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## Standard Practice for Ultrasonic Examination of Austenitic Steel Forgings<sup>1</sup>

This standard is issued under the fixed designation A745/A745M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope\*

1.1 This practice<sup>2</sup> covers the standards and procedures for the contact, pulse-echo ultrasonic examination of austenitic steel forgings by the straight or angle beam techniques, or both:

~~1.2 This practice shall be used whenever the inquiry, proposal, contract, order, or specification states that austenitic steel forgings are to be subject to ultrasonic examination in accordance with Practice A745/A745M. Ultrasonic examination of nonmagnetic retaining ring forgings should be made to Practice A388/A388M and Specifications A965/A965M and A1049/A1049M.~~

~~1.2 Ultrasonic examination of nonmagnetic retaining ring forgings should be made to Practice A531/A531M, not to this practice.~~

~~1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.~~

~~1.4 This practice and the applicable material specifications are expressed in both inch-pound units and SI units. However, unless the order specifies the applicable “M” specification designation [SI units], the material shall be furnished to inch-pound units, rather than this practice.~~

~~1.3 Supplementary requirements of an optional nature are provided for use at the option of the purchaser. The supplementary requirements shall apply only when specified individually by the purchaser in the purchase order or contract.~~

~~1.4 This practice is expressed in inch-pound and SI units; however, unless the purchase order or contract specifies the applicable “M” specification designation (SI units), the inch-pound units shall apply. The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the practice, the SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.~~

~~1.5 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.~~

### 2. Referenced Documents

#### 2.1 ASTM Standards:<sup>3</sup>

A388/A388M [Practice for Ultrasonic Examination of Steel Forgings](#)

A531/A531M [Practice for Ultrasonic Examination of Turbine-Generator Steel Retaining Rings](#)

A965/A965M [Specification for Steel Forgings, Austenitic, for Pressure and High Temperature Parts](#)

A1049/A1049M [Specification for Stainless Steel Forgings, Ferritic/Austenitic \(Duplex\), for Pressure Vessels and Related Components](#)

E317 [Practice for Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Instruments and Systems without the Use of Electronic Measurement Instruments](#)

E428 [Practice for Fabrication and Control of Metal, Other than Aluminum, Reference Blocks Used in Ultrasonic Testing](#)

#### 2.2 American Society for Nondestructive Testing Document:<sup>4</sup>

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.06 on Steel Forgings and Billets.

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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specification SA-745/SA-745M in Section II of that Code.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>4</sup> Available from the American Society for Nondestructive Testing, 1711 Arlingate Lane, P.O. Box 28518, Columbus, OH 43228-0518.

\*A Summary of Changes section appears at the end of this standard.

### 3. Ordering Information

3.1 When this practice is to be applied to an inquiry or purchase order, the purchaser shall furnish the following information:

3.1.1 Quality level of examination (see Section 12).

3.1.2 Additional requirements to this practice.

3.1.3 Applicability of supplementary requirements (see Supplementary Requirements section).

3.1.4 Supplementary requirements, if any.

3.2 When specified, the manufacturer shall submit an examination procedure for purchaser approval that shall include, but not be limited to, a sketch of the configuration as presented for ultrasonic examination showing the surfaces to be scanned, scanning directions, notch locations and sizes (if applicable), extent of coverage (if applicable), and an instruction listing calibration and inspection details and stage of manufacture.

### 4. Apparatus

~~4.1 An electronic, pulsed, reflection type of instrument shall be used for this examination. The system shall have a minimum capability for operating at frequencies from 0.5 to 5.0 MHz. Either video or r-f presentation is acceptable.~~

~~4.2 The ultrasonic instrument shall provide linear presentation (within  $\pm 5\%$  of the signal height) for at least 75% of the screen height (sweep line to top of screen). This 5% linearity is descriptive of the screen presentation of amplitude. Instrument linearity shall be verified in accordance with the intent of Practice~~

4.1 *Electronic Apparatus*—A pulse-echo instrument permitting inspection frequencies of 1, 2.25, and 5 MHz is required. The accuracy of discontinuity amplitude analysis using this practice involves a knowledge of the true operating frequency of the complete inspection system. One of the best ways to obtain the desired accuracy is by use of a tuned pulser and narrow band amplifier of known frequency response, with either a broadband transducer, or a narrow-band tuned transducer of known and matching frequency.

