Designation: A 418 – 99

Standard Test Method for Ultrasonic Examination of Turbine and Generator Steel Rotor Forgings[1]

This standard is issued under the fixed designation A 418; 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 (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method for ultrasonic examination applies to turbine and generator steel rotor forgings covered by Specifications A 293, A 469, and A 470. This standard shall be used for contact testing only.

1.2 This test method describes a basic procedure of ultrasonically inspecting turbine and generator rotor forgings. It shall in no way restrict the use of other ultrasonic methods such as reference block calibrations when required by the applicable procurement documents nor is it intended to restrict the use of new and improved ultrasonic test equipment and methods as they are developed. The procedure utilizes different calibration techniques than had been used in previous issues. The frequency or amplitudes of recordable indications should not be interpreted necessarily as a change in quality of the product being examined.

1.3 This test method is intended to provide a means of inspecting cylindrical forgings so that the inspection sensitivity at the forging center line or bore surface is constant, independent of the forging or bore diameter. To this end, inspection sensitivity multiplication factors have been computed from theoretical analysis, with experimental verification. These are plotted in Fig. 1 (bored rotors) and Fig. 2 (solid rotors), for a true inspection frequency of 2.25 MHz, and an acoustic velocity of 2.30×10^5 in./s (5.85×10^5 cm/s). Means of converting to other sensitivity levels are provided in Fig. 3. (Sensitivity multiplication factors for other frequencies may be derived in accordance with X1.1 and X1.2 of Appendix X1.)

1.4 Considerable verification data for this method have been generated which indicate that even under controlled conditions very significant uncertainties may exist in estimating natural discontinuities in terms of minimum equivalent size flat-bottom holes. The possibility exists that the estimated minimum areas of natural discontinuities in terms of minimum areas of the comparison flat-bottom holes may differ by 20 dB (factor of 10) in terms of actual areas of natural discontinuities. This magnitude of inaccuracy does not apply to all results but should be recognized as a possibility. Rigid control of the actual frequency used, the coil bandpass width if tuned instruments are used, etc. tend to reduce the overall inaccuracy which is apt to develop.

1.5 This test method for inspection applies to solid cylindrical forgings having outer diameters of not less than 2.5 in. (63.5 mm) nor greater than 100 in. (2540 mm). It also applies to cylindrical forgings with concentric cylindrical bores having wall thicknesses of 2.5 (63.5 mm) in. or greater, within the same outer diameter limits as for solid cylinders. For solid sections less than 15 in. (381 mm) in diameter and for bored cylinders of less than 7.5 in. (190.5 mm) wall thickness the transducer used for the inspection will be different than the transducer used for larger sections.

1.6 *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 The reference is to the latest issue of these designations that appear in the *Annual Book of ASTM Standards* or are available as separate reprints. It shall also apply to product specifications, which may be issued when specifically referenced therein.

2.2 *ASTM Standards:*

A 293 Specification for Steel Forgings, Carbon and Alloy, for Turbine Rotors and Shafts[2]

A 469 Specification for Vacuum-Treated Steel Forgings for Generator Rotors[3]

A 470 Specification for Vacuum-Treated Carbon and Alloy Steel Forgings for Turbine Rotors and Shafts[3]

E 317 Practice for Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Systems Without the Use of Electronic Measurement Instruments[4]

E 1065 Guide for Evaluating Characteristics of Ultrasonic Search Units[4]

