Designation: A609/A609M – 12 (Reapproved 2018)

Standard Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof[1]

This standard is issued under the fixed designation A609/A609M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This practice[2] covers the standards and procedures for the pulse-echo ultrasonic examination of heat-treated carbon, low-alloy, and martensitic stainless steel castings.

1.2 This practice is to be used whenever the inquiry, contract, order, or specification states that castings are to be subjected to ultrasonic examination in accordance with Practice A609/A609M.

1.3 This practice contains two procedures. Procedure A is the original A609/A609M practice and requires calibration using a series of test blocks containing flat-bottomed holes. It also provides supplementary requirements for angle beam testing. Procedure B requires calibration using a back wall reflection from a series of solid calibration blocks.

NOTE 1—Ultrasonic examination and radiography are not directly comparable. This examination technique is intended to complement Guide E94/E94M in the detection of discontinuities.

1.4 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.

1.5 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 nonconformance with the standard.

1.5.1 Within the text, the SI units are shown in brackets.

1.5.2 This practice is expressed in both inch-pound units and SI units; however, unless the purchase order or contract specifies the applicable M-specification designation (SI units), the inch-pound units shall apply.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

A217/A217M Specification for Steel Castings, Martensitic Stainless and Alloy, for Pressure-Containing Parts, Suitable for High-Temperature Service

E94/E94M Guide for Radiographic Examination Using Industrial Radiographic Film

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

2.2 *Other Document:*

SNT-TC-1A Recommended Practice for Nondestructive Testing Personnel Qualification and Certification[4]

3. Ordering Information

3.1 The inquiry and order should specify which procedure is to be used. If a procedure is not specified, Procedure A shall be used.

3.2 The purchaser shall furnish the following information:

3.2.1 Quality levels for the entire casting or portions thereof,

[1] This practice is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.18 on Castings.

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[2] For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-609 of Section II of that Code.

[3] 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.

[4] Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.

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

3.2.2 Sections of castings requiring longitudinal beam examination,

3.2.3 Sections of castings requiring dual element examination,

3.2.4 Sections of castings requiring supplementary examination, using the angle beam procedure described in Supplementary Requirement S1 in order to achieve more complete examination, and

3.2.5 Any requirements additional to the provisions of this practice.

PROCEDURE A – FLAT-BOTTOMED HOLE CALIBRATION PROCEDURE

4. Apparatus

4.1 *Electronic Apparatus:*

4.1.1 An ultrasonic, pulsed, reflection type of instrument that is capable of generating, receiving, and amplifying frequencies of at least 0.5 to 5 MHz.

4.1.2 The ultrasonic instrument shall provide linear presentation (within ±5 %) for at least 75 % of the screen height (sweep line to top of screen). Linearity shall be determined in accordance with Practice E317 or equivalent electronic means.

4.1.3 The electronic apparatus shall contain a signal attenuator or calibrated gain control that shall be accurate over its useful range to ±10 % of the nominal attenuation or gain ratio to allow measurement of signals beyond the linear range of the instrument.

4.2 *Search Units:*

4.2.1 *Longitudinal Wave,* internally grounded, having a ½ to 1-in. [13 to 25-mm] diameter or 1-in. [25-mm] square piezo-electric elements. Based on the signals-to-noise ratio of the response pattern of the casting, a frequency in the range from 0.5 to 5 MHz shall be used. The background noise shall not exceed 25 % of the distance amplitude correction curve (DAC). Transducers shall be utilized at their rated frequencies.

4.2.2 *Dual Element,* 5-MHz, ½ by 1 in. [13 by 25 mm], 12° included angle search units are recommended for sections 1 in. [25 mm] and under.

4.2.3 Other frequencies and sizes of search units may be used for evaluating and pinpointing indications.

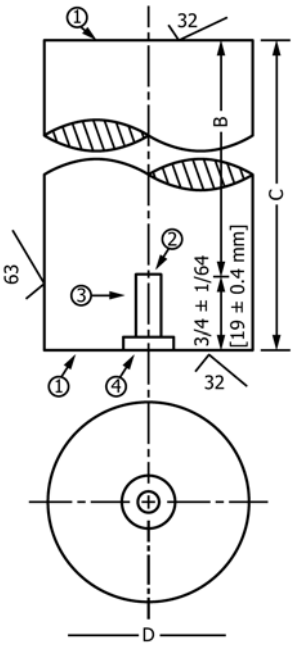
4.3 *Reference Blocks:*

4.3.1 Reference blocks containing flat-bottom holes shall be used to establish test sensitivity in accordance with 8.2.

4.3.2 Reference blocks shall be made from cast steels that give an acoustic response similar to the castings being examined.

