



Designation: ~~E 1416-04~~ Designation: **E1416 – 09**

Standard Test Method for Radioscopic Examination of Weldments¹

This standard is issued under the fixed designation E1416; 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.

1. Scope

1.1 This test method covers a uniform procedure for radioscopic examination of weldments. Requirements expressed in this test method are intended to control the quality of the radioscopic images and are not intended for controlling acceptability or quality of welds.

1.2 This test method applies only to the use of equipment for radioscopic examination in which the image is finally presented on a ~~television monitor~~ display screen (monitor) for operator evaluation. The examination may be recorded for later review. It does not apply to fully automated systems where evaluation is automatically performed by computer.

1.3 The radioscopic extent, the quality level, and the acceptance criteria to be applied shall be specified in the contract, purchase order, product specification, or drawings.

1.4 This test method can be used for the detection of discontinuities. This test method also facilitates the examination of a weld from several directions, such as perpendicular to the weld surface and along both weld bevel angles. The radioscopic techniques described in this test method provide adequate assurance for defect detectability; however, it is recognized that, for special applications, specific techniques using more stringent requirements may be needed to provide additional detection capability. The use of specific radioscopic techniques shall be agreed upon between purchaser and supplier.

1.5 The values stated in inch-pound units are to be regarded as the standard. The SI units given in ~~brackets~~ parentheses are for information only.

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.* Specific precautionary statements are given in Section 7.

2. Referenced Documents

2.1 ASTM Standards:²

E94 [Guide for Radiographic Examination](#)

E543 [Practice Specification for Agencies Performing Nondestructive Testing](#)

E747 [Practice for Design, Manufacture, and Material Grouping Classification of Wire Image Quality Indicators \(IQI\) Used for Radiology](#)

E1000 [Guide for Radioscopy](#)

E1025 [Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators \(IQI\) Used for Radiology](#)

E1255 [Practice for Radioscopy](#)

E1316 [Terminology for Nondestructive Examinations](#) Terminology for Nondestructive Examinations

E1453 [Guide for Storage of Magnetic Tape Media that Contains Analog or Digital Radioscopic Data](#)

E1475 [Guide for Data Fields for Computerized Transfer of Digital Radiological Examination Data](#)

E1647 [Practice for Determining Contrast Sensitivity in Radiology](#)

E1742 [Practice for Radiographic Examination](#)

2.2 ASNT Standards:³

ASNT Recommended Practice No. SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing

ANSI/ASNT CP-189-ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel

¹ This test method is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.01 on Radiology (X and Gamma) Method.

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² 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.

³ Available from The American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518.

2.3 National Aerospace Standard:⁴

NAS 410 Certification and Qualification of Nondestructive Test Personnel

3. Terminology

3.1 Definitions:

3.1.1 Definitions of terms applicable to this test method may be found in Terminology ~~E-1316~~E1316.

4. Apparatus

4.1 *Radiation Source (X-ray or Gamma-ray)*—Selection of the appropriate source is dependent upon variables regarding the weld being examined, such as material composition and thickness. The suitability of the source shall be demonstrated by attainment of the required image quality and compliance with all other requirements stipulated herein. Guidance on the selection of the radiation source may be found in Guide ~~E-1000~~E1000 and Practice ~~E-1255~~E1255.

4.2 *Manipulation System*—Selection of the appropriate manipulation system (where applicable) is dependent upon variables such as the size and orientation of the object being examined and the range of motions, speed of manipulation, and smoothness of motion. The suitability of the manipulation system shall be demonstrated by attainment of the required image quality and compliance with all other requirements stipulated herein. Guidance on the selection of the manipulation system may be found in Practice ~~E-1255~~E1255.

4.3 *Imaging System*—Selection of the appropriate imaging system is dependent upon variables such as the size of the object being examined and the energy and intensity of the radiation used for the examination. The suitability of the imaging system shall be demonstrated by attainment of the required image quality and compliance with all other requirements stipulated herein. Guidance on the selection of an imaging system may be found in Guide ~~E-1000~~E1000 and Practice ~~E-1255~~E1255.

4.4 *Image Processing System*—Where agreed between purchaser and supplier, image processing systems may be used for noise reduction through image integration or averaging, contrast enhancement and other image processing operations.

4.5 *Collimation*—Selection of appropriate collimation is dependent upon the geometry of the object being examined. It is generally useful to select collimation to limit the primary radiation beam to the weld and the immediately adjacent base material in order to improve radioscopic image quality.

4.6 *Filters and Masking*—Filters and masking may be used to improve image quality from contrast reductions caused by low-energy scattered radiation. Guidance on the use of filters and masking can be found in Guide ~~E-94~~E94.

4.7 *Image Quality Indicators (IQI)*—Unless otherwise specified by the applicable job order or contract, image quality indicators shall comply with the design and identification requirements specified in Practices ~~E-747 or E-1025~~E747, E1025, E1647, or E1742.

4.8 *Shims, Separate Blocks, or Like Sections*—Shims, separate blocks, or like sections made of the same or radioscopically similar materials (as defined in Practice ~~E-1025~~E1025) may be used to facilitate image quality indicator positioning as described in 9.10.3. The like section should be geometrically similar to the object being examined.

4.9 *Location and Identification Markers*—Lead numbers and letters should be used to designate the part number and location number. The size and thickness of the markers shall depend on the ability of the radioscopic technique to discern the markers on the images. As a general rule, markers from 0.06 to 0.12 in. ~~{1.5 to 3 mm}~~(1.5 to 3 mm) thick will suffice for most low energy (less than 1 MeV) X-ray and iridium¹⁹² radioscopy. For higher energy (greater than 1 MeV and cobalt⁶⁰) radioscopy, it may be necessary to use markers that are thicker (0.12 in. ~~{3 mm}~~(3 mm) thick or more). In cases where the system being used provides a display of object position within the image, this shall be acceptable as identification of object location.