[1] This test method is under the jurisdiction of ASTM Committee A-1 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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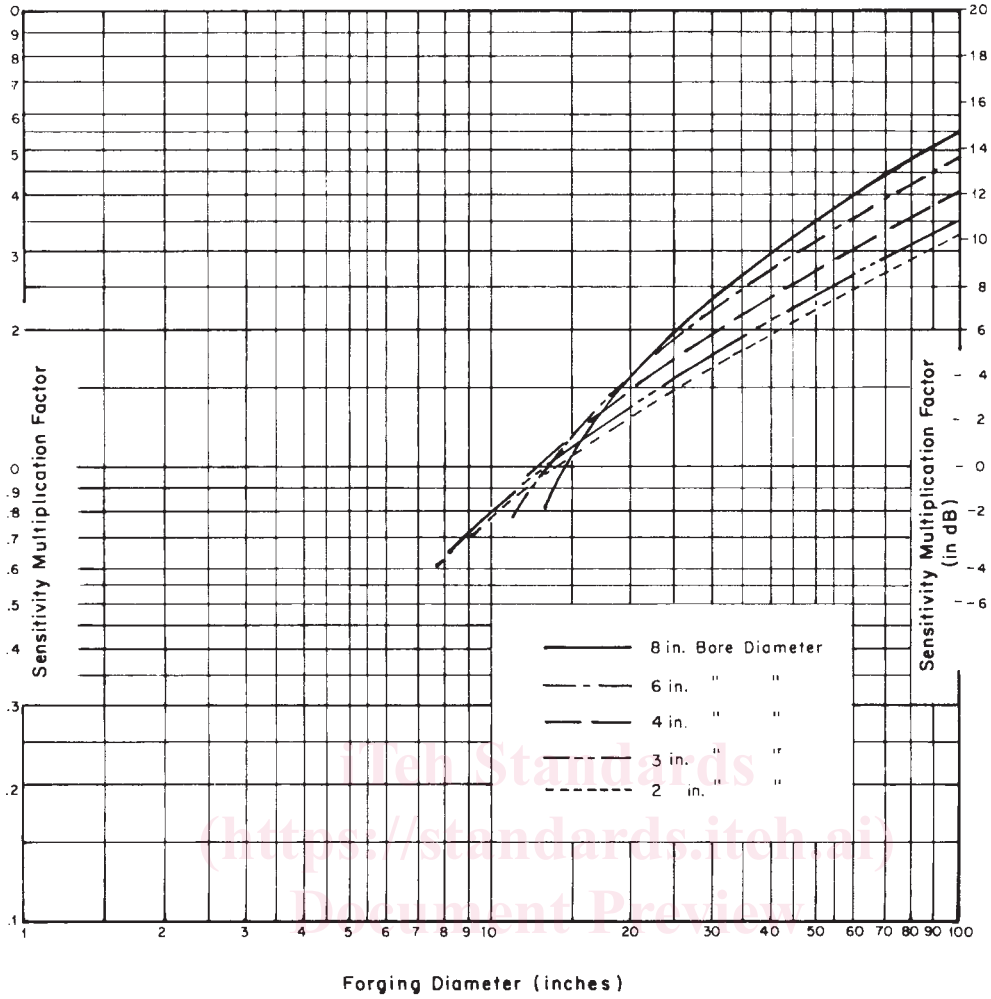
[2] Discontinued; Replaced by A 470, see 1983 *Annual Book of ASTM Standards*, Vol 01.05.

[3] *Annual Book of ASTM Standards*, Vol 01.05.

[4] *Annual Book of ASTM Standards*, Vol 03.03.



SENSITIVITY MULTIPLICATION FACTORS FOR BORED FORGINGS

NOTE—Sensitivity multiplication factor such that a 10 % indication at the forging bore surface will be equivalent to a ⅛ in. (3.175 mm) diameter flat bottom hole. Inspection frequency: 2.25 MHz. Material velocity: 2.30×10^5 in./s (5.85×10^5 cm/s).

FIG. 1 Bored Forgings

3. Application

3.1 This test method shall be used when ultrasonic inspection is required by the order or specification for inspection purposes where the acceptance of the forging is based on limitations of the number, amplitude or location of discontinuities or a combination thereof, which give rise to ultrasonic indications.

