Calibration shall include the entire ultrasonic system. Any change in one of the following: transducer(s), couplant(s), cable(s), batteries, or power-pacs, shall be cause for re-calibration.

7.2 Horizontal linearity of the cathode ray tube (CRT) presentation shall be within +5% of full screen height.

7.3 The ultrasonic system shall be calibrated at the beginning of each period of use. The system calibration shall be checked at intervals not to exceed 4 hours or at the end of each period of use whichever is the lesser.

7.4 Any change in vertical reference sensitivity level (RSL) or sweep (base line) calibration that exceeds 5 percent shall require re-calibration and reexamination of any areas examined since the last acceptable calibration.

7.5 <u>Angle Beam</u>

7.5.1 An IIW calibration block shall be used to determine the precise beam exit point of the search unit.

7.6 <u>Sweep (base line) Calibration</u>

7.6.1 Straight beam sweep calibration shall be established using the back wall reflection from a 1-inch block. The sweep controls shall be adjusted so that the horizontal distance along the base line shows at least twice the examination thickness.

7.6.2 Angle beam sweep shall be established using a 100mm radius and 25mm crescent notch on an IIW type 1 block, or the 100mm radius and 50mm crescent

notch or an IIW - type 2 block. The sweep controls shall be adjusted so that the horizontal distance along the base line shows at least 12/8 node (1 ½ V-Path).

7.7 Sensitivity (straight beam)

7.7.1 For straight beam examination use a nominal 2-1/4 MHz search unit whenever practical; however, 1 MHz is the preferred frequency for coarse grained austenitic materials and long testing distances. In many instances on examining coarse-grained austenitic materials it may be necessary to use a frequency of 0.4 MHz. Other frequencies may be used if desirable for better resolution, penetrability, or detect-ability of flaws.

7.7.2 Establish the instrument sensitivity from the ASTM Reference block with the applicable flat bottom hole (FBH).

Material Thickness (T)	Flat Bottom Hole (FBH)
<1-1/2”	1/16”
1-1/2” to 6”	1/8”
>6”	1/4"

7.7.3 Reference Block Calibration – The surface roughness height rating of the reference blocks and forging to be examined shall be reasonable equivalent. Adjust the instrument controls to obtain the required signal amplitude from the flat-bottom hole in the specified reference block. Utilize the attenuation in order to set up on amplitudes larger than the vertical linearity of the instrument. In those cases, remove the attenuation prior to scanning the forging. When utilizing flat surfaced reference blocks when examining curved surfaces the attenuation between the reference blocks and material shall be verified and compensated for accordingly.

7.7.4 During the examination of the forging, monitor the back reflection for any significant reduction in amplitude. Reduction in back reflection amplitude may indicate not only the presence of a discontinuity but also poor coupling of the search unit with the surface of the forging, non-parallel back reflection surface, or local variations of attenuation in the forging. Recheck any areas causing loss of back reflection.

7.8 Sensitivity (angle beam)

7.8.1 Perform the examination from the circumference of rings and hollow forgings that have an axial length greater than 2 in. (50.8mm) and an outside to inside diameter ratio of less than 2.0 to 1.

7.8.2 Use a 2.25 MHz 45 degrees angle beam search unit unless thickness, OD/ID ratio, or other geometric configuration results in failure to achieve calibration. For angle beam inspection of hollow forgings that have an OD/ID ratio up to 2.0 to 1, the transducer shall be provided with a wedge or shoe that will result in the beam mode and angle required by the size and shape of the cross section under examination.

7.8.3 Calibrate the instrument for the angle beam examination to obtain an indication amplitude of approximately 75 percent full screen height from the rectangular or 60 degree V-notch on inside diameter (ID) in the axial direction and parallel to the axis of the forging. A separate calibration standard may be used; however, it shall have the same nominal composition, heat treatment, and thickness as the

forging it represents. Where a group of identical forgings is made, one of these forgings may be used as the separate calibration standard. Cut the ID notch depth to 3 percent of the nominal thickness or 1/4 in. (6.35mm), whichever is smaller, and its length approximately 1 in. (25.4mm). At the same instrument setting obtain a reflection from a similar OD notch. Draw a line through the peaks of the reflections obtained from the ID and OD notches. This shall be the amplitude reference line. It is preferable to have the notches in excess metal or test metal when possible. When the OD notch cannot be detected when examining from OD surface, perform the examination, when practical (some ID's may be too small to permit examination), as indicated above from both the OD and ID surfaces utilizing the ID notch when inspecting from the ID. Curved wedges or shoes may be used when necessary and practical.

7.8.4 Perform the examination by scanning over the entire surface area circumstantially in both the clockwise and counterclockwise directions from the ID surface. Examine forgings, which cannot be examined axially using a straight beam in both axial directions with an angle beam search unit. For axial scanning, use rectangular or 60 degree V-notch on the ID and OD for the calibration. These notches shall be perpendicular to the axis for the forging and the same dimensions as the axial notch.