5. Materials

5.1 *Recording Media*—Recording media for storage of images shall be in a format agreed by the purchaser and supplier. This may include either analog or digital media.

6. Basis of Application

6.1 *Personnel Qualification*—NDT personnel shall be qualified in accordance with a nationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT-CP-189, SNT-TC-1A, NAS 410, or a similar document. The practice or standard used and its applicable revision shall be specified in the contractual agreement between the using parties.

6.2 *Qualification of Nondestructive Testing Agencies*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in Practice ~~E-543~~E543. The applicable edition of Practice ~~E-543~~E543 shall be specified in the contractual agreement.

6.3 *Time of Examination*—The time of examination shall be in accordance with 9.1 unless otherwise specified.

6.4 *Procedures and Techniques*—The procedures and techniques to be utilized shall be as described in this test method unless otherwise specified. Specific techniques may be specified in the contractual agreement.

6.5 *Extent of Examination*—The extent of examination shall be in accordance with 8.3 unless otherwise specified.

⁴ Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.

⁴ Available from Aerospace Industries Association of America, Inc. (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3928, <http://www.aia-aerospace.org>.

6.6 *Reporting Criteria/Acceptance Criteria*—Reporting criteria for the examination results shall be in accordance with Section 10 unless otherwise specified. Acceptance criteria shall be specified in the contractual agreement.

6.7 *Reexamination of Repaired/Reworked Items*—Reexamination of repaired/reworked items is not addressed in this test method and if required shall be specified in the contractual agreement.

7. Safety

7.1 Radioscopic procedures shall comply with applicable city, state, and federal safety regulations.

8. Requirements

8.1 *Procedure Requirement*—Unless otherwise specified by the applicable job order or contract, radioscopic examination shall be performed in accordance with a written procedure. Specific requirements regarding the preparation and approval of the written procedures shall be as agreed by purchaser and supplier. The production procedure shall address all applicable portions of this test method and shall be available for review during interpretation of the images. The written procedure shall include the following:

8.1.1 Material and thickness range to be examined,

8.1.2 Equipment to be used, including specifications of source parameters (such as tube voltage, current, focal spot size) and imaging equipment parameters (such as detector size, field of view, electronic magnification, camera black level, gain, look-up table (LUT)),

8.1.3 Examination geometry, including source-to-object distance, object-to-detector distance and orientation,

8.1.4 Image quality indicator designation and placement,

8.1.5 Test-object scan plan, indicating the range of motions and manipulation speeds through which the test object shall be manipulated in order to ensure satisfactory results (see description in 5.2.1.2 of Practice ~~E-1255~~E1255),

8.1.6 Image-processing parameters,

8.1.7 Image-display parameters, and

8.1.8 Image storage.

8.2 *Radioscopic Coverage*—Unless otherwise specified by purchaser and supplier agreement, the extent of radioscopic coverage shall include 100 % of the volume of the weld and the adjacent base metal.

8.3 *Examination Speed*—For dynamic examination, the speed of object motion relative to the radiation source and detector shall be controlled to ensure that the required radioscopic quality level is achieved.

8.4 *Radioscopic Image Quality*—All images shall be free of marks or other blemishes that could mask or be confused with the image of any discontinuity in the area of interest. It may be possible to prevent blemishes from masking discontinuities or being confused with discontinuities by moving the object being examined relative to the imaging device. If any doubt exists as to the true nature of an indication exhibited in the image, the image shall be rejected and a new image of the area shall be made.

8.5 *Radioscopic Quality Level*—Radioscopic quality level shall be determined upon agreement between the purchaser and supplier and shall be specified in the applicable job order or contract. Radioscopic quality shall be specified in terms of equivalent penetrameter (IQI) sensitivity and shall be measured using image quality indicators conforming to Practices ~~E-747 or E-1025~~E747, E1025, or E1742.

8.6 *Acceptance Level*—Accept and reject levels shall be stipulated by the applicable contract, job order, drawing, or other purchaser and supplier agreement.

8.7 *Image-Viewing Facilities*—Viewing facilities shall provide subdued background lighting of an intensity that will not cause troublesome reflection, shadows, or glare on the image.

8.8 *Storage of Images*—When storage is required by the applicable job order or contract, the images should be stored in a format stipulated by the applicable contract, job order, drawing, or other purchaser and supplier agreement. The image-storage duration and location shall be as agreed between purchaser and supplier (see Guides E1453 and E1475).

9. Procedure

9.1 *Time of Examination*—Unless otherwise specified by the applicable job order or contract, perform radioscopy prior to heat treatment.

9.2 *Surface Preparation*—Unless otherwise agreed upon, remove the weld bead ripple or weld-surface irregularities on both the inside and outside (where accessible) by any suitable process so that the image of the irregularities cannot mask, or be confused with, the image of any discontinuity. Interpretation can be optimized if surface irregularities are removed such that the image of the irregularities is not discernible.

9.3 *Source to Detector Distance*—Unless otherwise specified in the applicable job order or contract, geometric unsharpness (U_g) shall not exceed the following:

Material Thickness	U_g , max, in. (mm)
Material Thickness	U_g , max, in. (mm)
under 2 in. (50 mm)	0.020 (0.50)
under 2 in. (50 mm)	0.020 (0.50)
2 through 3 in. (50 through 75 mm)	0.030 (0.75)
2 through 3 in. (50 through 75 mm)	0.030 (0.75)