



Standard Reference Radiographs for Heavy-Walled (2 to 4½ in. (50.8 to 114 mm)) Steel Castings¹

This standard is issued under the fixed designation E186; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 These reference radiographs² illustrate various categories, types and severity levels of discontinuities occurring in steel castings that have section thicknesses of 2 to less than 4½ in. (50.8 to 114 mm). The reference radiograph films are an adjunct to this document and must be purchased separately from ASTM International, if needed (see 2.2). Categories and severity levels for each discontinuity type represented by these reference radiographs are described in 1.2.1. Note that the basis of application for these reference radiographs requires a prior purchaser/supplier agreement of radiographic examination attributes and classification criterion as described in Sections 4, 6, and 7 of this standard. Reference radiographs for other steel casting thicknesses may be found in Reference Radiograph standards E446 and E280. Reference Radiograph standards E446 and E280 provide some overlap of severity levels for similar discontinuity categories within the same energy level range (see 4.2, 5.1, and 6.3)

1.2 These reference radiographs consist of three separate volumes as follows:

1.2.1 Volume I: 1–MV X-rays and Iridium 192 (called “1 to 2–Mev X-rays” in previous editions)-Set of 28 plates (*nominal* 5 by 8 in. (127 by 203 mm) in a 15 by 17 in. (381 by 432 mm) ring binder).

1.2.2 Volume II: 2–MV X-rays and Cobalt-60 (called “gamma rays” in previous editions). This includes cobalt-60 or equivalent isotope radiation and from 2–MV up to 4–MV X-rays- Set of 28 plates (*nominal* 5 by 8 in.) in a 15 by 17 in. ring binder.

1.2.3 Volume III: 4–MV to 30–MV X-rays (called “10 to 24 Mev X-rays” in previous editions)- Set of 28 plates (*nominal* 5 by 8 in.) in a 15 by 17 in. ring binder.

1.2.4 Unless otherwise specified in a purchaser supplier agreement (see 1.1), each volume is for comparison only with

production radiographs produced with radiation energy levels within the thickness range covered by this standard. Each volume consists of three categories of graded discontinuities in increasing severity levels, and three categories of ungraded discontinuities. Reference radiographs containing ungraded discontinuities are provided as a guide for recognition of a specific casting discontinuity type where severity levels are not needed. Following is a list of discontinuity categories, types and severity levels for the adjunct reference radiographs of this standard:

1.2.4.1 *Category A*—Gas porosity; severity levels 1 through 5.

1.2.4.2 *Category B*—Sand and slag inclusions; severity levels 1 through 5.

1.2.4.3 *Category C*—Shrinkage; three types:

(1) *Ca*—linear shrinkage—severity levels 1 through 5. (Called Type 1 in previous revisions)

(2) *Cb*—feathery shrinkage—Severity levels 1 through 5. (Called Type 2 in previous revisions)

(3) *Cc*—sponge shrinkage—Severity levels 1 through 5. (Called Type 3 in previous revisions)

1.2.4.4 *Category D*—Crack; one illustration (D3 in pre-1972 documents).

1.2.4.5 *Category E*—Hot tear; one illustration in pre-1972 documents.

1.2.4.6 *Category F*—Insert; one illustration (EB3 in pre-1972 documents).

1.3 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 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.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical

¹ These reference radiographs are under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittees E07.02 on Reference Radiological Images and E07.93 on Illustration Monitoring.

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² For ASME Boiler and Pressure Vessel Code applications see related Reference Radiographs SE 186 in Section V of that Code.

conversions to SI units that are provided for information only and are not considered standard.

1.5 *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

E242 Reference Radiographs for Appearances of Radiographic Images as Certain Parameters are Changed

E280 Reference Radiographs for Heavy-Walled (4½ to 12-in. (114 to 305-mm)) Steel Castings

E446 Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness

E1316 Terminology for Nondestructive Examinations

2.2 ASTM Adjuncts:⁴

Reference Radiographs for Heavy-Walled (2 to 4½-in. (50.8 to 114-mm)) Steel Castings:

Volume I, 1-MV X-rays and Iridium-192⁵

Volume II, 2 to 4-MV X-rays and Cobalt-60⁶

Volume III, 4-MV to 30-MV X-rays⁷

3. Terminology

3.1 *Definitions*—For definitions of terms relating to radiographic examination, see Terminology **E1316**.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *production radiograph*—a radiograph under review for compliance with this standard.

3.2.2 *discontinuity type*—a specific discontinuity characterized by its cause and appearance. For example: linear shrinkage is a specific discontinuity type.

3.2.3 *discontinuity category*—a nomenclature system used for grouping discontinuity types. For example: linear shrinkage is assigned category “Ca” where “C” represents the general shrinkage category and “a” represents the specific linear shrinkage discontinuity type.

3.2.4 *discontinuity severity level*—a relative rank in terms of “quantity, size and distribution” of a collection of discontinuities where “1” is the least and “5” is the greatest “quantity, size and distribution” present on the reference radiograph. Example: a severity level of “1” is more restrictive (requires a higher level of workmanship fabrication quality) than a severity level of “2.”

3.2.5 *discontinuity class*—an assigned workmanship fabrication quality rating characterized by a discontinuity type,

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.

⁵ Order [RRE018601](#).

⁶ Order [RRE018602](#).

⁷ Order [RRE018603](#).

category and severity level. For example: “Ca 2” is a discontinuity class comprised of linear shrinkage with a severity level of “2.”

3.2.6 *classification specification*—a set of user defined acceptance criterion that prescribes the radiographic workmanship discontinuity class requirements for a specified user casting service application (see Sections 6 and 7).

3.2.7 *graded illustration*—a category of discontinuity that is assigned a severity level.

3.2.8 *ungraded illustration*—a category of discontinuity without an assigned severity level.

3.2.9 *prorating*—assignment of quantity, size and distribution on a production radiograph in proportion to a similar size area of a reference radiograph. For example: a production radiograph covers an area that is smaller than the unit area of a reference radiograph and the extent of discontinuity on the applicable reference radiograph is reduced proportionately.

4. Significance and Use

4.1 Graded reference radiographs are intended to provide a guide enabling recognition of specific casting discontinuity types and relative severity levels that may be encountered during typical fabrication processes. Reference radiographs containing ungraded discontinuities are provided as a guide for recognition of a specific casting discontinuity type where severity levels may not be needed. These reference radiographs are intended as a basis from which manufacturers and purchasers may, by mutual agreement, select particular discontinuity classes to serve as standards representing minimum levels of acceptability (see Sections 6 and 7).

4.2 Reference radiographs represented by this standard may be used, as agreed upon in a purchaser supplier agreement, for energy levels, thicknesses or both outside the range of this standard when determined applicable for the casting service application. Severity levels of similar discontinuity categories and energy level range of **E446** or **E280** reference radiographs may alternatively be used, as determined appropriate for the casting service application, if so agreed upon in a purchaser supplier agreement (see Section 1 and 5.1).

4.3 Procedures for evaluation of production radiographs using applicable reference radiographs of this standard are prescribed in Section 8; however, there may be manufacturing-purchaser issues involving specific casting service applications where it may be appropriate to modify or alter such requirements. Where such modifications may be appropriate for the casting application, all such changes shall be specifically called-out in the purchaser supplier agreement or contractual document. Section 9 addresses purchaser supplier requisites where weld repairs to castings may be required.

5. Method of Preparation

5.1 The original radiographs used to prepare the adjunct reference radiographs were produced on ASTM Class I or II film systems by the respective use of radiation energies stated in 1.2.1 to 1.2.3. The original radiographs were made with a