4.3.3 The design of reference blocks shall be in accordance with Fig. 1, and the basic set shall consist of those blocks listed in Table 1. When section thicknesses over 15 in. [380 mm] are to be inspected, an additional block of the maximum test thickness shall be made to supplement the basic set.

4.3.4 Machined blocks with 3⁄32-in. [2.4-mm] diameter flat-bottom holes at depths from the entry surface of ⅛ in. [3 mm], ½ in. [13 mm], or ½ *t* and ¾ in. [19 mm], or ¾ *t* (where *t* = thickness of the block) shall be used to establish the DAC for the dual element search units (see Fig. 2).



NOTE 1—Opposite ends of reference block shall be flat and parallel within 0.001 in. [0.025 mm].

NOTE 2—Bottom of flat-bottom hole shall be flat within 0.002 in. [0.051 mm] and the finished diameter shall be ¼ + 0.002 in. [6.4 + 0.050].

NOTE 3—Hole shall be straight and perpendicular to entry surface within 0°, 30 min and located within 1⁄32 in. [0.80 mm] of longitudinal axis.

NOTE 4—Counter bore shall be ½ in. [15.0 mm] diameter by ⅛ in. [5 mm] deep.

FIG. 1 Ultrasonic Standard Reference Block

TABLE 1 Dimensions and Identification of Reference Blocks in the Basic Set (See Fig. 1)

Hole Diameter in 1⁄64 ths, in. [mm]	Metal Distance *(B)*, in.[A] [mm]	Overall Length *(C)*, in. [mm]	Width or Diameter *(D)*, min, in. [mm]	Block Identification Number
16 [6.4]	1 [25]	1¾ [45]	2 [50]	16-0100
16 [6.4]	2 [50]	2¾ [70]	2 [50]	16-0200
16 [6.4]	3 [75]	3¾ [95]	2 [50]	16-0300
16 [6.4]	6 [150]	6¾ [170]	3 [75]	16-0600
16 [6.4]	10 [255]	10¾ [275]	4 [100]	16-1000
16 [6.4]	B	B + ¾ [B + 20]	5 [125]	16-B00[B]

[A] Tolerance ±⅛ in. [3 mm].

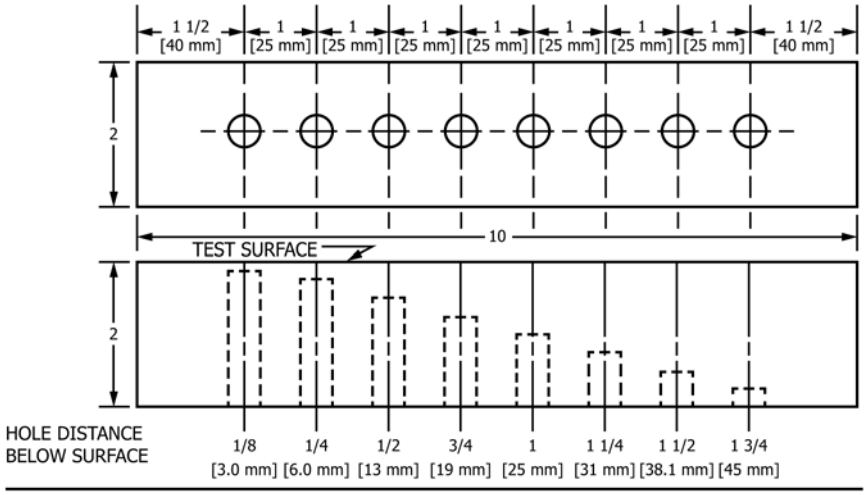
[B] Additional supplemental blocks for testing thickness greater than 10 in. [250 mm], see 4.3.3.

