



Designation: E3419 – 24

Standard Digital Reference Images for Steel Fusion Welds¹

This standard is issued under the fixed designation E3419; 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.

1. Scope

1.1 This standard provides digital reference images for steel fusion welds that contain typical discontinuities with varying severity levels in different thicknesses of material. The digital reference images are an adjunct to this standard and must be purchased separately from ASTM International if needed.

1.2 There are three volumes of digital reference images based on seven nominal weld thicknesses as follows:

1.2.1 *Vol I*—Set of 23 images covering base material up to and including $\frac{1}{4}$ in. (6.4 mm) in thickness.

1.2.2 *Vol II*—Set of 30 images covering base material over $\frac{1}{4}$ in. up to and including 3 in. (6.4 to 76 mm) in thickness.

1.2.3 *Vol III*—Set of 7 images covering base material over 3 in. up to and including 8 in. (76 to 203 mm) in thickness.

1.3 *Units*—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.

1.4 All areas of this standard may be open to agreement between the cognizant engineering organization and the supplier, or specific direction from the cognizant engineering organization. These items should be addressed in the purchase order or the contract.

1.5 Only licensed copies of the software and images shall be utilized for production inspection. A copy of the ASTM/user license agreement shall be kept on file for audit purposes. (See [Note 1.](#))

NOTE 1—The set of digital reference images consists of sixty digital data files, and software to load the desired format and specific instructions on the loading process. The sixty reference images illustrate both graded discontinuities and ungraded discontinuities. Available from ASTM International Headquarters, order Nos: RRE341901, RRE341902, and RRE341903.

1.6 These digital reference images are not intended to illustrate the types and degrees of discontinuities found in steel

fusion welds when performing film radiography. If performing film radiography of such weldments, refer to Reference Radiographs [E390](#).

1.7 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

[E94](#) Guide for Radiographic Examination Using Industrial Radiographic Film

[E390](#) Reference Radiographs for Steel Fusion Welds

[E1316](#) Terminology for Nondestructive Examinations

[E2002](#) Practice for Determining Image Unsharpness and Basic Spatial Resolution in Radiography and Radioscopy

2.2 *ASTM Adjuncts:*

Digital Reference Images for Steel Fusion Welds:

Volume I, Thickness Up to and Including $\frac{1}{4}$ in. (6.4 mm)³

Volume II, Thickness Over $\frac{1}{4}$ to 3 in. (6.4 to 76 mm), incl⁴

Volume III, Thickness Over 3 to 8 in. (76 to 203 mm), incl⁵

2.3 *SMPTE Practice:*⁶

[RP133](#) Recommended Practice Specifications for Medical Diagnostic Imaging Test Pattern for Television Monitors and Hard-Copy Recording Cameras

3. Terminology

3.1 *Definitions*—For definitions of terms used in this document, see Terminology [E1316](#), Section D.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from ASTM Headquarters. Order RRE341901.

⁴ Available from ASTM Headquarters. Order RRE341902.

⁵ Available from ASTM Headquarters. Order RRE341903.

⁶ Available from the Society of Motion Picture and Television Engineers, 3 Barker Avenue, White Plain, NY 10601, http://www.smpte.org/smpte_store.

¹ These digital reference images 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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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. These terms should be understood to refer to areas of greater or lesser radiologic transmission, respectively.

4. Significance and Use

4.1 These digital reference images may be used as a means for establishing the types and severity levels of discontinuities that are revealed by digital radiographic examination of steel fusion welds.

4.2 Personnel utilizing digital reference images to this standard shall be qualified to perform radiographic interpretation in accordance with a nationally or internationally recognized NDT personnel qualification practice or standard and certified by the employer or certifying agency, as applicable. The practice or standard used, and its applicable revision shall be identified in the contractual agreement between the using parties. If assistance is needed with interpreting specifications and product requirements as applied to the reference radiographs, a certified Level III shall be consulted before accept/reject decisions are made (if the Level III is the radiographic interpreter, this may be the same person).

