~~Designation:E428–05a~~ Designation: E 428 – 08

Standard Practice for Fabrication and Control of Metal, Other than Aluminum, Reference, Blocks Used in Ultrasonic ~~Examination~~Testing[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.

NOTE 1—Use of flat-surface reference blocks may not be suitable for cylindrical materials (**3**)[2].

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 2—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.

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

1.3 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.

1.4 *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:* [3]

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

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

E 1316 Terminology for Nondestructive ~~Testing~~Examinations

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

---

[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.~~ Method.

Current edition approved ~~Dec.~~July 1, ~~2005.~~2008. Published ~~January 2006.~~July 2008. Originally approved in 1971. Last previous edition approved in 2005 as E 428 - 05a.

[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[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.

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. Significance and Use

5.1 Reference blocks fabricated in accordance with this practice will exhibit specific area-amplitude and distance-amplitude relationships only with an immersion test at 5 MHz using the search unit, test instrument and test parameters described in this practice. Comparison test at other frequencies or with uncalibrated instruments will not necessarily give the same relationships shown in this practice. See Reference (**1**) for area-amplitude limitations at other frequencies and transducer diameters. Also see Reference (**2**) for cautions regarding use of standard blocks for test standardizations.

6. Material Selection

6.1 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, and so forth) are variables to be considered in matching acoustic responses.

6.1.1 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 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.

6.1.2 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.

6.1.3 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 6.1.2.

6.1.4 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]~~(1.2 mm) in diameter, the decay patterns shall compare within ±10 % or as required by the application.

6.1.5 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 6.1.4. 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.

7. Fabrication Procedure

7.1 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:

7.1.1 Distance-Amplitude Response (D/A),

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

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

7.2 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 3—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.

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

7.2.2 Drill the test hole to the nominal 3⁄4-in. ~~[19.0-mm]~~(19.0-mm) depth with a standard drill point.

7.2.3 Carefully prepare a flat-bottom drill or cutter with cutting edges square and flat within 0.0005 in. ~~[0.013 mm]~~(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).

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

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

7.2.6 Remove an additional 0.005 in. ~~[0.13 mm]~~(0.13 mm) of material from the hole bottom.

7.2.7 Recheck cutting edges of the drill on the optical comparator, regrind, if necessary, and repeat 7.2.5 and 7.2.6. Careful attention must be given to the squareness of corners of the cutter, the slightest radius reduces the reflective area of the hole bottom.

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. 1.
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.

Metal Travel and Designator				Distance/Amplitude, 19 in each set			Basic Set, 10 Total			Area/Amplitude Set, 8 Total						
							Diameter of Flat-Bottom Holes (1/64 in./1.6 mm) Dimension "D"									
Nominal MT	Dim. "A"		Desig.	3	5	8	3	5	8	1	2	3	4	5	6	7
(in.)	(in.)	(mm)														
0.063	0.0625	1.6	–0006	3	5	8	...	...	...							
0.125	0.125	3.2	–0012	3	5	8	...	5	...							
0.250	0.250	6.4	–0025	3	5	8	...	5	...							
0.375	0.375	9.5	–0038	3	5	8	...	...	...							
0.500	0.500	12.7	–0050	3	5	8	...	5	...							
0.625	0.625	15.9	–0062	3	5	8	...	...	...							
0.750	0.750	19.1	–0075	3	5	8	...	...	...							
0.875	0.875	22.2	–0088	3	5	8	...	...	...							
1.000	1.000	25.4	–0100	3	5	8	...	...	...							
1.250	1.250	31.8	–0125	3	5	8	...	...	...							
1.500	1.500	36.1	–0150	...	...	...	...	5	...							
1.750	1.750	44.5	–0175	3	5	8	...	...	...							
2.000	2.000	50.8	–0200	...	...	...	...	...	...							
2.250	2.250	57.2	–0225	3	5	8	...	...	...							
2.500	2.500	63.5	–0250	...	...	...	...	...	...							
2.750	2.750	69.9	–0275	...	...	...	...	...	...							
3.000	3.000	76.2	–0300	3	5	8	3	5	8	1	2	3	4	5	6	7
3.250	3.250	82.6	–0325	3	5	8	...	...	...							
3.500	3.500	88.9	–0350	...	...	...	...	...	...							
3.750	3.750	95.3	–0375	3	5	8	...	...	...							
4.000	4.000	101.6	–0400	...	...	...	...	...	...							
4.250	4.250	106.0	–0425	3	5	8	...	...	...							
4.500	4.500	114.3	–0450	...	...	...	...	...	...							
4.750	4.750	120.7	-0475	3	5	8	...	...	...							
5.000	5.000	127.0	–0500	...	...	...	...	...	...							
5.250	5.250	133.4	–0525	3	5	8	...	...	...							
5.500	5.500	139.7	–0550	...	...	...	...	...	...							
5.750	5.750	146.1	–0575	...	...	...	...	...	...							
6.000	6.000	152.4	–0600	3	5	8	...	5	8							
6.250	6.250	158.8	–0625													
6.500	6.500	165.1	–0650													

8. Checking Physical Characteristics

8.1 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]~~(1.2 mm) in diameter and larger may be checked by the following recommended technique for making and evaluating plastic replicas:

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

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

8.1.3 Force the material into the hole with a disposable medical syringe and needle of adequate size.

8.1.4 Fill the hole beginning at the bottom and gradually moving outward making certain that no air pockets or bubbles remain in the hole.

8.1.5 Insert a small wire, pin, needle, or other suitable object that will serve as a rigid core and facilitate removal of the replica.

8.1.6 After curing, the replica may be removed and examined. The replica shall indicate that the hole bottom is flat within 0.001 in. ~~[0.03 mm]~~/(0.03 mm)/1/8 in. ~~[3.2 mm]~~(3.2 mm) of diameter and roughness shall not be greater than 16 rms finish. For record purposes, the replica may be projected on a comparator screen and photographed as shown in Fig. 2.

9. Checking Ultrasonic Response Characteristics

9.1 All measurements of area-amplitude and distance-amplitude characteristics are to be made using a 5-MHz, 3/8-in. ~~[9.5-mm]~~(9.5-mm) flat transducer at a water path distance equal to the measured distance to the last near-field maximum (Y0+) and a previously linearity-calibrated test instrument. Reference blocks that exhibit satisfactory external physical characteristics and proper configuration of the replicated hole shall be subjected to additional examination to check their ultrasonic-response characteristics. If the ultrasonic-response characteristics are to be established by immersion techniques, the drilled flat-bottom