Designation: ~~E1734 – 16a~~ E1734 – 23

Standard Practice for Radioscopic Examination of Castings[1]

This standard is issued under the fixed designation E1734; 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 practice covers a uniform procedure for radioscopic examination of castings. Radioscopic examination of weldments can be found in E1416.

1.2 This practice applies only to radioscopic examination in which an image is finally presented on a display screen (monitor) for evaluation. Test part acceptance may be based on a static or dynamic image. The examination results may be recorded for later review. This practice does not apply to fully automated systems in which evaluation is performed automatically by a computer.

1.3 Due to the many complex geometries and part configurations inherent with castings, it is necessary to recognize the potential limitations associated with obtaining complete radioscopic coverage. Consideration shall be given to areas where geometry or part configuration does not allow for complete radioscopic coverage.

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

1.5 *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.*

1.6 *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

E543 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 Radiography

[1] 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.

Current edition approved ~~Dec. 1, 2016~~June 1, 2023. Published ~~December 2016~~June 2023. Originally approved in 1995. Last previous edition approved in 2016 as ~~E1734~~E1734 – 16a.~~–16.~~ DOI: ~~10.1520/E1734-16A.~~10.1520/E1734-23.

[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.

E1165 Test Method for Measurement of Focal Spots of Industrial X-Ray Tubes by Pinhole Imaging
E1255 Practice for Radioscopy
E1316 Terminology for Nondestructive Examinations
E1411 Practice for Qualification of Radioscopic Systems
E1416 Practice for Radioscopic Examination of Weldments
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~~
E2339 Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE)
E2903 Test Method for Measurement of the Effective Focal Spot Size of Mini and Micro Focus X-ray Tubes
~~2.2 *ASNT Standards:*~~[3]
~~ASNT SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing~~
~~ANSI/ASNT CP-189 Personnel Qualification and Certification in Nondestructive Testing~~
~~2.3 *National Aerospace Standard:*~~
~~NAS-410 NAS Certification and Qualification of Nondestructive Personnel (Quality Assurance Committee)~~[4]
~~2.4 *Other Standards:*.~~
~~ISO 9712 Non-Destructive Testing—Qualification and Certification of NDT Personnel~~[5]

3. Terminology

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

4. Significance and Use

4.1 The requirements in this practice are intended to control the quality of the radioscopic images to produce satisfactory and consistent results. This practice is not intended for controlling the acceptability of the casting. The radioscopic method may be used for detecting volumetric discontinuities and density variations that are within the sensitivity range of this practice. The dynamic aspects of radioscopy are useful for maximizing defect response.

5. Basis of Application

5.1 The following items shall be agreed upon between the purchaser and the supplier:

5.1.1 *Nondestructive Testing Agency Evaluation*—If specified in the contractual agreement, nondestructive testing (NDT) agencies shall be qualified and evaluated as described in Practice E543. The applicable edition of Practice E543 shall be specified in the contractual agreement.

5.1.2 *Personnel Qualification*—If specified in the contractual agreement, personnel performing examinations to this standard shall be qualified in accordance with a nationally or internationally recognized NDT personnel qualification practice or standard ~~such as ANSI/ANST-CP-189, SNT-TC-1A, NAS-410, ISO 9712, or similar document~~ 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.

5.1.3 *Recording Media*—If required, the recording media to be used shall be specified in accordance with the requirements of Section 6.

5.1.4 *Performance Measurements*—Performance measurement shall be specified in accordance with the requirements of Section 7.

5.1.5 *Procedure*—Procedural requirements shall be specified in the contractual agreement.

5.1.6 *Records*—Records shall be specified in the contractual agreement.

6. Apparatus

6.1 Success of the radioscopic 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. Initial qualification and periodic re-qualification of the radioscopic system is required (see Section 7). The suitability of the radioscopic system shall be demonstrated by attainment of the required image quality and compliance with all other requirements stipulated herein.

6.2 *Equipment:*

6.2.1 *Radiation Source (X-Ray or Gamma-Ray)*—Selection of the appropriate source is dependent on variables regarding the casting being examined, such as material composition and thickness. Guidance on selection of the radiation source may be found in Practice E1255 or Guides E94 and E1000.

6.2.2 *Manipulation Subsystem*—Selection of the appropriate manipulation system (where applicable) is dependent on variables such as the size and orientation of the object being examined and the range of motions, speed of travel, and smoothness of motion. Guidance on selection of the manipulation subsystem may be found in Practice E1255.

6.2.3 *Detector Subsystem*—Selection of the appropriate detection system is dependent on variables such as the material and size of the object being examined and the energy and intensity of the radiation used for the examination. Guidance on selection of the detector subsystem may be found in Guide E1000 or Practice E1255.

6.2.4 *Image Processing Subsystem*—Where agreed upon between the purchaser and the supplier, image processing systems may be used for noise reduction through image integration or averaging, contrast enhancement, and other image processing operations. Users of digital image processing are cautioned to test image processing parameters thoroughly before use. For example, some spatial filter functions produce directional results and may suppress desired image information. Other spatial filters can introduce artifacts into the image.

