Designation: E 1742 – 00

Standard Practice for Radiographic Examination[1]

This standard is issued under the fixed designation E 1742; 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[2] establishes 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. 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.

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

2.2 *ASTM Standards:*

E 543 Practice for Agencies Performing Nondestructive Testing[3]
E 747 Practice for Design, Manufacture, and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology[3]
E 801 Practice for Controlling Quality of Radiological Examination of Electronic Devices[3]
E 999 Guide for Controlling the Quality of Industrial Radiographic Film Processing[3]
E 1025 Practice for Design, Manufacturer, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology[3]
E 1030 Test Method for Radiographic Examination of Metallic Castings[3]
E 1032 Test Method for Radiographic Examination of Weldments[3]
E 1079 Practice for Calibration of Transmission Densitometers[3]
E 1165 Test Method for Measurement of Focal Spots of Industrial X-Ray Tubes by Pinhole Imaging[3]
E 1254 Guide for Storage of Radiographs and Unexposed Industrial Radiographic Film[3]
E 1255 Practice for Radioscopy[3]
E 1316 Terminology for Nondestructive Examinations[3]
E 1390 Guide for Illuminators Used for Viewing Industrial Radiographs[3]
E 1411 Practice for Qualification of Radioscopic Systems[3]
E 1416 Test Method for Radioscopic Examination of Weldments[3]

[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] *Annual Book of ASTM Standards*, Vol 03.03.

E 1815 Test Method for Classification of Film Systems, for Industrial Radiography[3]

2.3 *AWS Document:*

AWS A2.4 Symbols for Welding and Nondestructive Testing[4]

2.4 *Aerospace Industries Association Document:*

NAS 410 Certification & Qualification of Nondestructive Test Personnel[5]

2.5 *ASNT Documents:*

SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing[6]

ANSI/ASNT-CP-189 ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel[6]

2.6 *NCRP Documents:*

NCRP 51 Radiation Protection Design Guidelines for 0.1–100 MeV Particle Accelerator Facilities[7]

NCRP 91 Recommendations on Limits for Exposures to Ionizing Radiation[7]

2.7 *ANSI Standards:*

ANSI IT 9.1 Imaging Media (Film)—Silver-Gelatin Type Specifications for Stability[8]

ANSI PH 4.8 Photography (Chemicals)—Residual Thiosulphate and Other Chemicals in Films, Plates, and Papers—Determination and Measurement[8]

2.8 *Government Standard:*

MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification (Eddy Current, Liquid Penetrant, Magnetic Particle, Radiographic and Ultrasonic)[9]

2.9 *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 MeV[10]

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.

3. Terminology

3.1 *Definitions*—Definitions relating to radiographic examination, which appear in Terminology E 1316, 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 system 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, NDT, or quality groups and others, as appropriate.

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

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

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 Practice E 1025.

3.2.6 *NDT facility*—the NDT facility performing the radiographic examination.

3.2.7 *radiographic quality level*—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). Test Methods E 1030, E 1032, and E 1416 contain information to help develop detailed technique/procedure requirements.

5. General Practice

5.1 *Qualification*:

5.1.1 *Personnel Qualification*—Personnel performing examinations in accordance with this practice shall be qualified in accordance with MIL-STD-410, NAS 410, ANSI/ASNT-CP-189, or SNT-TC-1A and certified by the employer or certifying agency as applicable. Other equivalent qualification documents may be used when specified in the contract or purchase order.

5.1.2 *Agency Evaluation*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated in accordance with Practice E 543. The applicable revision of Practice E 543 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 51, NCRP 91 and NIST Handbook 114 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

[4] Available from American Welding Society (AWS), P.O. Box 351040, Miami, FL 33135.

[5] Available from Aerospace Industries Association, 1050 Eye St. N.W., Washington, DC 20005.

[6] Available from American Society for Nondestructive Testing, 1711 Arlingate Plaza, P.O. Box 28518, Columbus, OH 43228-0518.

[7] Available from National Council on Radiation Protection and Measurements, NCRP Publications, 7910 Woodmount Ave., Suite 800, Bethesda, MD 20814.

