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# Standard Guide for Material Selection and Fabrication of Reference Blocks for the Pulsed Longitudinal Wave Ultrasonic Examination Testing of Metal and Metal Alloy Production Material<sup>1</sup>

This standard is issued under the fixed designation E 1158; 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 guide covers general procedures for the material selection and fabrication of reference blocks made of metal or metal alloys and intended to be used for the examination of the same or similar production materials by pulsed longitudinal ultrasonic waves applied perpendicular to the beam entry surface. Primary emphasis is on solid materials but some of the techniques described may be used for midwall examination of pipes and tubes of heavy wall thickness. Near-surface resolution in any material depends upon the characteristics of the instrument and search unit employed.

1.2 This guide covers the fabrication of reference blocks for use with either the immersion or the ~~direct-contact~~ contact method of ultrasonic examination.

1.3 Reference blocks fabricated in accordance with this guide can be used to determine proper ultrasonic ~~examination~~ system operation. Area-amplitude and distance-amplitude curves can also be determined with these reference blocks.

1.4 This guide does not specify reference reflector sizes or product rejection limits. It does describe typical industry fabrication practices and commonly applied tolerances where they lend clarity to the guide. In all cases of conflict between this guide and customer specifications, the customer specification shall prevail.

1.5

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *This standard does not purport to address 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 to determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

E 127 Practice for Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks<sup>3</sup>

E 428 ~~Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Examination~~ Practice for Fabrication and Control of Metal, Other than Aluminum, Reference Blocks Used in Ultrasonic Testing

E 1316 Terminology for Nondestructive Examinations

## 3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide, see Terminology E 1316.

## 4. Summary of Guide

4.1 This guide describes a method of selecting suitable reference block material from current or previous production and the subsequent fabrication and checking of the resulting ultrasonic reference blocks.

<sup>1</sup> This guide is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.06 on Ultrasonic Method. Current edition approved February 1, 2004; 2009. Published March 2004; July 2009. Originally approved in 1990. Last previous edition approved in 1998 as E1158-98; E 1158 - 04.

<sup>2</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>3</sup> The reference blocks in Practice E 127 are used to check the performance of ultrasonic examination equipment and for standardization and control of ultrasonic examinations of aluminum alloy products. The ultrasonic response of the blocks in Practice E 127 is evaluated against a standard target. The blocks described in this standard are used for the examination of production material and may be used to establish accept-reject criteria.

## 5. Significance and Use

5.1 This guide is intended to illustrate the fabrication of ultrasonic reference blocks that are representative of the production material to be examined. Care in material selection and fabrication can result in the manufacture of reference blocks that are ultrasonically similar to the production material thus eliminating the reference block as an examination variable.

## 6. Material Selection

6.1 It is good practice to use a sample removed from the production lot of material as the reference block material. When this is not possible the following guidelines should be followed.

6.2 The reference block material should be of the same general shape and dimensions, surface finish, chemical composition, and microstructure as the production material to be examined.

6.3 To ensure that the material chosen is suitable for use as reference block material and is free of potentially interfering reflectors, ultrasonically examine the reference block material at the anticipated examining frequency and at a sensitivity that produces an acoustic noise level of 20 % screen height. The entire block should be scanned from the surface which will be used for standardization. Any discrete indication that exceeds 40 % screen height should be cause to remove the material from consideration as an ultrasonic reference block.

6.4 Reference block material that meets the guidelines of 6.3 should then be examined at a sensitivity that produces multiple reflections from the back surface (between 3 and 5 reflections in most metals and metal alloys). The production material should be examined at the same sensitivity level to determine that the same number of back reflections are obtained. This procedure may have to be repeated several times and an average number of back reflections determined in the case of some materials (see Note 1).

NOTE 1—In some highly attenuative materials more than one or two back reflections may not be attainable. In these cases, selection of the reference block material may be based on similar acoustic noise levels from both the production material and that chosen for a reference block.

## 7. Reference Block Configuration

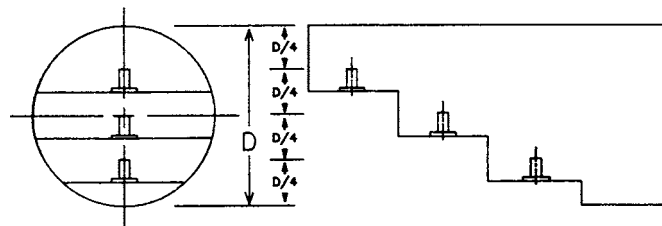
7.1 There are many different types of reference blocks used in industry depending upon the size and shape of the material to be examined. Some of the more common flat bottom hole (FBH) types are described in 7.2 through 7.7, and shown in Figs. 1-7. An alternate method for fabricating flat-bottom holes FBH's is described in the annex.

7.2 Fig. 1 shows the typical reference standards used for ultrasonic examination when the product to be examined consists of large round bar stock, between 1 and 10 in. (25.4 to 245.0 mm) in diameter. With such products it is often necessary to correct for the loss of signal with increasing examination distance (distance-amplitude-correction, or DAC). Therefore, a stepped block, as shown in Fig. 1 is commonly used. This type of block is typically referred to as a distance-amplitude-block. It contains a number of holes of the same size at various distances from the scan surface. A typical flat-bottom hole FBH size found in many such blocks is  $\frac{5}{64}$  in. (1.98 mm) or larger depending upon the ultrasonic attenuation, or the internal structure of the product, or both. For even larger diameter bars the distance amplitude correction reference standard may contain even larger flat bottom holes, FBH's, possibly  $\frac{1}{4}$  in. (6.35 mm) or greater.