4.1.1 *Apparatus Qualification and Calibration*—Basic qualification of the ultrasonic test instrument shall be performed at intervals not to exceed 12 months or whenever maintenance is performed that affects the equipment function. The date of the last calibration and the date of the next required calibration shall be displayed on the test equipment.

4.1.2 The horizontal linearity shall be checked on a distance calibration bar using the multiple order technique (see Practice E317:

~~4.3 Instruments with incremental gain control (accurate over its useful range to  $\pm 10\%$  of the nominal attenuation ratio) shall be used when possible to allow measurement of signals beyond the linear display range of the instrument. The horizontal linearity shall be  $\pm 2\%$  of the metal path.~~

4.1.3 The accuracy of the linearity shall be checked by ultrasonically verifying the thickness of the component in at least one location beyond the near field of the transducer. If necessary, minor adjustments for differences in the ultrasonic velocities between the calibration bar and the forging shall then be made.

4.2 *Amplifier*—The amplifier and display shall provide linear response within  $\pm 2\%$ , up to 100 % of full screen height.

4.2.1 *Amplifier Calibration*—An amplifier vertical linearity check shall be made prior to performing the test by observing a multiple order pattern from a calibration block using a 2.25 MHz transducer (see Practice E317). The first back reflection shall be set at 100 % of full screen height. The higher order back reflections, 10 % and higher in amplitude, shall also be positioned on the screen and their amplitudes noted. The first back reflection shall be reduced to 50 % and then 25 % of full screen height. The amplitudes of the higher order back reflections shall be noted at each step. The vertical linearity will be considered acceptable if the signal heights of the higher order reflections decrease in proportion to the decrease set for the first back reflection. The maximum acceptable error for the decrease of the higher order reflections is the greater of  $\pm 5\%$  of the expected back reflection height or  $\pm 2\%$  of full screen height.

4.3 *Signal Attenuator*—The instrument shall contain a calibrated gain control or signal attenuator that meets the requirements of Practice E317 (in each case, accurate within  $\pm 5\%$ ) that will allow indications beyond the linear range of the instrument to be measured. It is recommended that these controls permit signal adjustments up to 25 to 1 (28 dB).

4.4 *Search Units:*

~~4.4.1 Search units having transducers of either quartz or other piezoelectric materials may be employed.~~

~~4.4.2 The maximum nominal active area of 1½~~

4.4.1 The maximum nominal active area of 1½ in.<sup>2</sup> [970 mm<sup>2</sup>] with ½-in. [13 mm] minimum to 1½-in. [30 mm] maximum dimensions or ¾-in. [20 mm] diameter minimum dimension shall be used for straight-beam scanning.

4.4.3 Angle-beam scanning transducers shall have a nominal active area of ½ to 1 in.<sup>2</sup> [325 to 650 mm<sup>2</sup>]. The search unit used for angle-beam examination shall produce a beam angle of 30 to 70° in the material.

4.4.4 Other search units, including frequencies other than those listed in Section 8, may be used for evaluating and pinpointing indications of discontinuities.

4.5 *Couplant*—A suitable couplant having good wetting characteristics shall be used between the transducer and the examination surface. The same couplant shall be used for calibration and examination.

4.6 *Reference Blocks:*

4.6.1 All ultrasonic standard reference blocks shall be in accordance with the general guidelines of Practice E428. However, absolute conformance to Practice E428 is not mandatory due to the nature of the material covered by this practice.

4.6.2 The reference block grain size, as measured by the relative acoustic penetrability of the reference blocks, should be reasonably similar to the forging under examination. However, it must be recognized that large austenitic forgings vary considerably in acoustic penetrability throughout their volume due to variations in grain size and structure. Reference blocks should be chosen that reasonably approximate the average penetrability of the forging under examination. Supplementary blocks of coarser or finer grain may be used for evaluation of indications as covered in Section 11.

