



Standard Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness¹

This standard is issued under the fixed designation E446; 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 These reference radiographs² illustrate various categories, types, and severity levels of discontinuities occurring in steel castings that have section thicknesses up to 2 in. (50.8 mm) (see [Note 2](#)). The reference radiograph films are an adjunct to this standard 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 [1.3](#).

NOTE 1—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.

NOTE 2—Reference radiographs previously used for this thickness range carried the designation E71, but included a now rarely used gamma source, that is, radium. The current document is also updated by inclusion of several recognized *shrinkage* or *C* categories and by elimination of the crack and hot tear categories except for one example of each of these discontinuity types. Reference radiographs for thicker sections may be found in Reference Radiograph standards [E186](#) and [E280](#). Reference Radiograph standards E446 and [E186](#) 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 film reference radiographs are not intended to illustrate the types and degrees of discontinuities found in steel castings when performing digital radiography. If performing digital radiography of steel castings up to 2 in. (50.8 mm) in thickness, refer to Digital Reference Image Standard [E2868](#).

1.3 These reference radiographs consist of three separate volumes (see [Note 3](#)) as follows: (I) medium voltage (nominal 250-kV) X-rays. (II) 1-MV X-rays and Iridium-192 radiation, and (III) 2-MV to 4-MV X-rays and cobalt-60 radiation. 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

six categories of graded discontinuities of increasing severity level and four 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:

- 1.3.1 *Category A*—Gas porosity; severity levels 1 through 5.
- 1.3.2 *Category B*—Sand and slag inclusions; severity levels 1 through 5.
- 1.3.3 *Category C*—Shrinkage; 4 types:
 - 1.3.3.1 *Ca*—linear shrinkage—Severity levels 1 through 5.
 - 1.3.3.2 *Cb*—feathery shrinkage—Severity levels 1 through 5.
 - 1.3.3.3 *Cc*—sponge shrinkage—Severity levels 1 through 5.
 - 1.3.3.4 *Cd*—combinations of linear, feathery and sponge shrinkage—Severity levels 1 through 5.
- 1.3.4 *Category D*—Crack; 1 illustration.
- 1.3.5 *Category E*—Hot tear; 1 illustration.
- 1.3.6 *Category F*—Insert; 1 illustration.
- 1.3.7 *Category G*—Mottling; 1 illustration.

NOTE 3—The reference radiographs consist of the following:

Volume I: Medium Voltage (nominal 250 kVp) X-ray Reference Radiographs—set of 34 illustrations (nominal 5 by 7 in.) in a 15 by 17-in. ring binder.

Volume II: 1-MV X-rays and Iridium-192 Reference Radiographs—Set of 34 illustrations (nominal 5 by 7 in.) in a 15 by 17-in. ring binder.

Volume III: 2-MV to 4-MV X-rays and Cobalt-60 Reference Radiographs—Set of 34 illustrations (nominal 5 by 7 in.) in a 15 by 17-in. ring binder.

NOTE 4—Although Category G—Mottling is listed for all three volumes, the appearance of mottling is dependent on the level of radiation energy. Mottling appears reasonably prominent in Volume I; however, because of the higher radiation energy levels mottling may not be apparent in Volume II nor Volume III.

1.4 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

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 For ASME Boiler and Pressure Vessel Code applications see related Reference Radiographs SE-446 in Section V of that Code.

adjunct reference radiographs remain valid for use with this standard regardless of the date of production or the revision level of the text standard.

1.5 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.

1.6 *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:³

E94 Guide for Radiographic Examination

E186 Reference Radiographs for Heavy-Walled (2 to 4½-in. (50.8 to 114-mm)) Steel Castings

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

E1316 Terminology for Nondestructive Examinations

E2868 Digital Reference Images for Steel Castings up to 2 in. (50.8 mm) in Thickness

2.2 ASTM Adjuncts:⁴

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

Volume I, Medium Voltage (Nominal 250 kVp) X-Rays⁵

Volume II, 1-MV X-Rays and Iridium-192⁶

Volume III, 2-MV to 4-MV X-Rays and Cobalt-60⁷

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, 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 are not 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 **E186** reference radiographs may alternatively be used, as determined appropriate for the casting service application, if so agreed upon in the purchaser supplier agreement (see **Note 2** 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 for where weld repairs may be required.

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 **RRE044601**.

⁶ Order **RRE044602**.

⁷ Order **RRE044603**.