4.3 The combined volumes contain illustrations of representative graded and ungraded discontinuities applicable to seven thickness ranges, as shown in Table 1. Table 2 lists the discontinuity types and severities illustrated for each thickness of base material. Each of the graded discontinuity types has five severity levels, 1 through 5 in order of increasing severity. The ungraded discontinuities are included for informational purposes.

4.4 These digital reference images may be used in contractual specifications, for which agreement has been reached between purchaser and supplier, to establish acceptance limits of the types and severity levels of discontinuities revealed by digital radiographic examination.

4.5 The use of this document is not intended to be restricted to the specific energy levels given in Table 3 or to the thickness limits given in Table 1. This 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.

TABLE 1 Applicable Thickness Ranges

Illustration Thickness, in. (mm)	Base Material Thickness Range, in. (mm) ^a
Vol I	
0.030 (0.8)	to and including 0.050 (1.2)
0.080 (2.0)	over 0.050 (1.2) to and including ⅛ (3.2)
⅜ (4.8)	over ⅛ (3.2) to and including ¼ (6.4)
Vol II	
⅝ (9.5)	over ¼ (6.4) to and including ½ (13)
¾ (19)	over ½ (13) to and including 1½ (38)
2 (51)	over 1½ (38) to and including 3 (76)
Vol III	
5 (127)	over 3.0 (76) to and including 8 (203)

^a In the special cases of joining two members of unequal thickness, the standard applicable to the thinner member shall be used.

5. Description of Discontinuities

5.1 *Porosity* occurs as voids caused by gas trapped in the weld metal deposit. The voids may occur as spherical, elongated, or “worm hole” shapes and in patterns that are random, clustered, or linear. On a radiograph, the spherical voids have the appearance of a rounded dark area, while the nonspherical voids have an elongated dark area with a smooth outline.

5.2 *Tungsten Inclusions* are tungsten particles entrapped in the weld deposit. These inclusions are particles broken off or melted from the electrodes and may be caused by faulty equipment or poor manipulation. On the radiograph, the tungsten inclusions are lighter than the surrounding areas and may be rounded or irregularly shaped.

5.3 *Incomplete Penetration* is a discontinuity that occurs at the root of welds designed for through penetration where full penetration has not been achieved. The discontinuity appears on a radiograph as a straight dark line that may be either continuous or intermittent. The indication may be thin and sharp, broad and diffuse or two parallel lines depending upon the specific geometry of the joint and the width of the discontinuity.

5.4 *Slag Inclusions* are particles of slag entrapped in the weld metal or along the fusion planes. The particles appear darker than the surrounding area and may be irregular in shape or elongated in the direction of the deposited weld bead.

5.5 *Lack of Fusion* is a discontinuity caused by molten weld metal which has failed to bond to the base metal or to a previously deposited weld bead. On the radiograph, it appears as a dark indication usually elongated and varying in width.

5.5.1 Although all of the illustrations for lack of fusion show the discontinuity near the edge of a weld joint, this discontinuity may exist anywhere in the weld.

5.6 A *crack* is a rupture of solidified metal. Cracks associated with welding may be longitudinal, transverse, or radially oriented and may occur in the weld metal, base metal, or through both. Radially oriented cracks are called crater cracks because they generally originate in a weld bead crater. When the plane of the crack is perpendicular to the film, the radiographic image appears as either a jagged or a straight line. As the plane of the crack deviates from the direction of the radiation beam, the appearance of the crack becomes an increasingly broad and poorly defined line.

5.7 *Icicles (Teardrops)* are fused droplets of weld metal extending beyond the root of the weld. They appear as individual, rounded, lighter indications with an occasional small dark spot in the center of a drop. Icicles occur in seams welded from one side only.

5.8 A *burn through* is a melting of the metal from the root of the weld or through the backing strip. It appears on the radiograph as an individual darkened area of elongated or rounded contour which may be surrounded by a lighter ring. This discontinuity occurs in seams welded from one side only.

5.9 An *undercut* is a longitudinal groove melted into the base metal adjacent to the toe of a weld and filled with