Designation: E 428 – 00

Standard Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Examination [1]

This standard is issued under the fixed designation E 428; 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 specification has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This practice covers a procedure for fabrication and control of metal alloy reference blocks used in ultrasonic examination that have a flat-surface sound entry, are cylindrical in shape, and contain flat-bottom holes (FBH) which may be used for checking the performance of ultrasonic examination instrumentation and search units and for standardization and control of ultrasonic examination of metal alloy products. The reference blocks described are suitable for use with either the direct-contact method or immersion pulse-echo ultrasonic methods.

1.2 While this procedure is basically designed for the fabrication and control of carbon and alloy steel blocks to be used in conjunction with the examination of these materials, the fabrication and control procedures may also be suitable for the preparation of blocks for other types of materials such as nickel-base alloys, certain types of aluminum alloys, and so forth. Additional procedures and controls may be required when fabricating reference blocks from other than carbon or alloy steel material. This practice shall in no way preclude the specification or addition of any supplemented requirements as deemed necessary for the specific application. This practice, however, must not be confused with, nor does it supersede Practice E 127, specifically governing the fabrication and evaluation of 7075-T6 aluminum alloy ultrasonic standard reference blocks.

NOTE 1—Practice E 127 and Guide E 1158 also describe procedures for selecting material, fabricating blocks, and checking response. Unlike this practice, Practice E 127 has requirements for evaluation relative to a specified standard target.

1.3 The values stated in inch-pound units are to be regarded as the standard.

1.4 *This standard does not purport to address all of the safety problems, 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:*

E 127 Practice for Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks[2]

E 1158 Guide for Material Selection and Fabrication of Reference Blocks for the Pulsed Longitudinal Wave Ultrasonic Examination of Metal and Metal Alloy Production Material[2]

E 1316 Terminology for Nondestructive Examinations[2]

3. Terminology

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

4. Summary of Practice

4.1 This practice details a basic fabrication and control procedure and defines the minimum requirements to be met in matching carbon and alloy steel reference blocks with the material to be examined. Additional supplemental requirements may be needed when using this practice to fabricate reference blocks from other types of materials or with larger diameter holes. The physical characteristics of the hole may be established by evaluating plastic replicas. It must be recognized however that there are limitations on the size hole that may be replicated and evaluated.

5. Material Selection

5.1 The material to be used for reference blocks should be similar in its acoustic attenuation to the material which is to be examined. The grain size, heat treat condition, physical and chemical composition, surface finish, and manufacturing procedure (rolling, forging, etc.) are variables to be considered in matching acoustic responses.

5.1.1 The general evaluation procedure shall be to introduce a longitudinal pulse-echo beam into either side of the block on the axis to be used for determining metal-path distance. An

[1] This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.06 on Ultrasonic Testing Procedures.

Current edition approved July 10, 2000. Published September 2000. Originally published as E 428 – 71. Last previous edition E 428 – 92.

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

immersion examination method using clean water as a couplant or, a contact method using appropriate couplant (oil, glycerin, and so forth) is satisfactory. The examination instruments, frequency, and search unit used in the evaluation of the raw material intended for the fabrication of the reference blocks shall be comparable to that used in the examination of the production material.

5.1.2 The material used for reference blocks shall be 100 % scanned while the examination system is adjusted to display, whenever possible, an acoustic noise level from the material of 20 % of full-scale deflection (FSD). In cases of materials that are acoustically transparent to the extent that this requirement cannot be satisfied, a readable acoustic noise level shall be displayed. The acoustic noise level from the material is not to be confused with inherent electrical instrument noise often observed when the system sensitivity is adjusted to its maximum level range.

5.1.3 The material used for reference blocks shall be free of discrete ultrasonic discontinuity indications greater than twice the amplitude of the noise level displayed in accordance with the requirements of 5.1.2.

5.1.4 Attenuation shall be checked by comparing multiple reflections from the back surface of the test block material with that of the material to be examined. With the amplitude from the first back reflection adjusted to 90 % of FSD, the sum of the amplitude of the first three back reflections from both samples shall compare within ±25 % or as required by the application. On samples that are to have FBHs smaller than 3⁄64 in. (1.2 mm) in diameter, the decay patterns shall compare within ±10 % or as required by the application.

5.1.5 Lowering the examination frequency tends to minimize discernible differences in response. At 1.0 MHz, a large group of materials may be acoustically penetrable with relatively similar results and may satisfy the requirements of 5.1.4. At frequencies such as 5.0 MHz and higher, microstructure changes usually yield readily discernible differences in acoustic response and restrict the applicability of reference blocks.