4.3.5 Each reference block shall be permanently identified along the side of the block indicating the material and the block identification.

4.4 *Couplant*—A suitable couplant having good wetting characteristics shall be used between the search unit and examination surface. The same couplant shall be used for calibrations and examinations.

5. Personnel Requirements

5.1 Personnel performing ultrasonic examination in accordance with this practice shall be qualified and certified in



NOTE 1—Entrant surface shall be 250 µin. [6.3 µm] or finer.

NOTE 2—The 3⁄32-in. [2.4-mm] flat-bottom hole must be flat within 0.002 in. [0.05 mm]. Diameter must be within +0.005 in. [0.13 mm] of the required diameter. Hole axis must be perpendicular to the block and within an angle of 0°, 30 min.

NOTE 3—Hole shall be plugged following checking for ultrasonic response.

in.	[mm]	in.	[mm]
⅛	[3]	1¼	[32]
¼	[6]	1½	[38]
½	[13]	1¾	[44]
¾	[19.0]	2	[50]
1	[25]	10	[254]

FIG. 2 Ultrasonic Standard Reference Block for Dual-Search Unit Calibration

accordance with a written procedure conforming to Recommended Practice No. SNT-TC-1A or another national standard acceptable to both the purchaser and the supplier.

6. Casting Conditions

6.1 Castings shall receive at least an austenitizing heat treatment before being ultrasonically examined.

6.2 Test surfaces of castings shall be free of material that will interfere with the ultrasonic examination. They may be as cast, blasted, ground, or machined.

6.3 The ultrasonic examination shall be conducted prior to machining that prevents an effective examination of the casting.

7. Test Conditions

7.1 To ensure complete coverage of the specified casting section, each pass of the search unit shall overlap by at least 10 % of the width of the transducer.

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

7.3 The ultrasonic beam shall be introduced perpendicular to the examination surface.

8. Procedure

8.1 Adjust the instrument controls to position the first back reflection for the thickness to be tested at least one-half of the distance across the instrument screen.

8.2 Using the set of reference blocks spanning the thickness of the casting being inspected and overlays or electronic markers, note the flat-bottom hole indication height for each of the applicable blocks on the instrument screen. Draw a curve through these marks on the screen or on suitable graph paper. The maximum signal amplitude for the test blocks used shall peak at approximately three-fourths of the screen height above the sweep by use of the attenuator. This curve shall be referred to as the 100 % distance amplitude correction (DAC) curve. If the attenuation of ultrasound in the casting thickness being examined is such that the system's dynamic range is exceeded, segmented DAC curves are permitted.

8.3 The casting examination surface will normally be rougher than that of the test blocks; consequently, employ a transfer mechanism to provide approximate compensation. In order to accomplish this, first select a region of the casting that has parallel walls and a surface condition representative of the rest of the casting as a transfer point. Next, select the test block whose overall length, *C* (Fig. 1), most closely matches the reflection amplitude through the block length. Place the search unit on the casting at the transfer point and adjust the instrument gain until the back reflection amplitude through the casting matches that through the test block. Using this transfer technique, the examination sensitivity in the casting may be expected to be within ±30 % or less of that given by the test blocks.

8.4 Do not change those instrument controls and the test frequency set during calibration, except the attenuator or calibrated gain control, during acceptance examination of a given thickness of the casting. Make a periodic calibration during the inspection by checking the amplitude of response from the ¼-in. [6.4-mm] diameter flat-bottom hole in the test block utilized for the transfer.

NOTE 2—The attenuator or calibrated gain control may be used to change the signal amplitude during examination to permit small amplitude signals to be more readily detected. Signal evaluation is made by returning the attenuator or calibrated gain control to its original setting.

8.5 During examination of areas of the casting having parallel walls, recheck areas showing 75 % or greater loss of back reflection to determine whether loss of back reflection is due to poor contact, insufficient couplant, misoriented discontinuity, etc. If the reason for loss of back reflection is not evident, consider the area questionable and investigate further.