[8] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[9] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[10] Available from National Institute of Standards and Technology (NIST), Gaithersburg, MD 20899.

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 film under examination, (see 6.27.4).

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 E 1815 shall be used.

5.3.1.1 *Non-film Recording Media*—Other recording media, such as paper and analog tape, 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 E 999 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 kV, 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 film.

TABLE 1 Lead Screen Thickness

KV Range	Lead Thickness[A]	
	Front Screen Maximum, in.	Back Screen Minimum, in.
0 to 150 kV[B]	0.000	0.005 (0.127 mm)[C]
150 to 200 kV–Ir 192	0.005 (0.127 mm)	0.005 (0.127 mm)
200 kV to 2 MV–Co 60	0.005 to 0.010 (0.126 to 0.254 mm)	0.010 (0.254 mm)
2 to 4 MV	0.010 (0.254 mm)	0.010 (0.254 mm)
4 to 10 MV	0.010 to 0.030 (0.254 to 0.762 mm)	0.010 (0.254 mm)
10 to 25 MV	0.010 to 0.050 (0.254 to 1.27 mm)	0.010 (0.254 mm)

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

[B] Prepackaged film without lead screens may be used up to 150 kV. Prepackaged film with lead screens may be used from 80 to 150 kV. Both types of prepackaged film may be used at higher energy levels provided the contrast, density, radiographic quality level, and backscatter requirements are achieved.

[C] No back screen is required provided the back scatter requirements of 6.22 are met.

5.4.3.2 *Fluorescent, Fluorometallic, or Other Metallic Screens*—Fluorescent, fluorometallic, or other metallic screens may be used provided the specified radiographic quality level, density, and contrast are obtained.

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 film with varying densities.

5.4.4.2 The light source shall have sufficient intensity to enable viewing of film densities in the area of interest (see 6.27.6).

5.4.4.3 The light enclosure shall be designed to provide a uniform brightness level over the entire viewing screen.

5.4.4.4 The viewer shall be equipped with a suitable fan, blower, or other means to provide stable temperature at the viewing port to avoid damaging the radiographic film while viewing.

5.4.4.5 The viewer shall be equipped with a translucent material front in each viewing port, except for localized high-intensity viewing of high-density film areas through separate viewing ports, apertures, or other suitable openings.

5.4.4.6 A set of opaque masks, an iris-type aperture, or any other method to reduce the viewing area to suit the size of the area of interest shall be provided.

5.4.4.7 Illuminators procured to, or meeting the requirements of, Guide E 1390 are acceptable for use.

5.4.5 *Digitizing Techniques*—The use of film digitizing techniques is acceptable when approved by the cognizant engineering organization.

5.4.6 *Densitometers*—The densitometer shall be capable of measuring the light transmitted through a radiograph with a film density up to 4.0 with a density unit resolution of 0.02. When film densities greater than 4.0 are permitted, a densitometer capable of measuring densities up to the maximum density permitted is required.

5.4.7 *Film Viewing Aids*—Magnifiers shall be available to provide magnification between 3× and 10× to aid in interpretation and determine indication size, as applicable. The specific

magnifier used should be determined by the interpretation requirements. Devices used for determining defect size shall be calibrated as scheduled in Table 2.

5.5 *Image Quality Indicators (IQI's)*:

5.5.1 *Image Quality Indicators (IQI's)*—The IQI's shall be in accordance with contract requirements. Hole-type IQI's in accordance with this practice, Practice E 1025, or the alternate design of Annex A1. or wire-type IQI's in accordance with Practice E 747, shall be used when IQI's are required. If wire IQI's are used, they shall be correlated to hole-type radiographic quality levels in accordance with Practice E 747. For the radiography of electronic devices, Practice E 801 shall be used.

5.5.2 *Radiographically Similar IQI Material*—Materials shall be considered radiographically similar if the following requirements are satisfied. Two blocks of equal thickness, one of the material to be radiographed and one of the material of which the IQI's are made, shall be exposed together on the same film at the lowest energy level to be used for production radiographs. If the film density of the IQI material to be radiographed is within the range from 0 to +15 % of the material to be radiographed, it shall be considered radiographically similar. The film density readings shall be between 2.0 and 4.0 for both materials. The IQI's of a lower radiographic density may be used.