6. Fabrication Procedure

6.1 Unless otherwise specified, select the blocks to be made from those listed in Table 1. Block sets conforming to customary commercial practice are grouped as follows:

6.1.1 Distance-Amplitude Response (D/A),

6.1.2 Area-Amplitude Response (A/A), and

6.1.3 Basic (selected from D/A and A/A groups).

6.2 All blocks are to be fabricated in accordance with Fig. 1. Dimension “A” (metal travel) and Dimension “D” (FBH diameter) are given in Table 1; Dimension “E” (block length) is derived. The following machining sequence is recommended:

NOTE 2—This practice may be used to produce blocks with flat-bottom holes of a larger diameter than described. Utilization of larger flat-bottom holes shall be by agreement of the using parties.

TABLE 1 Standard Block Sizes and Recommended Block Sets

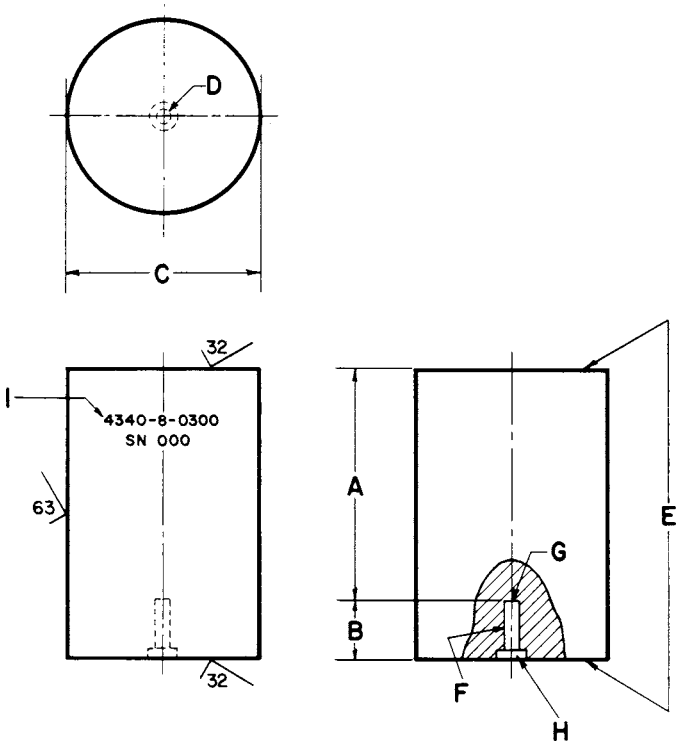
NOTE 1—Material to be as specified by the user.

NOTE 2—All dimensions and tolerances are to be in accordance with Fig. 11.

NOTE 3—1 in. = 25.4 mm.

NOTE 4—Block sets shown are typical of established commercial practice: more or fewer blocks may be required for specific applications.

				Distance/Amplitude, 19 in each set			Basic Set, 10 Total			Area/Amplitude Set, 8 total							
Metal Travel and Designator				Diameter of Flat-Bottom Holes (1/64th in./1.6mm) Dimension "D"													
Nominal MT	Dim. "A"		Desig.	3	5	8	3	5	8	1	2	3	4	5	6	7	8
(in.)	(in.)	(mm)															
1/16	0.0625	(1.6mm)	-0006	3	5	8	...	...	...								
1/8	0.125	(3.2mm)	-0012	3	5	8	...	5	...								
1/4	0.250	(6.4mm)	-0025	3	5	8	...	5	...								
3/8	0.375	(9.5mm)	-0038	3	5	8	...	...	...								
1/2	0.500	(12.7mm)	-0050	3	5	8		5	...								
5/8	0.625	(15.9mm)	-0062	3	5	8	...	...	...								
3/4	0.750	(19.1mm)	-0075	3	5	8	...	5	...								
7/8	0.875	(22.2mm)	-0088	3	5	8	...	...	...								
1	1.000	(25.4mm)	-0100	3	5	8	...	...	...								
1 1/4	1.250	(31.8mm)	-0125	3	5	8	...	...	...								
1 1/2	1.500	(38.1mm)	-0150	...	...	...	...	5	...								
1 3/4	1.750	(44.5mm)	-0175	3	5	8	...	...	...								
2	2.000	(50.8mm)	-0200	...	...	...	...	...	...								
2 1/4	2.250	(57.2mm)	-0225	3	5	8	...	...	...								
2 1/2	2.500	(63.5mm)	-0250	...	...	...	...	...	...								
2 3/4	2.750	(69.9mm)	-0275	3	5	8	3	5	8	1	2	3	4	5	6	7	8
3	3.000	(76.2mm)	-0300	...	...	...	...	...	...								
3 1/4	3.250	(82.6mm)	-0325	3	5	8	...	...	...								
3 1/2	3.500	(88.9mm)	-0350	...	...	...	...	...	...								
3 3/4	3.750	(95.3mm)	-0375	3	5	8	...	...	...								
4	4.000	(101.6mm)	-0400	...	...	...	...	...	...								
4 1/4	4.250	(108.0mm)	-0425	3	5	8	...	...	...								
4 1/2	4.500	(114.3mm)	-0450	...	...	...	...	...	...								
4 3/4	4.750	(120.7mm)	-0475	3	5	8	...	...	...								
5	5.000	(127.0mm)	-0500	...	...	...	...	...	...								
5 1/4	5.250	(133.4mm)	-0525	3	5	8	...	...	...								
5 1/2	5.500	(139.7mm)	-0550	...	...	...	...	...	...								
5 3/4	5.750	(146.1mm)	-0575	3	5	8	...	5	8								
6	6.000	(152.4mm)	-0600														
6 1/4	6.250	(158.8mm)	-0625														
6 1/2	6.500	(165.1mm)	-0650														