3.2 The acceptance criteria shall be clearly stated as order requirements.

4. General Requirements

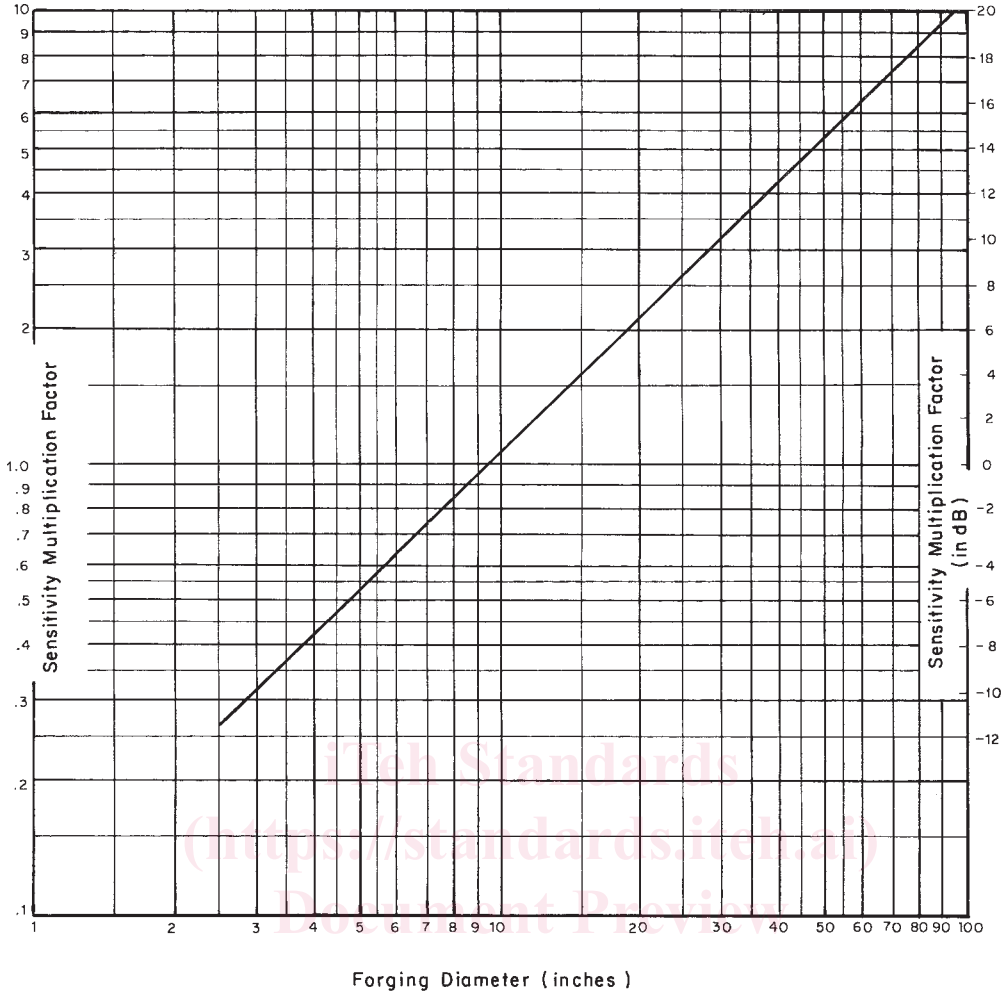
4.1 As far as possible, the entire volume of the forging shall be subjected to ultrasonic inspection. Because of fillets at stepdowns and other local configurations, it may be impossible to inspect some small portions of a forging.

4.2 The ultrasonic inspection shall be performed after final heat treatment of the forging. In those cases in which wheels, slots, or similar features are machined into the forging before heat treatment, the entire forging shall be inspected ultrasonically before such machining, and as completely as practicable after the final heat treatment.

4.3 For overall scanning, the ultrasonic beam shall be introduced radially. To conform with this requirement, external conical surfaces of the forging shall be replaced by stepped surfaces in order to maintain the ultrasonic beam perpendicular to the longitudinal axis. Such stepped surfaces shall be shown on the forging drawing.

4.4 Forgings may be tested either stationary or while rotated by means of a lathe or rollers. If not specified by the purchaser, either method may be used at the manufacturer's option. Scanning speed shall not exceed 6 in./s (15.24 cm/s).

4.5 To ensure complete coverage of the forging volume, the search unit shall be indexed approximately 75 % of the transducer width with each pass of the search unit. Mechanized



SENSITIVITY MULTIPLICATION FACTORS
FOR SOLID FORGINGS

NOTE—Sensitivity multiplication factor such that a 10 % indication at the forging centerline surface will be equivalent to a ⅛ in. (3.175 mm) diameter flat bottom hole. Inspection frequency: 2.25 MHz. Material velocity: 2.30×10^5 in./s (5.85×10^5 cm/s).

FIG. 2 Solid Forgings

inspection of the rotating forging wherein the search unit is mechanically controlled is an aid in meeting this requirement.

4.6 Frequencies of 1, 2.25, and 5 MHz may be used for accurately locating, determining orientation, and defining specific discontinuities detected during overall scanning as described in 4.4.

4.7 Axial scanning, if required, shall be performed at that frequency and transducer diameter which minimizes interfering ultrasonic reflections due to forging geometry and which gives optimum resolution. (Axial tests are normally used as a supplement to radial tests.)

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. Pulsed Ultrasonic Reflection Equipment and Accessories

6.1 *Electronic Apparatus*—A pulse-echo instrument permitting inspection frequencies of 1 MHz, 2.25 MHz, and 5 MHz is required. The accuracy of discontinuity amplitude analysis using this test method 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 broad-band transducer, or a narrow-band tuned transducer of known and matching frequency.

6.1.1 *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.