6.2.5 *Image Display Subsystem*—Selection of the appropriate image display is critical to the transfer of image information from the radioscopic system to the person making the accept-reject decision. The image display should be suitably sized and placed in a controlled environment with subdued lighting to maximize the transfer of image information to the radioscopic system operator.

6.2.6 *Collimation*—Selection of appropriate collimation is dependent on the geometry of the object being examined. It is generally useful to select collimation to limit the primary radiation beam to the detector area or region of interest, whichever is smaller, thereby limiting scatter radiation in order to improve radioscopic image quality.

6.2.7 *Filters and Masking*—Filters and masking may be used to improve image quality by alleviating contrast reductions caused by low-energy scattered radiation. Guidance on the use of filters and masking is provided in Guide E94.

6.3 *Location and Identification Markers*—Lead numbers and letters may be used to designate the part number and location number, as needed, provided they do not mask regions of interest on the casting. On-part identification is not required where the manipulator is programmable or manipulator coordinates are provided as a means of ensuring that all regions of interest are covered. A video typewriter or similar device may be used to display location and identification information electronically. When identification is not provided on the part, the method of identification shall be documented in the records in accordance with Section 11.

6.4 Areas that are considered impractical or very difficult to view (see 9.2), shall be marked in the Radioscopic Shooting Sketch.

6.5 *Recording Media*—Recording media for storage of analog or digital images shall be agreed upon between the purchaser and the supplier. Guidance on selection and usage of recording media may be found in Practice E1255.

7. System- and Product-Specific Qualification

7.1 *System 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. Radioscopic quality shall be specified in terms of equivalent penetrameter (IQI) sensitivity and shall be measured using image quality indicators conforming to Practices~~ The Radioscopic ~~E747, E1025, E1647, or E1742. In addition,~~

~~if system unsharpness measurement is required, the Practice~~ system ~~E2002 duplex wire gauge shall be used. 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~~ shall be qualified according to ~~7.2.1, 7.2.2, 7.2.3, or combinations thereof,~~ Practice E1411 ~~or Appendix X1 of Practice E1255~~.

7.1.1 ~~*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~~Performance Measurement Intervals shall be according to Practice E1411 ~~possibility of time-dependent performance variations.~~unless otherwise specified.

~~7.2 *Product-Specific Qualification*—System performance should be measured for production.~~

~~7.2.1 *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. 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.~~

~~7.2.2 *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.~~

~~7.2.2.1 *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.~~

~~7.2.2.2 *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.~~

~~7.2.3 *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).~~

~~7.2.3.1 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.~~

~~7.2.3.2 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.~~

~~7.2.3.3 A system that exhibits a thin section contrast sensitivity of 3 %, a thick section contrast sensitivity of 2 %, and a 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 Practice E2002.~~

~~7.2.3.4 The line pair test pattern and step wedge may be used to make more frequent periodic system performance checks than are required in 7.1.1. 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 7.2.1 or 7.2.2 and immediately thereafter determining the equivalent unsharpness and contrast sensitivity values.~~

8. Safety

8.1 Radioscopic procedures shall comply with applicable local, state, and federal safety regulations.

9. Requirements

9.1 *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:

9.1.1 Material and thickness range to be examined,

9.1.2 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)),

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

9.1.4 Image quality indicator designation and placement,

9.1.5 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~~ results,~~E1255~~),

9.1.6 Image-processing parameters,

9.1.7 Image-display parameters,

9.1.8 Image storage, and

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

9.2 *Radioscopic Coverage*—Unless otherwise specified by purchaser and supplier agreement, the extent of radioscopic coverage shall include 100 % of the volume of the casting (see paragraph 6.4). In this case a radioscopic shooting sketch (RSS) in accordance with Appendix X1 shall be required.

9.3 *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.

9.4 *Radioscopic Image Artifacts*—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.

9.5 *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. If no quality level is defined, an equivalent penetrameter sensitivity (EPS) of 2% or 2-2T shall be the standard. Radioscopic spatial resolution shall be determined upon agreement between the purchaser and supplier and shall be specified in the applicable job order or contract.

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

9.7 *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. The image display performance, size, and placement are important radioscopic system considerations. A test pattern similar to SMPTE RP133 shall be used to qualify the display.

9.8 *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 and Practice E2339).

9.9 *Initial Qualification*—An initial qualification of the radioscopic system shall be performed in accordance with paragraph 7.1. The periodic re-qualification shall be performed in accordance with paragraph 7.1.1. The suitability of the radioscopic system shall be demonstrated by attainment of the required image quality and compliance with all other requirements stipulated herein.

10. Procedure Considerations

10.1 *Time of Examination*—Radioscopy may be performed in the as-cast, intermediate, or final machined condition, as may be specified by the applicable job order or contract.

