



Standard Reference Radiographs of Investment Steel Castings for Aerospace Applications¹

This standard is issued under the fixed designation E192; 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 The reference radiographs provided in the adjunct to this standard illustrate various types and degrees of discontinuities occurring in thin-wall steel investment castings.² Use of this standard for the specification or grading of castings requires procurement of the adjunct reference radiographs which illustrate the discontinuity types and severity levels. They are intended to provide the following:

1.1.1 A guide enabling recognition of thin-wall steel casting discontinuities and their differentiation both as to type and degree through radiographic examination.

1.1.2 Example radiographic illustrations of discontinuities and a nomenclature for reference in acceptance standards, specifications and drawings.

1.2 Two illustration categories are covered as follows:

1.2.1 *Graded*—Six common discontinuity types each illustrated in eight degrees of progressively increasing severity.

1.2.2 *Ungraded*—Twelve single illustrations of additional discontinuity types and of patterns and imperfections not generally regarded as discontinuities.

1.3 The reference radiographs were developed for casting sections up to 1 in. (25.4 mm) in thickness.

1.4 This document may be used where there is no other applicable document existing or for other material thicknesses for which it is found to be applicable and for which agreement has been reached between the purchaser and manufacturer.

NOTE 1—The set of reference radiographs, produced with X-rays in the range from 130 to 250 kVp, consist of 16 plates (8½ by 11 in. (216 by 279 mm)) in a 9¾ by 11½-in. (248 by 292-mm) ring binder.

1.5 From time to time, there may be minor changes to the process for manufacturing of the reference radiograph adjunct materials. These changes could include changes in the films or

¹ These reference radiographs are under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and are the direct responsibility of Subcommittee E07.02 on Reference Radiological Images.

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² The reference radiographs are considered to be applicable to all thin-wall steel castings, requiring close tolerances. Such castings generally include those made by the lost wax, frozen mercury, ceramicast or shell mold processes.

processing chemicals used, changes in the dies or printing for the cardboard mats, etc.; however, in all cases, these changes are reviewed by the Illustration Monitoring Subcommittee and all reference radiographs are reviewed against a fixed prototype image to ensure that there are no changes to the acceptance level represented by the reference radiographs. Therefore, the adjunct reference radiographs remain valid for use with this standard regardless of the date of production or the revision level of the text standard.

1.6 These film reference radiographs are not intended to illustrate the types and degrees of discontinuities found in aerospace investment castings when performing digital X-ray imaging. When performing digital X-ray imaging of these castings, refer to Digital Reference Image Standard E2660.

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

1.8 *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*:³

E94 Guide for Radiographic Examination

E1025 Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology

E1316 Terminology for Nondestructive Examinations

E2660 Digital Reference Images for Investment Steel Castings for Aerospace Applications

2.2 *ASTM Adjuncts*:

Reference Radiographs of Investment Steel Castings for Aerospace Applications⁴

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 ASTM Headquarters, Order RRE0192.

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

3. Terminology

3.1 *Definitions*—Definitions of terms used in this standard may be found in Terminology E1316, Section D.

3.2 The terms relating to discontinuities present in these reference radiographs are described based upon radiographic appearance. The terms “darker” and “lighter” as used in this standard refer to the optical density of a radiographic film. Where other radiographic imaging media are used, these terms should be understood to refer to areas of greater or lesser radiologic transmission, respectively.

3.2.1 *Gas:*

3.2.1.1 *gas holes*—round or elongated, smooth edged dark spots, occurring individually, in clusters, or distributed randomly throughout the casting.

3.2.2 *Shrinkage:*

3.2.2.1 *shrinkage cavity*— an area with distinct jagged boundaries.

3.2.2.2 *shrinkage, sponge*—an area, lacy in texture, with a very diffuse outline.

3.2.2.3 *shrinkage, dendritic*—a distribution of very fine lines or small elongated cavities that may vary in darkness and are usually unconnected.

3.2.2.4 *shrinkage, filamentary*—usually a continuous structure of connected lines or branches of variable length, width and darkness, or occasionally, a network.

3.2.3 *Heterogeneities:*

3.2.3.1 *foreign material less dense*—irregularly shaped indications darker than the adjacent material, but lighter than gas holes of similar magnitude.

3.2.3.2 *foreign material more dense*—irregularly shaped indications lighter than the adjacent material.

