



Designation: E3420 – 24

Standard Digital Reference Images for Aluminum Fusion Welds¹

This standard is issued under the fixed designation E3420; 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 These digital reference images illustrate various types and severity levels of discontinuities in aluminum fusion welds that may be revealed by digital radiographic examination. These digital reference images do not specify the acceptable level of these discontinuities, rather they provide a visual reference for communicating the acceptable level.

1.2 These digital reference images are based on two nominal weld thicknesses in wrought aluminum products and are applicable to the thickness ranges shown in [Table 1](#). The welds were produced using base material plates of 6061 and 5083 alloys and 5356 and 4043 gas metal-arc (GMA) electrodes. These digital reference images are intended for use in evaluating digital radiographs of welds in wrought aluminum products. They are not recommended for use with repair welds in cast materials; however, they are appropriate for use with assembly or fabrication welds. Digital reference images for aluminum and magnesium castings are available in Digital Reference Images [E2422](#) and [E2973](#).

1.3 The adjunct contains illustrations of representative graded and ungraded discontinuities. [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.

1.4 *Units*—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.

1.5 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.

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

aluminum fusion welds when performing film radiography. If performing film radiography of such weldments, refer to Reference Radiographs [E1648](#).

1.7 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 eight digital data files, and software to load the desired format and specific instructions on the loading process. The eight reference image pages illustrate both graded discontinuities and ungraded discontinuities. Available from ASTM International Headquarters, Order No: RRE3420.

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

1.9 *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
- [E1032](#) Practice for Radiographic Examination of Weldments Using Industrial X-Ray Film
- [E1316](#) Terminology for Nondestructive Examinations
- [E1648](#) Reference Radiographs for Examination of Aluminum Fusion Welds
- [E2002](#) Practice for Determining Image Unsharpness and Basic Spatial Resolution in Radiography and Radioscopy
- [E2422](#) Digital Reference Images for Inspection of Aluminum Castings
- [E2973](#) Digital Reference Images for Inspection of Aluminum and Magnesium Die Castings

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

Current edition approved July 15, 2024. Published August 2024. DOI: 10.1520/E3420-24.

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.

TABLE 1 Applicable Thickness Ranges

Illustration Thickness, in. (mm)	Base Material Thickness, in. (mm)
0.125 (3.2)	to and including 0.375 (9.5)
0.50 (12.7)	over 0.375 (9.5) to and including 0.75 (19)

TABLE 2 Types of Discontinuities Illustrated for Each Thickness of Base Material

Discontinuity Type	Base Material Thickness, in. (mm) and Grading	
	0.125 (3.2)	0.50 (12.7)
Fine Scattered Porosity	Grades 1 through 5	Grades 1 through 5
Coarse Scattered Porosity	...	Grades 1 through 5
Aligned Porosity	Grades 1 through 5	Grades 1 through 5
Clustered Porosity	...	Ungraded
Incomplete Penetration	Ungraded	Ungraded
Tungsten Inclusions	...	Ungraded
Undercut	Ungraded	Ungraded
Cracks (longitudinal and transverse)	Ungraded	Ungraded
Crater Crack	...	Ungraded

2.2 ASTM Adjuncts:

Digital Reference Images for Aluminum Fusion Welds:

Volume 1, Thicknesses Up to and Including 0.75 in. (19 mm)³

2.3 SMPTE Practice:⁴

RP133 Recommended Practice Specifications for Medical Diagnostic Imaging Test Pattern for Television Monitors and Hard-Copy Recording Cameras

3. Terminology

3.1 Definitions—Definitions of terms relating to X-ray and gamma radiology, as used in these digital reference images, may be found in Terminology **E1316**, Section D.

4. Significance and Use

4.1 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).

4.2 Use of these digital reference images requires agreement between the using parties as to the acceptable level of each discontinuity type. Illustrations are provided for welds in 0.125 in. (3.2 mm) thick material and 0.50 in. (12.7 mm) thick material. These illustrations are intended to be representative of base material thicknesses up to 0.75 in. (19 mm). Use of these digital reference images is not intended to be restricted to the specific energy level or the absolute thickness limits that are illustrated. These digital reference images may be used,

where there is no other applicable document, for other energy levels or thicknesses, or both, for which agreement has been reached between the purchaser and the manufacturer. Standard digital reference images should be used in accordance with contractual specifications.

5. Preparation of Digital Reference Images

5.1 The illustrations in adjunct are derived from digital scan of a master film radiographic set. The radiographs were made to a quality level of at least 2–2T in accordance with Guide **E94**. Additional details regarding the radiographic technique used are provided in Practice **E1032**.

6. Description of Discontinuities

6.1 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 aligned. 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. Aligned porosity appears as a string of pores which are generally aligned with the direction of a weld pass. The spacing between the pores may be relatively uniform or irregular.

6.2 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 welding technique. On the radiograph, the tungsten inclusions are lighter than the surrounding areas and may be rounded or irregularly shaped.

6.3 Incomplete Penetration is a discontinuity that occurs at the root of welds where full penetration has not been achieved. The discontinuity generally appears on a radiograph as a straight dark line that may be either continuous or intermittent. The indication is typically a sharply defined line or two parallel lines depending upon the specific geometry of the joint and the width of the discontinuity (see **Note 2**).

NOTE 2—Some welds may be designed for, or permit, incomplete penetration of the weld. Appropriate drawings and specifications shall be consulted to determine whether the indication represents an unacceptable condition. Where the condition exceeds specification limits, it is referred to by some specifications (for example, American Welding Society (AWS)) as Inadequate Penetration.

6.4 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. When the plane of the crack is aligned with the direction of the radiation beam, its radiographic image will appear as a well-defined jagged or a relatively straight line. As the plane of the crack deviates from the direction of the radiation beam, the appearance of the crack becomes increasingly broad and poorly defined.

6.4.1 Longitudinal Cracks are oriented in a direction that is generally parallel to the weld bead.

6.4.2 Transverse Cracks are oriented such that they tend to cross (at least partially) the weld bead.

6.4.3 Radially oriented cracks are called *crater cracks*, because they generally originate in a weld crater.

³ Available from ASTM Headquarters. Order RRE3420.

⁴ Available from the Society of Motion Picture and Television Engineers, 3 Barker Avenue, White Plain, NY 10601, http://www.smpete.org/smpete_store.