7.9 Sensitivity (API Stem Material)

7.9.1 A 1/8-inch (3.2mm) Flat Bottom Hole for straight beam examination and 1/16-inch (1.6mm) Side Drilled Hole for angle beam examination. Holes should be drilled radially to a depth of ¾-inch (19mm) or 1/2t, whichever is less.

8.0 METHOD/TECHNIQUE

8.1 As far as practical, subject the entire volume of the forging to ultrasonic examination. Because of radius at change of sections and other local configurations, it may be impossible to examine some sections of a forging.

8.1.1 If the configuration of the forging will not allow the examination of the entire forging by the stated technique then an individual scan plans shall be developed to insure complete volumetric coverage.

8.1.2 Perform the ultrasonic examination after final heat treatment, but prior to drilling holes, cutting keyways, tapers, grooves, or machining sections to contour. If the configuration of the forging required for the treatment for mechanical properties prohibits a subsequent complete examination of the forging, it shall be permissible to examine prior to heat treatment. In such cases, reexamine the forging ultrasonic as completely as possible after final heat treatment.

8.1.3 To assure complete coverage of the forging volume, index the search unit with at least 15 percent overlap with each pass.

8.1.4 Do not exceed a scanning rate of 6 in./s (152.4 mm/s).

8.1.5 If possible, scan all sections of forgings in two perpendicular directions.

8.1.6 Scan disk forgings using a straight beam from at least one flat face and radially from the circumference, whenever practical.

8.1.7 Scan cylindrical sections and hollow forgings radially using a straight beam technique. When practical, also examine the forging in the axial direction. Forgings and bars which cannot be effectively examined axially from both ends using a straight beam shall be examined with the beam directed along the arcs in both directions with an angle beam technique.

8.1.8 In addition, examine hollow forgings by angle beam technique from the outside diameter surface as required in 7.8.1.

9.0 RECORDING

9.1 Straight Beam Examination – The following indication shall be recorded:

9.1.1 An indication that is continuous the same plane regardless of amplitude, and found over an area larger than twice the diameter of search unit. The extent of such an indication shall be accurately measured along with variations in amplitudes of reflections.

9.1.1.1 Planar indications shall be considered continuous over a plane if they have a major axis greater than 1 inch (25.4mm). In recording these indications corrections must be made for the beam divergence at the estimated flaw depth.

9.1.2 Discontinuity indications that travel or continuous, or appear as clusters which equal or exceed 10 percent of the back reflection using the back reflection technique or which amplitude using the reference-block technique.

9.1.2.1 Traveling indications are herein defined as indications whose leading edge moves a distance equivalent to 1 inch or more of metal depth with movement of the search unit over the surface of the forging.

9.1.2.2 A cluster of indications is defined as five or more indications located in a volume representing a 2-inch (59.8-mm) or smaller cube in the forging.

9.2 Angle Beam Examination - Record discontinuity indications equal to or exceeding 50 percent of the indications from the reference line cannot be generated, record discontinuity indications equal to or exceeding 50 percent of the referenced notch.

10.0 REFERENCE ACCEPTANCE CRITERIA

10.1 The below is only for reference as applicable as it would be nearly impossible to list all of the codes applicable to every part inspected by P&B Testing, Inc. True acceptance criteria shall be determined by any one or more of the following; router, PO, ITP, QP, drawing, engineering specification or contract. When adherence to a specific code or standard is required, verification of the applicable revision level is mandatory. When the Level II is not certain which acceptance criteria to apply to a specific part, he/she shall consult their Quality Manager for clarification.

Reference Criteria for Materials For API 6A/API 17D, PSL 2, 3, and 4 materials:

Straight Beam:

No single indication exceeding reference distance amplitude curve.
No multiple indications exceeding 50% of reference distance amplitude curve.

Multiple indications are defined as two or more indications (each exceeding 50% of the distance amplitude curve) within ½" (13mm) of each other in any direction.

Angle Beam:

No single indication exceeding reference amplitude curve.
No multiple indications exceeding 50% of reference amplitude curve.

Reference Criteria for Materials for API 6A/ API 17D, PSL 4 materials:

Shall be the same acceptance criteria as PSL 2 and 3, Additionally, No continuous cluster of indications on the same plane regardless of amplitude found over an area twice the diameter of the search unit.

11.0 EXAMINATION REPORT

11.1 For each ultrasonic examination, the following information shall be identified and recorded as a minimum.

11.1.1 Procedure number and revision level

11.1.2 Ultrasonic examination system (equipment)

11.1.3 Technicians printed name, signature, NDE level and date.

11.1.4 Type, size, frequency

11.1.5 Map or record of indications

11.1.6 Couplant used

11.1.7 Calibration block size

11.1.8 Surface condition

11.1.9 Date of examination

11.1.10 Accept/Reject

11.1.11 Any special equipment used in examination

11.1.12 Part serial, job, and heat numbers.

12.0 RECORDS

12.1 All the NDE reports required by this specification shall be maintained, in a traceable manner and for the time period specified in the P & B TESTING, Inc. Quality Assurance Manual.