3.2.4 *Discrete Discontinuities:*

3.2.4.1 *hot tears*—ragged dark lines of variable width and numerous branches. They have no definite lines of continuity and may exist in groups. They may originate internally or at the surface.

3.2.4.2 *cold cracks*— straight or jagged lines usually continuous throughout their length. Cold cracks generally appear singly. They start at the surface.

3.2.4.3 *cold shut*—a distinct dark line or band of variable length and definite smooth outline.

3.2.4.4 *misruns*—prominent dark areas of variable dimensions with a definite smooth outline.

3.2.4.5 *core shift*—a variation in wall thickness.

3.2.5 *defective mold*, is illustrated by such common defects as mold crack, mold ridge, rattle, scab, and fin. These conditions appear as areas or lines of different darkness than the adjacent material. Illustrations of the defect include:

3.2.5.1 *mold buckle, positive*—a lightened irregularly shaped area lightest near the center and gradually increasing in darkness away from the center.

3.2.5.2 *mold buckle, negative*—a darkened irregularly shaped area darkest near the center and gradually getting lighter away from the center.

3.2.6 *Diffraction Pattern:*

3.2.6.1 *columnar*—few or many lines or arrays of linear indications that are both darker and lighter than the surrounding area.

3.2.6.2 *mottled*—indistinct areas of darker and lighter images.

4. Description

4.1 The range of radiographic illustrations is given in Table 1. The graded discontinuities are illustrated in eight grades. These grades range from that discernible at a 2-1T quality level or better to that evident of poor workmanship and commonly rejectable in commercial practice.⁵ The ungraded illustrations have been included to establish the appearance of the radiographic indications they represent in thin-wall steel castings. The alloys used are listed in Table 2.

4.2 The ASTM penetrameters included on each graded plate were used for contrast and resolution control only, and in accordance with Practice E1025. All of the references are

⁵ Each grade of a given discontinuity type is contained in an individual approximate 2 by 2¾-in. (51 by 70-mm) machined casting block. These blocks were inserted in steel keeper plates with radiographic characteristics equivalent to the casting blocks. The assembled plates were then radiographed to obtain the various gradations shown.

TABLE 1 Range of Illustration

Illustrations	Illustration Plate Thickness, in. (mm)	Applicable Casting Thickness, in. (mm)
<i>Graded:</i>		
Gas holes	⅛ (3.2)	¼ (6.4) and under
Gas holes	⅜ (9.5)	Over ¼ to ½ (6.4 to 12.7), incl
Gas holes	¾ (19)	Over ½ to 1 (12.7 to 25.4), incl
Shrinkage cavity	¾ (19)	All thicknesses
Shrinkage, sponge	⅛ (3.2)	¼ (6.4) and under
Shrinkage, sponge	⅜ (9.5)	Over ¼ to ½ (6.4 to 12.7), incl
Shrinkage, sponge	¾ (19)	Over ½ to 1 (12.7 to 25.4), incl
Shrinkage, dendritic	⅛ (3.2)	¼ (6.4) and under
Shrinkage, dendritic	⅜ (9.5)	Over ¼ to ½ (6.4 to 12.7), incl
Shrinkage, dendritic	¾ (19)	Over ½ to 1 (12.7 to 25.4), incl
Shrinkage, filamentary	¾ (19)	All thicknesses
Foreign material, less dense	⅛ (3.2)	¼ (6.4) and under
Foreign material, less dense	⅜ (9.5)	Over ¼ to ½ (6.4 to 12.7), incl
Foreign material, less dense	¾ (19)	Over ½ to 1 (12.7 to 25.4), incl
<i>Ungraded:</i>		
<i>Discrete Discontinuities:</i>		
Foreign material, more dense	⅜ (9.5)	
Hot tear	⅜ (9.5)	
Cold crack	⅜ (9.5)	
Cold shut	⅜ (9.5)	
Misrun	⅜ (9.5)	
Core shift	⅜ (9.5)	
<i>Defective Mold:</i>		
Mold buckle, positive	⅜ (9.5)	
Mold buckle, negative	⅜ (9.5)	
Mold ridge	⅜ (9.5)	
Excess metal in cracked core	⅜ (9.5)	
<i>Diffraction pattern:</i>		
Columnar	⅜ (9.5)	
Mottled	⅜ (9.5)	