9. Report

9.1 The manufacturer's report of final ultrasonic examination shall contain the following data and shall be furnished to the purchaser:

9.1.1 The total number, location, amplitude, and area when possible to delineate boundaries by monitoring the movement of the center of the search unit of all indications equal to or greater than 100 % of the DAC,

9.1.2 Questionable areas from 8.5 that, upon further investigation, are determined to be caused by discontinuities,

9.1.3 The examination frequency, type of instrument, types of search units employed, couplant, manufacturer's identifying numbers, purchaser's order number, and data and authorized signature, and

9.1.4 A sketch showing the physical outline of the casting, including dimensions of all areas not inspected due to geometric configuration, with the location and sizes of all indications in accordance with 9.1.1 and 9.1.2.

10. Acceptance Standards

10.1 This practice is intended for application to castings with a wide variety of sizes, shapes, compositions, melting processes, foundry practices, and applications. Therefore, it is impractical to specify an ultrasonic quality level that would be universally applicable to such a diversity of products. Ultrasonic acceptance or rejection criteria for individual castings should be based on a realistic appraisal of service requirements and the quality that can normally be obtained in production of the particular type of casting.

10.2 Acceptance quality levels shall be established between the purchaser and the manufacturer on the basis of one or more of the following criteria:

10.2.1 No indication equal to or greater than the DAC over an area specified for the applicable quality level of Table 2.

10.2.2 No reduction of back reflection of 75 % or greater that has been determined to be caused by a discontinuity over an area specified for the applicable quality level of Table 2.

10.2.3 Indications producing a continuous response equal to or greater than the DAC with a dimension exceeding the maximum length shown for the applicable quality level shall be unacceptable.

TABLE 2 Rejection Level

NOTE 1—The areas in the table refer to the surface area on the casting over which a continuous indication exceeding the amplitude reference line or a continuous loss of back reflection of 75 % or greater is maintained.

NOTE 2—Areas shall be measured from the center of the search unit.

NOTE 3—In certain castings, because of very long test distances or curvature of the test surface, the casting surface area over which a given discontinuity is detected may be considerably larger or smaller than the actual area of the discontinuity in the casting; in such cases, a graphic plot that incorporates a consideration of beam spread should be used for realistic evaluation of the discontinuity.

Ultrasonic Testing Quality Level	Area, in.^{2} [cm^2] (see 10.2.1 and 10.2.2)	Length, max, in. [mm]
1	0.8 [5]	1.5 [40]
2	1.5 [10]	2.2 [55]
3	3 [20]	3.0 [75]
4	5 [30]	3.9 [100]
5	8 [50]	4.8 [120]
6	12 [80]	6.0 [150]
7	16 [100]	6.9 [175]

10.2.4 Other criteria agreed upon between the purchaser and the manufacturer.

10.3 Other means may be used to establish the validity of a rejection based on ultrasonic inspection.

NOTE 3—The areas for the ultrasonic quality levels in Table 2 refer to the surface area on the casting over which a continuous indication exceeding the DAC is maintained.

NOTE 4—Areas are to be measured from dimensions of the movement of the search unit by outlining locations where the amplitude of the indication is 100 % of the DAC or where the back reflection is reduced by 75 %, using the center of the search unit as a reference point to establish the outline of the indication area.

NOTE 5—In certain castings, because of very long metal path distances or curvature of the examination surfaces, the surface area over which a given discontinuity is detected may be considerably larger or smaller than the actual area of the discontinuity in the casting; in such cases, other criteria that incorporate a consideration of beam angles or beam spread must be used for realistic evaluation of the discontinuity.

PROCEDURE B – BACK WALL REFLECTION CALIBRATION PROCEDURE

11. Apparatus

11.1 Apparatus shall be kept on a regular six-month maintenance cycle during which, as a minimum requirement, the vertical and horizontal linearities, sensitivity, and resolution shall be established in accordance with the requirements of Practice E317.

11.2 *Search Units*—Ceramic element transducers not exceeding 1.25 in. [32 mm] diameter or 1 in.^{2} [645 mm^2] shall be used.

11.3 *Search Units Facing*—A soft urethane membrane or neoprene sheet, approximately 0.025 in. [0.64 mm] thick, may be used to improve coupling and minimize transducer wear caused by casting surface roughness.

11.4 *Calibration/Testing*—The same system, including the urethane membrane, used for calibration shall be used to inspect the casting.