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Standard Reference Radiographs for Tin Bronze Castings[1]

This standard is issued under the fixed designation E310; 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 Department of Defense.

ε[1] NOTE—Editorial changes were made throughout in May 2004.

1. Scope

1.1 These reference radiographs are reproductions of original radiographs and illustrate various types and degrees of discontinuities occurring in tin bronze and related types of alloys. The reference radiograph films are an adjunct to this document and must be purchased separately from ASTM International if needed. They are intended to provide the following:

1.1.1 A guide to the recognition of common discontinuities and their differentiation both as to type and severity level.

1.1.2 A standard nomenclature for reference in acceptance standards, specifications and drawings.

1.1.3 A source of reference radiographs from which manufacturers and purchasers may, by mutual agreement, select particular radiographs to serve as standards representing minimum acceptability. The standards so established are identified by an alphabetic defect type and severity level (or class) designation.

1.2 The original radiographs are of discontinuities in sand cast 88:8:4 Cu-Sn-Zn, "G" type, bronze alloy plates. These discontinuities are representative of those found in wide solidification range copper-tin base alloys. The following ASTM specifications illustrate alloys covered by these standards; however, it is intended that these reference radiographs also apply to related Government and commercial material specifications:

Valve bronze castings	B61B61[A]
Composition bronze or ounce metal castings	B62B62[B]
Tin bronze sand castings	B584B584
Leaded red brass sand castings	B584B584
Copper-base alloy centrifugal castings (as applicable)	B271B271

[A] Similar to MIL-B-16541.
[B] Similar to MIL-B-16444.

1.3 The discontinuity types and severity levels represented by the reference radiographs are shown in Table 1, which also indicates the code designation for each discontinuity type.

1.4 The use of this document is not intended to be restricted to the specific energy level or to the absolute thickness limits that are contained in the document title. The title is intended to be descriptive and not restrictive. The document may be used, where there is no other applicable document, for other energy levels or thicknesses, or both, for which it is found to be applicable and for which agreement has been reached between purchaser and manufacturer.

NOTE 1—The reference radiographs consist of twenty-two 2½ by 5½-in. [63.5 by 139.7-mm] radiograph reproductions of low voltage X rays. Fifteen of these were made with newly developed 1-in. [25.4 mm] plate castings and seven were made with ¾-in. plate castings used originally for documents NAVSHIPS 250-537-1 and -2. The new plate castings cover Gas Porosity, Linear Shrinkage, and Feathery Shrinkage discontinuity types.

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

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 *ASTM Standards:*[2]

B61 Specification for Steam or Valve Bronze Castings
B62 Specification for Composition Bronze or Ounce Metal Castings
B271 Specification for Copper-Base Alloy Centrifugal Castings
B584 Specification for Copper Alloy Sand Castings for General Applications
E94 Guide for Radiographic Examination
E1316 Terminology for Nondestructive Examinations

2.2 *ASTM Adjuncts:*

Reference Radiographs for Tin Bronze Castings[3]

[1] These reference radiographs are under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.02 on Reference Radiographs.

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[2] 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.

[3] Available from ASTM International Headquarters. Order RRE0310.

TABLE 1 Discontinuity Types and Severity Levels Illustrated by the Reference Radiographs[A]

Discontinuity Type	Code	Severity Level or Classes[B] Based on 1-in. [25.4-mm] Thick Plates
Gas porosity	A	1 to 5
Sand inclusions[C]	B	1 to 5
Shrinkage, linear	Ca	1 to 5
Shrinkage, feathery or spongy	Cd	1 to 5
Hot tear[C]	Da	1 illustration
Inserts, chaplets[C]	Eb	1 illustration

[A] The radiographs are applicable to and including 2-in. thick sections. Upon agreement between manufacturer and purchaser, they may be used for larger section thicknesses.

[B] The discontinuity types are numbered according to severity level or class, one representing the highest quality.

[C] Standards are taken from NAVSHIPS 250-537-1.

3. Terminology

3.1 *Definitions*—For definitions of terms used in this document, see Terminology E1316, Section D.