7.3 To determine the linearity of the examination and to establish the quality level of the large-diameter product, (7.2), an area-amplitude reference block as shown in Fig. 2 is common. An area-amplitude-block contains holes of different cross-sectional areas placed at the same distance from the scan surface. Typical hole sizes range from between  $\frac{3}{64}$  and  $\frac{5}{64}$  in. (0.79(0.79 and 3.18 mm) with even larger flat-bottom holes used in reference blocks intended for use for the largest bars.

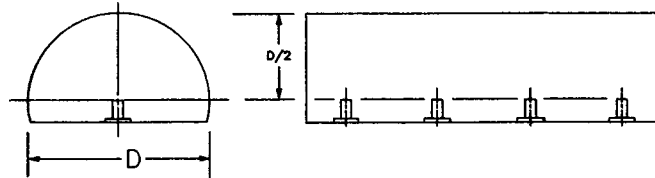
7.4 For small round bar stock, typically 1 in. (25.4 mm) and under, a distance-amplitude block is normally not required. The typical area-amplitude block for this product is the same as for the larger diameter material as shown in Fig. 2, but on a smaller scale. The hole sizes typically range from between  $\frac{3}{64}$  and  $\frac{5}{64}$  in. (0.79(0.79 and 1.98 mm) for many metal and metal alloy products.

7.5 When the product to be examined consists of large square or rectangular bar stock, the distance-amplitude reference block is often of the type shown in Fig. 3. The typical area-amplitude reference block is shown in Fig. 4. The reference block hole sizes



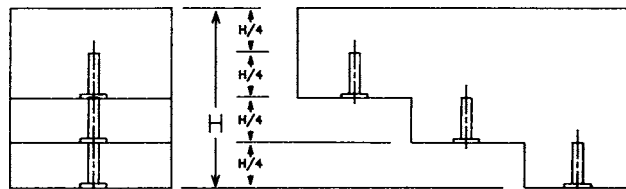
NOTE 1—All holes are the same diameter.

**FIG. 1 Typical Distance-Amplitude Reference Block Configuration for the Ultrasonic Examination of Large Metal and Metal Alloy Bars of from 1 to 10 in. (25.4 to 254.0 mm) Diameter and Larger**



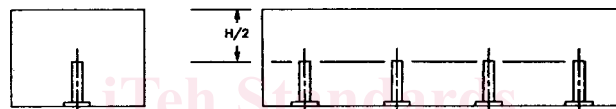
NOTE 1—Holes are of different diameters.

FIG. 2 Typical Area-Amplitude Reference Block for use in Ultrasonic Examination of Round Bars as in Fig. 1



NOTE 1—All holes are the same diameter.

FIG. 3 Typical Distance-Amplitude Reference Block for the Ultrasonic Examination of Large Square or Rectangular Bars Greater than 1 in. (25.4 mm)



NOTE 1—Holes are of different diameters.

FIG. 4 Typical Area-Amplitude Reference Block for the Ultrasonic Examination of Square or Rectangular Bars

are typically the same as those used for similar thickness round bars.

7.6 The smaller sizes of square or rectangular bar stock, 1 in. (25.4 mm) and under in the direction of examination, often do not require the use of a distance-amplitude reference block. The area-amplitude block may be similar to that shown in Fig. 4. The reference block hole sizes are usually similar to those used for round bars of the same thickness.

7.7 The reference blocks used for the ultrasonic examination of products with more complex geometries are normally fabricated from production samples so that the effects of geometry variations are minimized.

## 8. Fabrication Procedure

8.1 Specific fabricating procedures are dependent upon the configuration of the reference block, the block composition, the examination criticality, and even the skill of the machinists. Some general guidelines are given in 8.2 through 8.3.2.

8.2 *Flat-Bottom Holes*—Flat-bottom holes (FBH's)—FBH's should be drilled such that the hole bottom is perpendicular to the examining sound beam. For the fabrication of reference standards of the types shown in Figs. 1-4, a common procedure involves the drilling of the chosen hole sizes/diameters to a desired depth using a conventional fluted drill bit. In Fig. 1 this depth would be 3/4 in. (19.05 mm). The fluted drill bit, or another of the same size, is carefully ground to remove the point and square the tip. An optical comparator or tool maker's microscope is useful to determine when the point has been completely removed and the drill bit end is flat and square.

8.2.1 The flattened drill bit is then used to carefully flatten the bottom of the drilled hole. This operation normally requires great care to avoid drill breakage while still ensuring that the hole bottom is flat. A physician's ear examination microscope with a tip of the proper diameter is helpful in determining when the hole bottom is truly flat.

8.2.2 If the ultrasonic examination is to be conducted with the product (and therefore the reference block) immersed in a liquid, it is considered good practice to plug the flat-bottom holes's in the reference block. Before plugging the holes it is important that the holes be free of debris and totally dry. Moisture, metal shavings, or both, can influence the ultrasonic response from the hole bottom.

8.2.3 When using metal plugs, counter bores are machined in the block to seat the plugs. An alternative method is to use plastic or rubber type sealant forced a short distance into the holes and allowed to harden.

8.3 *Diffusion Bonding Method*—The diffusion bonding technique offers an alternative method of reference block manufacture. With this method it is possible to fabricate reference blocks containing flat disc-shaped ultrasonic reflectors instead of flat-bottom holes. FBH's. In many cases this permits the examination of the reference block from more than one direction thus enhancing the utility of the block.