



Standard Practice for Radiographic Examination of Advanced Aero and Turbine Materials and Components¹

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1. Scope

1.1 This practice establishes the minimum requirements for radiographic examination of metallic and nonmetallic materials and components used in designated applications such as gas turbine engines and flight structures.

1.2 The requirements in this practice are intended to control the radiographic process to ensure the quality of radiographic images produced for use in designated applications such as gas turbine engines and flight structures; this practice is not intended to establish acceptance criteria for material or components. When examination is performed in accordance with this practice, engineering drawings, specifications or other applicable documents shall indicate the acceptance criteria.

1.3 All areas of this practice may be open to agreement between the cognizant engineering organization and the supplier, or specific direction from the cognizant engineering organization.

1.4 *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.*

2. Referenced Documents

2.1 ASTM Standards:²

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

E999 Guide for Controlling the Quality of Industrial Radiographic Film Processing

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

E1030 Test Method for Radiographic Examination of Metallic Castings

E1032 Test Method for Radiographic Examination of Weldments

E1079 Practice for Calibration of Transmission Densitometers

E1165 Test Method for Measurement of Focal Spots of Industrial X-Ray Tubes by Pinhole Imaging

E1254 Guide for Storage of Radiographs and Unexposed Industrial Radiographic Films

E1390 Specification for Illuminators Used for Viewing Industrial Radiographs

E1316 Terminology for Nondestructive Examinations

E1815 Test Method for Classification of Film Systems for Industrial Radiography

E1817 Practice for Controlling Quality of Radiological Examination by Using Representative Quality Indicators (RQIs)

E2033 Practice for Computed Radiology (Photostimulable Luminescence Method)

E2698 Practice for Radiological Examination Using Digital Detector Arrays

2.2 AWS Documents:³

ANSI/AWS A2.4 Symbols for Welding and Nondestructive Testing

2.3 AIA Documents:⁴

NAS-410 Certification and Qualification of Nondestructive Test Personnel

2.4 NCRP Documents:⁵

NCRP 51 Radiation Protection Design Guidelines for 0.1-100 MeV Particle Accelerator Facilities

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.

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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 American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126, <http://www.aws.org>.

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

⁵ Available from National Council on Radiation Protection and Measurements (NCRP), NCRP Publications, 7910 Woodmount Ave., Suite 800, Bethesda, MD 20814.

NCRP 91 Recommendations on Limits for Exposures to Ionizing Radiation

2.5 Other Government Documents:

NIST Handbook 114 General Safety Standard for Installations Using Non-Medical X-ray and Sealed Gamma-ray Sources, Energies up to 10 MeV⁶

NOTE 1—DoD Contracts: Unless otherwise specified, the issues of the documents that are DoD adopted are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) cited in the solicitation.

NOTE 2—Order of Precedence: Contractual requirements and specific direction from the cognizant engineering organization shall take precedence over the requirements in this practice. In the event of conflict between the text of this practice and the references cited herein, the text of this practice shall take precedence. However, nothing in this practice shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. Terminology

3.1 *Definitions*—Definitions relating to radiographic examination which appear in Terminology E1316 shall apply to the terms used in this practice.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *cognizant engineering organization*—the company, government agency or other authority responsible for the design, or end use, of the material or component for which radiographic examination is required. This, in addition to design personnel, may include personnel from engineering, material and process engineering, stress analysis, NDE, quality assurance and others, as appropriate.

3.2.2 *component*—the part(s) or element of the system assembled or processed to the extent specified by the drawing, purchase order or contract for which radiographic examination is required.

3.2.3 *film system*—the combination of a film and a processing system. A processing system is defined by the chemistry used and the specified developer immersion time and temperature.

3.2.4 *like section*—a separate section of material that is similar in shape and cross section to the component or part being radiographed, and is made of the same or radiographically similar material.

3.2.5 *material group*—materials that have the same predominant alloying elements and which can be examined using the same IQI. A listing of common material groups is given in Practices E747 and E1025.

3.2.6 *NDE facility*—the NDE agency performing the radiographic examination.

3.2.7 *radiographic quality level*—the ability of a radiographic procedure to demonstrate a specified IQI sensitivity (see Table 3).

