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Standard Practice for Radiographic Examination[1]

This standard is issued under the fixed designation E1742/E1742M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This practice[2] covers the minimum requirements for radiographic examination for metallic and nonmetallic materials.

1.2 *Applicability*—The criteria for the radiographic examination in this practice are applicable to all types of metallic and nonmetallic materials. When specified, it may be used for radiographic inspection of metallic or non-metallic materials, weldments, castings, and brazed materials. The requirements expressed in this practice are intended to control the quality of the radiographic images and are not intended to establish acceptance criteria for parts and materials.

1.3 *Basis of Application*—There are areas in this practice that may require 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.

1.3.1 DoD contracts.
1.3.2 Personnel qualification, 5.1.1.
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1.3.20 Acceptable parts, 6.28.1.

1.4 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

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, 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 The following documents form a part of this practice to the extent specified herein:

2.2 *ASTM Standards:*[3]

E94/E94M 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
E801 Practice for Controlling Quality of Radiographic Examination of Electronic Devices
E999 Guide for Controlling the Quality of Industrial Radiographic Film Processing

[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] This practice replaced MIL-STD-453.

[3] 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.

***A Summary of Changes section appears at the end of this standard**

E1025 Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiography
E1030/E1030M Practice for Radiographic Examination of Metallic Castings
E1032 Practice for Radiographic Examination of Weldments Using Industrial X-Ray Film
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
E1255 Practice for Radioscopy
E1316 Terminology for Nondestructive Examinations
E1390 Specification for Illuminators Used for Viewing Industrial Radiographs
E1416 Practice for Radioscopic Examination of Weldments
E1815 Test Method for Classification of Film Systems for Industrial Radiography
E2033 Practice for Radiographic Examination Using Computed Radiography (Photostimulable Luminescence Method)
E2698 Practice for Radiographic Examination Using Digital Detector Arrays

2.3 *AWS Document:*
AWS A2.4 Standard Symbols for Welding, Brazing, and Nondestructive Examination[4]

2.4 *NCRP Documents:*[5]
NCRP 116 Limitation of Exposure to Ionizing Radiation
NCRP 144 Radiation Protection for Particle Accelerator Facilities
NCRP 147 Structural Shielding Design for Medical X-ray Imaging Facilities

2.5 *ANSI/ISO Standards:*[6]
ANSI/NCSL Z540-3 Requirements for the Calibration of Measuring and Test Equipment
ISO 10012 Measurement Management Systems—Requirements for Measurement Processes and Measuring Equipment
ISO 5579 Non-Destructive Testing-Radiographic Examination of Metallic Materials by X-and Gamma-Rays-Basic Rules

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

NOTE 2—*Order of Precedence:* In the event of conflict between the text of this practice and the references cited herein, the text of this practice takes precedence. Nothing in this practice, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

[4] Available from American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126, http://www.aws.org.
[5] Available from National Council on Radiation Protection and Measurements, NCRP Publications, 7910 Woodmount Ave., Suite 800, Bethesda, MD 20814.
[6] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

3. Terminology

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

3.1.1 *Optical density* is the correct term for assessing the developed film obtained from a penetrating radiation film inspection. Historically, the terms *film* or *radiographic density*, or both, have been used to describe the measurements taken from viewing the images, but the current definition of *film density*, in Terminology E1316, is "the quantitative measure of diffuse optical light transmission (optical density, blackening) through a developed film." In addition, with the advent of digital radiography, these historical terms may cause confusion to those utilizing more than the film technique. For standards purposes, the correct term is *optical density* and has been replaced throughout this standard.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *component, n*—the part(s) or element of a system, assembled or processed to the extent specified by the drawing, purchase order, or contract.

3.2.2 *energy, n*—a property of radiation that determines its penetrating ability. In X-ray radiography, energy machine rating is determined by kilovolts (keV), million electronvolts (MeV). In gamma ray radiography, energy is a characteristic of the source used.

3.2.3 *like section, n*—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.

3.2.4 *material group, n*—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 Practice E1025.

3.2.5 *NDT facility, n*—the NDT facility performing the radiographic examination.

3.2.6 *radiographic quality level, n*—the ability of a radiographic procedure to demonstrate a certain IQI sensitivity.

4. Significance and Use

4.1 This practice establishes the basic parameters for the application and control of the radiographic method. This practice is written so it can be specified on the engineering drawing, specification, or contract. It is not a detailed how-to procedure to be used by the NDT facility and, therefore, must be supplemented by a detailed procedure (see 6.1). Practices E1030/E1030M, E1032, and E1416 contain information to help develop detailed technique/procedure requirements.

5. General Practice

5.1 *Qualification:*

5.1.1 *Personnel Qualification*—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 shall be identified in the contractual agreement between the using parties.

5.1.2 *Agency Evaluation*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated in accordance with Specification E543. The applicable revision of Specification E543 shall be specified in the contractual agreement.

5.2 *Laboratory Installations:*

5.2.1 *Safety*—The premises and equipment shall present no hazards to the safety of personnel or property. NCRP 147, NCRP 116, and NCRP 144 may be used as guides to ensure that radiographic procedures are performed so that personnel shall not receive a radiation dosage exceeding the maximum permitted by city, state, or national codes.