4. Significance and Use

4.1 These reference radiographs were produced by the use of 88:8:4, Cu-Sn-Zn, "G" plate castings. Table 2 lists the chemical composition and mechanical property limits for the alloy type. The references illustrate the appearance of the various radiographic severity levels when the original radiographs are produced to an optical density of 2.0 ± 0.2 on high contrast, fine grain film with a sensitivity (quality level), as determined by standard penetrameters, of 2 % (2-2T). In selecting these reference radiographs, the aim was to obtain a progressively graduated series for each type of discontinuity (Note 2). It was not intended that alike numbered levels or classes be considered of equal severity (as far as deterioration of mechanical properties is concerned) for the various categories.

NOTE 2—For a description of sensitivity or quality levels, see Guide E94.

4.2 The reproductions have been prepared to an *H* and *D* density of 2.0 ± 0.2 and have retained substantially the contrast of the original radiographs. Details of the technique used in the original radiography are listed in Table 3. These data are presented as a matter of record and are not to be construed as the only recommended techniques to be used for the radiography of castings to be evaluated by these references.

TABLE 2 Alloy Type Used to Produce Plate Castings for Original Radiographs

Chemical Composition, %		
	min	max
Copper	86.00	89.00
Tin	7.50	9.00
Zinc	3.00	5.00
Nickel	...	1.00
Lead	...	0.30
Iron	...	0.15
Phosphorus	...	0.05
Mechanical Properties		
Tensile strength, min, psi [MPa]	40 000 [275]	
Elongation in 2 in. or 51 mm, min,	20	

4.3 *Film Deterioration*—Radiographic films are subject to wear and tear from handling and use. The extent to which the image deteriorates over time is a function of storage conditions, care in handling and amount of use. Reference radiograph films are no exception and may exhibit a loss in image quality over time. The radiographs should therefore be periodically examined for signs of wear and tear, including scratches, abrasions, stains, and so forth. Any reference radiographs which show signs of excessive wear and tear which could influence the interpretation and use of the radiographs should be replaced.

5. Descriptions of Discontinuities

5.1 The following paragraphs are provided to aid in the identification and classification of discontinuities (Note 3). They briefly describe the radiographic appearance of common types of discontinuities and indicate their probable cause.

5.1.1 *Gas Holes*—Round or elongated, smooth-edged dark spots which may occur either individually, in clusters, or distributed throughout the casting section. They are generally caused by trapped air or mold gases.

NOTE 3—Discontinuities caused by evolved gases may occur as more or less spherical voids, but may also occur as elongated "worm holes" or cavities somewhat resembling certain types of shrinkage. It is recommended that the "worm hole" cavities be evaluated by the use of the feathery or sponge shrinkage category reference radiographs.

5.1.2 *Shrinkage*—Shrinkage is generally associated with improper feeding and manifests itself in the following different indication forms:

5.1.2.1 *Linear Shrinkage*—Usually a continuous structure of connected lines, branches or network of variable length, width, and density.

5.1.2.2 *Feathery Shrinkage*—Appears on the radiographs as sponge but with a more feathery outline.

5.1.2.3 *Sponge Shrinkage*—Appears on the radiographs as a dark area or areas, lacy in texture, usually with a diffuse outline.

5.1.3 *Hot Tears*—The similarly, appearing "hot tear" and "linear shrinkage" have distinctive characteristics. The following information is presented as guide to interpreters to minimize confusion in distinguishing hot tears from linear shrinkage:

5.1.3.1 Hot tears usually occur singly; shrinkage will generally be multiple.

5.1.3.2 Hot tears propagate at or near the surface; shrinkage appears to propagate at or near the midsection.

5.1.3.3 Hot tears generally occur at hot spots or section changes; linear shrinkage frequently occurs at uniform sections also.

5.1.3.4 Hot tears occur where temperature gradients are high; shrinkage occurs where temperature gradients are low.

5.1.3.5 Hot tears occur transverse to the direction of greatest stress.

5.1.3.6 Hot tears can only be counteracted by altering the stress pattern or thermal pattern; shrinkage can always be countered by sufficient feed metal.