A—Metal travel distance ±0.015 in. (0.38 mm)
B—Hole depth ¾ in. nominal ±1⁄16 in. (1.6 mm)
C—Block diameter tolerance ±0.030 in. (0.76 mm)
2 in. (50.8 mm) dia for test distances up to 6 in. (152 mm)
2½ in. (63.5 mm) dia for test distances over 6 in. up to 12 in. (305 mm)
Larger dia or serrations may be required for test distances over 12 in.
D—Hole diameter tolerance ±0.0005 in. (0.013 mm) for holes 1⁄16 in. (1.6 mm) and smaller, ±0.001 in. (0.03 mm) for holes larger than 1⁄16 in. (1.59 mm)
E—Surfaces to be flat within 0.0005 in. (0.01 mm) and parallel to within 0.001 in. (0.02 mm).
Due to possible edge build-up during the plating process, this tolerance applies only to the area exclusive of that within ⅛ in. (3.2 mm) of the block edges.
F—Hole must be straight and perpendicular to the test surface within 0° 20 min.
G—Hole bottom must be flat within 0.001 in./⅛ in. (1 mm/125 mm) and located within 0.015 in. (0.38 mm) of longitudinal axis.
H—Flat counterbore 0.250 diameter by 0.064 in. deep.
I—Typical Block Identification:
4340 = Typical alloy designation.
8 = Hole size in 1⁄64 -in. increments.
0300 = Metal travel in 00.00 in.

FIG. 1 Ultrasonic Reference Block Physical Dimensions and Tolerances

6.2.1 Machine all blocks to a uniform 32 rms finish and to the required dimensional tolerances.

6.2.2 Drill the test hole to the nominal ¾ in. (19.0 mm) depth with a standard drill point.

6.2.3 Carefully prepare a flat-bottom drill or cutter with cutting edges square and flat within 0.0005 in. (0.013 mm) and perpendicular to its longitudinal axis (flatness, squareness, etc., should be checked at a minimum of 60× magnification on an optical comparator).

6.2.4 Continue to drill as needed to remove all the conical configuration of the bottom of the hole.

6.2.5 Remove drill, check cutting edge, regrind, if necessary.

6.2.6 Remove an additional 0.005 in. (0.13 mm) of material from the hole bottom.

6.2.7 Recheck cutting edges of the drill on the optical comparator, regrind, if necessary, and repeat 6.2.5 and 6.2.6. Careful attention must be given to the squareness of corners of the cutter, the slightest radius reduces the reflective area of the hole bottom.

7. Checking Physical Characteristics

7.1 All dimensions of the reference blocks including the diameter and perpendicularity of the examination hole may be checked by normal quality control procedures for physical measurements. The configuration, squareness, flatness, and surface finish for hole bottoms 3⁄64 in. (1.2 mm) in diameter and larger may be checked by the following recommended technique for making and evaluating plastic replicas:

7.1.1 Clean hole with a suitable oil-free noncorrosive solvent and dry with a stream of dried and filtered air.

7.1.2 Mix the replicating material in accordance with the manufacturer's instructions.