



Designation: **E1416—16a E1416 – 23**

## Standard Practice for Radioscopic Examination of Weldments<sup>1</sup>

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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

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

1.2 This practice applies only to the use of equipment for radioscopic examination in which the image is finally presented on a 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 practice can be used for the detection of discontinuities. This practice 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 practice 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 Units—The values stated in inch-pound units are to be regarded as the standard. The SI units given in 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, safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use. Specific precautionary statements are given in Section 7.*

1.7 *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:<sup>2</sup>

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

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

<sup>1</sup> This practice 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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<sup>2</sup> 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.

- 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 Radiography
- E1032 Practice for Radiographic Examination of Weldments Using Industrial X-Ray Film
- E1255 Practice for Radioscopy
- E1316 Terminology for Nondestructive Examinations
- E1411 Practice for Qualification of Radioscopic Systems
- 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
- E2002 Practice for Determining Image Unsharpness and Basic Spatial Resolution in Radiography and Radioscopy
- E2033 Practice for Radiographic Examination Using Computed Radiography (Photostimulable Luminescence Method)
- E2698 Practice for Radiographic Examination Using Digital Detector Arrays
- ~~2.2 ASNT Standards:<sup>3</sup>~~
- ~~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~~
- ~~2.3 National Aerospace Standard:<sup>4</sup>~~
- ~~NAS 410 Certification and Qualification of Nondestructive Test Personnel~~
- ~~2.2 Other Standards: Standard:~~
- ~~ISO 9712 Non-Destructive Testing—Qualification and Certification of NDT Personnel<sup>53</sup>~~
- ~~SMPTE RP 133 Specifications for Medical Diagnostic Imaging Test Pattern for Television Monitors and Hard-Copy Recording Cameras~~

### 3. Terminology

#### 3.1 Definitions:

3.1.1 Definitions of terms applicable to this practice may be found in Terminology **E1316**.

### 4. Apparatus

4.1 Success of the radioscopy process depends on the overall system configuration and the selection of appropriate subsystem components. Guidance on the selection of sub-system components and the overall system configuration is provided in Guide **E1000** and Practice **E1255**. Guidance on the initial qualification and periodic re-qualification of the radioscopy system is provided in Practice **E1411**. The suitability of the radioscopy system shall be demonstrated by attainment of the required image quality and compliance with all other requirements stipulated herein; unless otherwise specified by the cognizant engineering organization, the default image quality level shall be 2-2T.

4.2 *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 **E1000** and Practice **E1255**.

4.3 *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 **E1255**.

4.4 *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

<sup>3</sup> Available from The American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlington Ln., Columbus, OH 43228-0518; Society of Motion Picture and Television Engineers (SMPTE), [www.smpte.org](http://www.smpte.org).

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

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 [E1000](#) and Practice [E1255](#).

4.5 *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.

4.6 *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.

4.7 *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 [E94](#).

4.8 *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 [E747](#), [E1025](#), [E1647](#), [E1742](#), or [E2002](#).

4.9 *Shims, Separate Blocks, or Like Sections*—Shims, separate blocks, or like sections made of the same or radioscopically similar materials (as defined in Practice [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.

4.10 *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) thick will suffice for most low energy (less than 1 MeV) X-ray and iridium<sup>192</sup> radioscopy. For higher energy (greater than 1 MeV and cobalt<sup>60</sup>) radioscopy, it may be necessary to use markers that are thicker (0.12 in. (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. In case of digital storage of the images, digital markers and annotations in the image may be used if they are stored permanently with the image.

## 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.

<https://standards.iteh.ai/catalog/standards/sist/a2150fff-b9f8-45b4-b26e-c3e89fc6b122/astm-e1416-23>

## 6. Basis of Application

6.1 The following items are subject to contractual agreement between the parties using or referencing this practice.

6.2 ~~*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, ISO 9712, or a similar document. The practice or standard used and its applicable revision shall be specified in the contractual agreement between the using parties.~~  
*Personnel Qualification:*

6.2.1 If specified in the contractual agreement, personnel performing examinations to this practice shall be qualified 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.

6.3 *Qualification of Nondestructive Testing Agencies*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in Practice Specification [E543](#). The applicable edition of Practice Specification [E543](#) shall be specified in the contractual agreement.

6.4 *Performance Measurement*—~~Radioscopic examination system performance parameters must be determined initially and monitored regularly to ensure consistent results. The best measure of total radioscopic examination system performance can be made with the system in operation, using a test object similar to the test part under actual operating conditions. This indicates the use of an actual or simulated test object or calibration block containing actual or simulated features that must be detected reliably.~~

Such a calibration block will provide a reliable indication of the radioscopic examination system's capabilities. Conventional wire or plaque-type image quality indicators (IQIs) may be used in place of, or in addition to, the simulated test object or calibration block. Performance measurement methods are subject to agreement between the purchaser and the supplier of radioscopic examination services; if no special agreements are done the performance shall be measured in accordance with The radioscopic system shall be qualified according to 6.3.2, 6.3.3, 6.3.4 or combinations thereof, or Practice E1411 or Appendix X1 of E1255.