5.2.2 *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.

5.2.3 *Darkroom*—Darkroom facilities, including equipment and materials, shall be capable of producing uniform radiographs free of blemishes or artifacts, which might interfere with interpretation in the area of interest.

5.2.4 *Film Viewing Area*—The film viewing room or enclosure shall be an area with subdued lighting to preclude objectionable reflective glare from the surface of the radiograph under examination (see 6.27.6).

5.3 *Materials:*

5.3.1 *Film*—Film selection for production radiographs should be based on radiation source energy level, part thickness/configuration, and image quality. Only film systems having cognizant engineering organization approval or meeting the class requirements of Test Method E1815 shall be used.

5.3.1.1 *Nonfilm Recording Media*—Other recording media may be used when approved by the cognizant engineering organization.

5.3.2 *Film Processing Solutions*—Production radiographs shall be processed in solutions capable of consistently producing radiographs that meet the requirements of this practice. Solution control shall be in accordance with Annex A4. Guide E999 should be consulted for guidance on film processing.

5.4 *Equipment:*

5.4.1 *Radiation Sources:*

5.4.1.1 *X-Radiation Sources*—Selection of appropriate X-ray voltage and current levels is dependent upon variables regarding the specimen being examined (material type and thickness) and exposure time. The suitability of these exposure parameters shall be demonstrated by attainment of the required radiographic quality level and compliance with all other requirements stipulated herein.

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

5.4.2 *Film Holders and Cassettes*—Film holders and cassettes shall be light tight, constructed of materials that do not interfere with the quality or sensitivity of radiographs, and shall be handled properly to reduce damage. In the event that light leaks into the film holder and produces images on the radiograph, the radiograph need not be rejected unless the images obscure, or interfere with, the area of interest. If the film holder exhibits light leaks it shall be further repaired before use, or discarded. Film holders and cassettes should be routinely examined for cracks or other defects to minimize the likelihood of light leaks.

5.4.3 *Intensifying Screens:*

5.4.3.1 *Lead Foil Screens*—When using a source greater than 150 keV, intensifying screens of the lead foil type are recommended. Screens shall have the same area dimensions as the film being used and shall be in intimate contact with the film during exposure. Recommended screen thicknesses are listed in Table 1 for the applicable voltage range being used. Screens shall be free from any cracks, creases, scratches, or foreign material that could render undesirable nonrelevant images on the radiograph.

5.4.3.2 *Fluorescent, Fluorometallic, or Other Metallic Screens*—Fluorescent, fluorometallic, or other metallic screens may be used. However, they must be capable of demonstrating the required penetrameter (IQI) sensitivity. Fluorescent or fluorometallic screens may cause limitations in image quality (see Guide E94/E94M, Appendix X1).

5.4.4 *Film Viewers*—Viewers used for final interpretation shall meet the following requirements:

5.4.4.1 The viewer shall contain a variable control to allow the selection of optimum intensities for radiographs with varying optical densities.

5.4.4.2 The light source shall have sufficient intensity to enable viewing of optical densities in the area of interest (see 6.27.4).

TABLE 1 Lead Screen Thickness[A]

Energy Range/ Isotopes	Front Screen	Back Screen Minimum	Front and Back Screens[B]
	in.	in.	mm
0 keV – 150 keV[C]	0.000 to 0.001	0.005[D]	0–0.15
151 keV – 200 keV	0.000 to 0.005	0.005[D]	0.02–0.15
201 keV – 320 keV	0.001 to 0.010	0.005	0.02–0.2
Se-75	0.001 to 0.010	0.005	0.1–0.2
321 keV – 450 keV	0.005 to 0.015	0.01	0.1–0.2
Ir-192	0.005 to 0.015	0.01	0.02–0.2
451 keV – 2 MeV	0.005 to 0.020	0.01	0.1–0.5
Co-60	0.005 to 0.020	0.01	0.1–0.5
2 MeV – 4 MeV	0.010 to 0.020	0.01	0.1–0.5
4 MeV – 10 MeV	0.010 to 0.030	0.01	0.5–1.0
10 MeV – 25 MeV	0.010 to 0.050	0.01	1.0–2.0

[A] The lead screen thickness listed for the various energy ranges are recommended thicknesses and not required thicknesses. Other thicknesses and materials may be used provided the required radiographic quality level, contrast, and optical density are achieved.

[B] Lead screen thicknesses in accordance with EN 444 and ISO 5579 in SI units. For energy ranges of Co-60 and 451 keV to 4 MeV, steel or copper screens of 0.1 mm to 0.5 mm may be used. For energy ranges above 4 MeV to 10 MeV, 0.5 mm to 1.0 mm steel or copper or up to 0.5 mm tantalum screens are recommended. Additional back scatter shielding may be achieved by additional lead screens behind the cassettes.

[C] Prepackaged film with lead screens may be used from 80 keV to 150 keV. No lead screens are recommended below 80 keV. Prepackaged film may be used at higher energy levels provided the contrast, optical density, radiographic quality level, and backscatter requirements are achieved. Additional intermediate lead screens may be used for reduction of scattered radiation at higher energies.

[D] No back screen is required provided the backscatter requirements of 6.22 are met.