3.2.8 *radiographic technique*—a procedure which details the exact radiographic setup to be used for each exposure to be made (see 7.1).

⁶ Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, http://www.nist.gov.

TABLE 1 Lead Screen Thickness^A

Energy Range/ Isotopes	Lead Thickness, in. (mm)	
	Front Screen (Maximum)	Back Screen ^{B,C} (Minimum)
0 – 100 keV	0.001 (0.025)	0.005 (0.127)
101 – 200 keV	0.005 (0.127)	0.005 (0.127)
201 – 320 keV	0.010 (0.254)	0.005 (0.127)
Se-75	0.010 (0.254)	0.005 (0.127)
321 – 450 keV	0.015 (0.381)	0.010 (0.254)
Ir-192	0.015 (0.381)	0.010 (0.254)
451 keV – 2 MeV	0.020 (0.508)	0.010 (0.254)
Co-60	0.020 (0.508)	0.010 (0.254)
>2 MeV	0.125 (3.175)	0.010 (0.254)

^A Pre-packed film, with or without lead screens, may be used provided radiographic quality level, contrast, density and back scatter requirements are met.

^B Back scatter radiation shall still be monitored per the requirements of 7.11.

^C A back screen is not required provided the back scatter requirements of 7.11 are met through the use of alternate measures.

TABLE 2 Maximum Allowable Unsharpness (U_g) for Directional Exposures

Material Thickness (t), in. (mm)	U _g , in. (mm)
t ≤ 0.5 (12.7)	0.008 (0.203)
0.5 (12.7) < t ≤ 1.0 (25.4)	0.010 (0.254)
1.0 (25.4) < t ≤ 2.0 (50.8)	0.020 (0.508)
2.0 (50.8) < t ≤ 4.0 (101.6)	0.030 (0.762)
4.0 (101.6) < t	0.040 (1.016)

TABLE 3 Quality Levels of Examination

Radiographic Quality Level	Maximum IQI Thickness, % ^A	Minimum Visible Hole Diameter ^B	Equivalent IQI Sensitivity, % ^C
1-1T	1	1T	0.7
1-2T	1	2T	1.0
2-1T	2	1T	1.4
2-2T	2	2T	2.0
2-4T	2	4T	2.8

^A Expressed as a percentage of material thickness.

^B Expressed as a multiple thickness of IQI.

^C Equivalent IQI sensitivity is that thickness of the IQI expressed as a percentage of the specimen thickness in which a 2T hole would be clearly visible under the same radiographic conditions.

4. Significance and Use

4.1 The requirements for radiographic examination in this practice are applicable to all types of metallic and nonmetallic material used in designated applications such as gas turbines and flight structures.

4.2 This practice establishes the basic parameters for the application and control of the radiographic process. This practice may be specified on an engineering drawing, specification or contract; however, it is not a detailed radiographic technique and must be supplemented. Section 7 and Test Methods E1030 and E1032 contain information to help develop detailed radiographic techniques.

5. Basis of Application

5.1 *Personnel Qualification*—Personnel performing examinations to this practice shall be qualified in accordance with NAS-410 and certified by the employer. Other qualification documents may be used when specified in the contract or purchase order. The applicable revision shall be the latest unless otherwise specified in the contractual agreement.

5.2 *Qualification of Nondestructive Examination Agencies*—NDE agencies shall be approved by the cognizant engineering organization. Specification E543 may be used to facilitate this approval.

5.3 *Timing of Examination*—The timing of examination shall be in accordance with 7.2 unless otherwise specified.

5.4 *Extent of Examination*—The extent of examination shall be in accordance with 7.3 or 7.18.2.2, as applicable, unless otherwise specified.

5.5 *Reporting Criteria/Acceptance Criteria*—Reporting criteria for the examination results shall be in accordance with 8.2 unless otherwise specified. Since acceptance criteria are not specified in this standard, they shall be specified in the engineering drawing, specification or contractual agreement.

5.6 *Reexamination of Repaired/Reworked Items*—Reexamination of repaired and reworked items shall be in accordance with 7.7.7 and 8.3, unless otherwise specified.