**6.3.1 Performance Measurement Intervals**—System performance measurement techniques should be standardized so that performance measurement tests may be duplicated readily at specified intervals. Radioscopic examination performance should be evaluated at sufficiently frequent intervals, as may be agreed upon between the purchaser and the supplier of radioscopic examination services, in order to minimize the possibility of time-dependent performance variations.

**6.4.1 Measurement with IQIs**—System performance measurements using IQIs shall be in accordance with accepted industry standards describing the use of IQIs. The IQIs should be placed on the radiation source side of the test object, as close as possible to the region of interest. Performance measurement intervals shall be according to Practice E1411 of interest. The use of wire IQIs should also take into account the fact that the radioscopic examination may exhibit asymmetrical sensitivity, in which case the wire diameter axis shall be oriented along the system's axis of least sensitivity. Selection of IQI thickness should be consistent with the test part radiation path length, unless otherwise specified.

**6.3.3 Measurement With a Calibration Block**—The calibration block may be an actual test part with known features that are representative of the range of features to be detected, or it may be fabricated to simulate the test object with a suitable range of representative features. Alternatively, the calibration block may be a one-of-a-kind or few-of-a-kind reference test object containing known imperfections that have been verified independently. Calibration blocks containing known, natural defects are useful on a single-task basis, but they are not universally applicable. A duplicate manufactured calibration block should be used where standardization among two or more radioscopic examination systems is required. The calibration blocks should approximate the test object as closely as is practical, being made of the same material with similar dimensions and features in the radioscopic examination region of interest. Manufactured calibration blocks shall include features at least as small as those that must be detected reliably in the actual test object in locations where they are expected to occur. It is permissible to produce the calibration block in sections where features are internal to the test object. Calibration block details are a matter of agreement between the purchaser and the supplier of radioscopic examination services.

**6.3.3.1 Use of a Calibration Block**—The calibration block shall be placed in the radioscopic examination system in the same position as the actual test object. The calibration block may be manipulated through the same range of motions as are available for the actual test object so as to maximize the radioscopic examination system's response to the simulated imperfections.

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**6.3.3.2 Radioscopic Examination Techniques**—Techniques used for the calibration block shall be identical to those used for actual examination of the test part. Technique parameters shall be listed and include, as a minimum, radiation beam energy, intensity, focal spot size, enlargement, digital image processing parameters, manipulation scan plan, and scanning speed.

**6.3.4 Use of Calibrated Line Pair Test Pattern and Step Wedge**—A calibrated line pair test pattern and step wedge may be used, if desired, to determine and track the radioscopic system performance in terms of unsharpness and contrast sensitivity. The line pair test pattern is used without an additional absorber to evaluate system unsharpness (see Practices E1411 and E2002). The step wedge is used to evaluate system contrast sensitivity (see Practice E1647).

**6.3.4.1** The step wedge must be made of the same material as the test part, with steps representing 100, 99, 98, 97, and 96 % of both the thickest and thinnest material sections to be examined. The thinner steps shall be adjacent to the 100 % thickness in order to facilitate discerning the minimum visible thickness step. Other thickness steps are permissible upon agreement between the purchaser and the supplier of radioscopic examination services.

**6.3.4.2** The line pair test pattern and step wedge tests shall be conducted in a manner similar to the performance measurements for the IQI or calibration block. It is permissible to adjust the X-ray energy and intensity to obtain a usable line pair test pattern image brightness. In the case of a radioisotope or X-ray generating system in which the energy or intensity cannot be adjusted, additional filtration may be added to reduce the brightness to a useful level. Contrast sensitivity shall be evaluated at the same energy and intensity levels as are used for the radioscopic technique.

**6.3.4.3** A system that exhibits a thin section contrast sensitivity of 3 %, a thick section contrast sensitivity of 2 %, and an unsharpness of 3 line pairs/mm may be said to have a quality level of 3 % – 2 % – 3 lp/mm. A conversion table from duplex wire read-out to lp/mm can be found in Practices E1411 or E1255.

6.3.4.4 The line pair test pattern and step wedge may be used to make more frequent periodic system performance checks than are required in 6.3.1. Resolution and contrast sensitivity checks must be correlated with IQI or calibration block performance measurements. This may be accomplished by first evaluating the system performance in accordance with 6.3.2 or 6.3.3 and immediately thereafter determining the equivalent unsharpness and contrast sensitivity values.

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

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

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

6.8 *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.

6.9 *Reexamination of Repaired/Reworked Items*—Reexamination of repaired/reworked items is not addressed in this practice 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 practice 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), type of display monitor),

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 6.2.1.2 of Practice E1255),

8.1.6 Image-processing parameters,

8.1.7 Image-display parameters,

8.1.8 Image storage, and

8.1.9 Plan for system qualification and periodic requalification as described in Practices Practice E1255 and E1411.

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.