



Designation: E186-98 (Reapproved 2004)^{ε1} Designation: E186 - 10

Standard Reference Radiographs for Heavy-Walled (2 to 4½-in. [51 to 114-mm]) Steel Castings-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 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.

^{ε1}Note—Editorial changes made throughout in January 2004.

1. Scope

1.1 These reference radiographs Scope

1.1 These reference radiographs² for heavy-walled steel castings are applicable to nominal section thicknesses of 2 to 4½ in. [51 to 114 mm] and consists of three separate sets as follows:

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

1.1.2 Volume 2: 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 (5 by 8 in.) in a 15 by 17 in. ring binder.

1.1.3 Volume 3: 4-MV to 30-MV X rays (called “10 to 24 Mev X rays” in previous editions)- Set of 28 plates (5 by 8 in.) in a 15 by 17 in. ring binder.

1.1.4 Each set consists of three categories of graded discontinuities in increasing severity levels, and three categories of ungraded discontinuities furnished as examples only, as follows:

1.1.4.1 *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.

1.1.4.2

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 Radiographs.

Current edition approved January 1, 2004. Published February 2004. Originally approved in 1962. Last previous edition approved in 1998 as E186-98. DOI: 10.1520/E0186-98R04E01 on Reference Radiological Images and E07.93 on Illustration Monitoring.

Current edition approved Jan. 1, 2010. Published February 2010. Originally approved in 1962. Last previous edition approved in 2004 as E186 - 98(2004) ^{ε1}. DOI: 10.1520/E0186-10.

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

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

†1.1.4.3

1.2.4.3 *Category C*—Shrinkage; three types:

(1) *Type 1*—Severity levels 1 through 5.

(2) *Type 2*—Severity levels 1 through 5.

(3) *Type 3*—Severity levels 1 through 5.

†1.1.4.4—*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.

†1.1.4.5—*Crack; one illustration (D3 in pre-1972 documents).*

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

†1.1.4.6

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

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

†3—*Insert; one illustration (EB3 in pre-1972 documents).*

1.3 The values stated in inch-pound units are to be regarded as the standard. SI values are shown for information only.

1.4 *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 \(412 to 12-in. \(114 to 305-mm\)\) Steel Castings](#)

E446 [Reference Radiographs for Steel Castings Up to 2 in. \[51 mm\] in Thickness](#)

E1316 [Terminology for Nondestructive Examinations](#)

2.2 *ASTM Adjuncts:*⁴

Reference Radiographs for Heavy-Walled (2 to 4½-in. [51(50.8 to 114-mm)]114-mm) Steel Castings:

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

Volume II, 2-MV X-Rays and Cobalt-60

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 used in this document, see Terminology —For definitions of terms relating to radiographic examination, see Terminology E1316, Section D.

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, 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 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.

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 These reference radiographs are reproductions of original radiographs and are supplied as a means for establishing the categories and severity levels of discontinuities in steel castings that may be revealed by radiographic examination. They may be used in accordance with contractual specifications.

4.2 Radiographs for evaluation are to be compared with these reference radiographs for classification on the basis of the category and severity level of the discontinuity.

4.3 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. 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 accompanying reference radiographs were produced on high contrast, fine grain film by the respective use of radiation energies stated in 1.1.1.

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 1.1.31.2.3. The original radiographs were made with a penetrometer sensitivity, as determined by ASTM penetrameters (see Guide E94) of 2-2T. The reproductions have been prepared to an optical density of 2.00 to 2.25 and they have retained substantially the contrast of the original radiographs. The adjunct reference radiographs are reproductions prepared to an optical density of 2.00 to 2.25 and have substantially retained the contrast of the original radiographs. In preparing these reference radiographs, the objective was to obtain progressively graduated severity levels for each graded discontinuity category of this standard. Additionally, some overlap of severity levels may occur for similar discontinuity categories of Reference Radiograph standard E446 or E280 with the same energy level range (see 6.3).

5.2 *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.

6. Determination of Radiographic Classification

6.1 For purposes of evaluation of castings, a determination must be made of the radiographic classification to be assigned to individual castings or specific areas of castings. The determination of the applicable radiographic classification shall be based on an evaluation of the casting applications, design, and service requirements. In these evaluations, consideration shall be given to such factors as pressure, temperature, section thickness, applicable design safety factor, vibration, shock, resistance to corrosion, involvement of penetrating radiations or radiation products, and involvement of dangerous gases or liquids.

7.

6.1 For purposes of evaluation of castings, a determination must be made of the radiographic discontinuity classifications to be assigned to individual castings or specific areas of castings. The determination of the applicable radiographic discontinuity