6. General Practice

6.1 Facilities:

6.1.1 *Safety*—The work environment and equipment shall be designed and utilized to ensure the safety of personnel and property. NCRP 51, NCRP 91 and NIST Handbook 114 may be used as guides to ensure that radiographic procedures are performed such that personnel do not receive a radiation dosage exceeding the maximum permitted by city, state, or national codes.

6.1.2 *Radiographic Exposure Areas*—Radiographic exposure areas shall be clean and equipped so that acceptable radiographs may be produced in accordance with the requirements of this practice.

6.1.3 *Darkroom*—Darkroom facilities, including equipment and materials, shall be clean and maintained in such a manner as to be capable of consistently producing radiographs free of blemishes or artifacts which might interfere with interpretation in the area of interest.

6.1.4 *Film Viewing Area*—Subdued lighting in the viewing room is preferred rather than total darkness. Background illumination lighting shall be arranged such that light reflections do not interfere with review of radiographs.

6.2 Equipment and Materials:

6.2.1 Radiation Sources:

6.2.1.1 *X-Radiation Sources*—X-ray sources that are used shall be capable of demonstrating the required radiographic quality level.

6.2.1.2 *Gamma Radiation Sources*—Isotope sources that are used shall be capable of demonstrating the required radiographic quality level.

6.2.2 *Film Systems*—Only film systems (see 3.2.3) having cognizant engineering organization approval or meeting the requirements of Test Method E1815 Class I, Class II, or special shall be used.

6.2.3 *Non-film Recording Media*—Analog and digital recording media or radiosopic devices may be used when approved by the cognizant engineering organization.

6.2.4 *Film Holders and Cassettes*—Film holders and cassettes shall be light tight, constructed of materials that do not

TABLE 4 Process Control Checks

Device or Condition	Calibration	Verification	Paragraph Ref.
Image Quality Indicators			6.3.5
Material	When Procured		
Dimensional	When Procured	Annually (3)	
Physical Condition		Prior to Each Use (2)	
Indication Measuring Devices	When Procured	Prior to Each Use (2)	6.2.10
Densitometers	Annually	Each Shift and (1)	6.2.8.1
Visible Light Meters (footlamberts or candelas)	Semi-annually		
Viewer Intensity	When Procured	Monthly and (1)	
Schedule 1		(1)	6.2.9.1
Schedule 2		daily (2)	6.2.9.1
Thermometers	Semi-annually		
Automatic Film Processors			6.2.6
Developer Temperature		Prior to Each Use (2)	
Processor Performance		Daily	
Base + Fog		Daily	
Replenishing Rate		(1)	
Developer Immersion Time		(1)	
Manual Film Processing			6.2.6
Developer Temperature		Prior to Each Use (2)	
Processing Performance		Daily	
Base + Fog		Daily	
Usage Log		Daily	
Replenishment Log		(1)	

(1) Immediately after preventative maintenance, repair and changes in configuration, bulb(s), or setup.

(2) Does not need to be documented.

(3) Annual Dimensional and Alloy Verifications of IQI's are not required when they are permanently attached to shims, blocks, or stepwedges, and/or encased in clear plastic or similar material, provided there is no physical evidence of damage.

interfere with the quality or sensitivity of the radiographs and shall be in appropriate working condition.

6.2.5 Intensifying Screens:

6.2.5.1 *Lead Foil Screens*—Intensifying screens of the lead foil type shall be used in accordance with 7.8. Screens shall have approximately the same area dimensions as the film used and shall be in intimate contact with the film during exposure. Screens shall be free from any cracks, creases, scratches or foreign material that could produce undesirable, nonrelevant images on the radiograph.

6.2.5.2 *Other Metallic Screens*—Other metallic screens may be used provided the specified radiographic quality level, density, and contrast are obtained and use is approved by the cognizant engineering organization.

6.2.5.3 *Fluorescent and Fluorometallic Screen/Film Combinations*—Fluorescent and fluorometallic screen/film combinations are not allowed unless approved by the cognizant engineering organization.

6.2.6 *Film Processors*—Film processors shall be capable of producing radiographs that meet the requirements of this practice and shall be maintained and used in accordance with manufacturers' recommendations. Film processing shall be controlled and monitored as recommended in Guide E999 and as scheduled in Table 4.