10.2 Material and thickness range to be examined.

10.3 *Surface Preparation*—While no surface preparation is required for radioscopy, the removal of flash, surface blemishes, and debris that could adversely affect the radioscopic image is recommended.

10.4 *Examination Speed*—For dynamic examination, the speed of the test object relative to the radiation source and detector shall be subject to agreement between the purchaser and the supplier. Base this determination on the achievement of the required radioscopic quality level at that examination speed.

10.5 *Direction of Radiation*—The direction of radiation shall be governed by the geometry of the casting, coverage, and quality requirements stipulated by the applicable job order or contract. Practically, place the central beam of the radiation perpendicular to and centered on the surface of the detector.

10.6 *Scattered Radiation*—Scattered radiation (radiation scattered from the test object and surrounding structures) reduces radioscopic contrast and may reduce radioscopic quality. Precautions such as collimation of the source, collimation of the detector, and additional shielding should be used, as appropriate.

10.7 *IQI Selection*—Where specified, IQI selection shall be based on the following: if the thickness to be inspected exceeds the design thickness of the finished piece, the IQI size shall be based on the thickness that does not exceed the design thickness of the finished piece by more than 20 % or ¼ in. (6.35 mm), whichever is greater. The IQIs should be of the same or similar material to that being examined. In no case shall the IQI size be based on a thickness greater than the thickness to be examined.

10.8 *Number of Image Quality Indicators:*

10.8.1 Where an IQI is required, at least one IQI (Practice E747, Practice E1025, or Practice E1742) shall be placed in the area of interest in which the brightness or signal level is relatively uniform.

10.8.2 When a series of radioscopic images is made under similar conditions of unsharpness, it is permissible for the IQIs to be used only on the first and last images in an inspection series subject to agreement between the purchaser and the supplier. Where the irregular shape or size of a casting makes meaningful IQI placement difficult, the qualifying images may be of the IQIs on mounting blocks, simulating the thinnest and thickest sections of the casting that must be imaged.

10.8.3 Qualifying images shall be retained as part of the radioscopic examination record in order to validate the required IQI sensitivity and placement.

10.9 *IQI Placement:*

10.9.1 Wherever possible, placement of the IQI shall be on the source side of the casting or mounting block.

10.9.2 *Detector Side IQIs*—In those cases in which the physical placement of the image quality indicators on the source side is not possible, the IQIs may be placed on the detector side of the casting, along with a lead letter "D." The applicable job order or contract shall specify the applicable detector-side quality level. The accompanying documents shall indicate clearly that the IQIs were located on the detector side.

10.9.3 When Practice E1025 IQIs are used on mounting blocks, the mounting block length and width dimensions shall exceed the IQI length and width dimensions by at least 0.12 in. (3 mm) on at least three sides. At least three edges of the IQI shall be visible in the radioscopic image.

10.9.4 *Image Identification*—A system of positive identification of the radioscopic image shall be provided. As a minimum, the following shall appear along with the radioscopic image: the name or symbol of the company performing radioscopy, date, and casting identification number traceable to part and contract. Reshots and different views of the same test part area shall be identified uniquely. Subsequent images made of a repaired area shall be identified using "R-1," "R-2," and so forth. For digitally stored images, the identification of the image shall be in the filename or tags associated with the file (see Guide E1475).

10.10 *Radioscopic Techniques:*

10.10.1 *Single-Wall Technique*—A technique in which the radiation passes through only one casting wall to form the radioscopic image.

10.10.2 *Double-Wall Technique*—A technique in which the radiation passes through both casting walls to form the radioscopic image.

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

10.12 *Radioscopic Image Quality*—All images shall be free of artifacts that could mask or be confused with the image of any discontinuity in the area of interest. It may be possible to prevent artifacts from masking discontinuities or being confused with discontinuities by moving the object being examined relative to the direction of radiation. If any doubt exists concerning 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.

10.13 *Image Viewing Facilities*—Viewing facilities shall provide subdued background lighting with an intensity that will not cause troublesome reflection, shadows, or glare on the image. The image-viewing environment should be conducive to operator concentration, thereby improving the quality of the accept-reject decision.

10.14 *Storage of Images*—When storage is required by the applicable job order or contract, the images shall be stored in a format stipulated by the applicable contract, job order, drawing, or other purchaser and supplier agreement. Guide E1453 should be consulted for radioscopic data media storage precautions. Guide E1475 should be consulted if stored radioscopic data is to be shared with dissimilar radioscopic storage, retrieval, display, and hard copy systems. Image-storage duration and location shall be subject to agreement between the purchaser and the supplier.

11. Records

11.1 Records shall be maintained for a specified period of time. As a minimum, the following records shall be maintained as subject to agreement between the purchaser and the supplier:

11.1.1 Radioscopic shooting sketch (RSS), including examination geometry, source-to-object distance, object-to-detector distance, and orientation;

11.1.2 Material and thickness range examined;

11.1.3 Radioscopic system qualification details, as specified in Practice E1411;

11.1.4 Qualifying images;