4.6.3 As an alternative method, where practicable, the appropriate size of reference hole (or holes) or notches may be placed in representative areas of the forging for calibration and examination purposes when removed by subsequent machining. When holes or notches are not removed by subsequent machining, the purchaser must approve the location of holes or notches.

## 5. Personnel Requirements

5.1 Personnel performing the ultrasonic examinations to this practice shall be qualified and certified in accordance with a written procedure conforming to Recommended Practice No. SNT-TC-1A or another national standard that is acceptable to both the purchaser and the supplier.

## 6. Forging Conditions

6.1 Forgings shall be ultrasonically examined after heat treating.

6.2 The surfaces of the forging to be examined shall be free of extraneous material such as loose scale, paint, dirt, etc.

6.3 The surface roughness of scanning surfaces shall not exceed 250  $\mu\text{in}$ . [6  $\mu\text{m}$ ] unless otherwise stated in the order or contract.

6.4 The forgings shall be machined to a simple configuration, that is, rectangular or parallel or concentric surfaces where complete volumetric coverage can be obtained.

6.5 In certain cases, such as with contour forged parts, it may be impractical to assure 100 % volumetric coverage. Such forgings shall be examined to the maximum extent possible. A procedure indicating the extent of examination coverage shall be submitted for the purchaser's approval (see 3.2).

## 7. Procedure

7.1 Perform the ultrasonic examination after heat treatment when the forging is machined to the ultrasonic configuration but prior to drilling holes, cutting keyways, tapers, grooves, or machining sections to final contour.

7.2 To ensure complete coverage of the forging volume when scanning, index the search unit with at least 15 % overlap with each pass.

7.3 The scanning rate shall not exceed 6 in. [150 mm]/s.

7.4 Scan all regions of the forging in at least two perpendicular directions to the maximum extent possible.

7.5 Scan disk and disk-type forgings using a straight beam from at least one flat face and radially from the circumference when practicable. For the purposes of this practice, a disk is a cylindrical shape where the diameter dimension exceeds the height dimension. Disk-type forgings made as upset-forged "pancakes" shall be classified as disks for inspection purposes although at the time of inspection, the part may have a center hole, counterturned steps, or other detail configuration.

7.6 Scan cylindrical sections, ring and hollow forgings from the entire external surface (sides or circumference), using the straight-beam technique, and scan the forging in the axial direction to the extent possible. When the length divided by the diameter ratio (slenderness ratio) exceeds 6 to 1 (or axial length exceeds 24 in. [600 mm]), scan axially from both end surfaces to the extent possible. If axial penetration is not possible due to attenuation, angle-beam examination directed axially may be substituted in place of axial straight beam. Examine ring and hollow forgings having an outside-diameter to inside-diameter ratio of less than 2 to 1 and a wall thickness less than 8 in. [200 mm] by angle-beam techniques from the outside diameter or inside diameter, or both, using full node or half-node technique (see 10.1.2 and 10.1.3) as necessary to achieve either 100 % volumetric coverage or the extent of coverage defined by an approved procedure (see 3.2).

## 8. Examination Frequency

8.1 Perform all ultrasonic examination at the highest frequency practicable (as specified in 8.1.1, 8.1.2, or 8.1.3) that will adequately penetrate the forging thickness and resolve the applicable reference standard. Include in the ultrasonic examination report the examination frequency used. Determine the test frequency at the time of actual examination by the following guidelines:

8.1.1 The nominal test frequency shall be 2.25 MHz. Use of this frequency will generally be restricted due to attenuation.

8.1.2 One megahertz is acceptable and will be the frequency generally applicable.

8.1.3 When necessary, due to attenuation, 0.5-MHz examination frequency may be used. The purchaser may request notification before this lower frequency is employed.

8.1.4 In the event that adequate penetration of certain regions is not possible even at 0.5 MHz, alternative nondestructive examination methods (such as radiography) may be employed to ensure the soundness of the forging by agreement between the purchaser and the manufacturer.

## 9. Straight-Beam Examination

9.1 *Method of Calibration:*