5.5.3 *Alternate IQI Types*—The use of other types of IQI's, or modifications to types specified in 5.5.1, is permitted upon approval of the cognizant engineering organization. Details of the design, materials designation, and thickness identification of the IQI's shall be in the written procedure, or documented on a drawing that shall be referenced in the written procedure (see 6.1).

5.5.4 *IQI Control*—The IQI's shall be procured or fabricated to the requirements of Practice of E 1025, or the alternate design of Annex A1, as applicable, with a manufacturer's certification of compliance with respect to alloy and dimensions. Users shall visually inspect IQI's for damage and cleanliness in accordance with Table 2.

TABLE 2 Process Control Checks

Check	Frequency	Paragraph
Defect measuring device	[A,B]	5.4.7
Image quality indicators:		
Certified	when procured	5.5.4
Check (condition)	prior to use[C]	5.5.4
Automatic processing		
Processor performance:	daily	A4.2.1
Base fog	daily	A4.2.5
Developer temperature	prior to use[C]	A4.2.3
Replenishing flow rate	[D]	A4.2.2
Transport speed	[E]	A4.2.4
Manual Processing:		
Processing performance	daily	A4.3.1
Base fog	monthly	A4.2.5
Developer temperature	prior to use[F]	
Viewer intensity	[G]	6.27.4
Thermometer calibration	6 months[B]	A4.2.3
Densitometer:		
Verification check	[H]	6.27.5
Ambient visible light	6 months	6.27.6
Visible light meter	annual[B]	6.27.6
Stepwedge calibration	annual	6.27.5

[A] *Optical Devices*—When procured; mechanical devices (see Footnote *B*).

[B] Calibrated and recorded in accordance with MIL-STD-45662, ANSI Z-540, or ISO 10012, as applicable.

[C] Documentation of this check not required.

[D] Measured and recorded when solutions are changed during preventative maintenance or repair.

[E] Measured and recorded during preventative maintenance or repair and recorded.

[F] Temperatures shall be checked prior to each use. Daily documentation of this check is required.

[G] When procured, when bulb type or wattage is changed or maintenance is performed.

[H] Each shift or when maintenance is performed (bulb or aperture changed).

6. Detail Requirements

6.1 *Written Procedure*—It shall be the responsibility of the NDT facility to develop a workable examination technique recorded as a written procedure that is capable of consistently producing the desired results and radiographic quality level. When required by contract or purchase order, the procedure shall be submitted to the cognizant engineering organization for approval. The written procedure shall contain, as a minimum, the following information:

6.1.1 A drawing, sketch, or photograph of the component showing the location of the film and IQI with respect to the radiation source for each exposure. Included shall be the angle of the radiation beam in relation to the component, the source-to-film distance, and any blocking or masking, if used.

6.1.2 Part zone, if applicable, and acceptance criteria. This may be accomplished through drawings and tables or by reference to documents where such information is found.

6.1.3 The nominal exposure for X-ray machines, the voltage, milliamps, time (or rads as applicable), and effective focal spot size. For radioisotope sources, the isotope type, source strength (curies), exposure time, and source size.

6.1.4 Film designation, intensifying screens, or filters used and the desired film density range.

6.1.5 Thickness and type of material.

6.1.6 The IQI size and type, and the required radiographic quality level. If alternate IQI's are used (see 5.5.3), include details of the design or reference to documents where such information is found.

6.1.7 Thickness and type of material for shims or blocks, or both, if used.

6.1.8 Name and address of the NDT facility and the date, or revision, of the procedure.

6.1.9 Radiographic identification scheme used to correlate part-to-film. If the examination procedures are similar for many components, a master written procedure may be used that covers the details common to a variety of components. All written procedures shall be approved by an individual qualified and certified as a Level III for radiography in accordance with 5.1.1.

6.2 *Acceptance Requirements*—When examination is performed in accordance with this practice, engineering drawings, specifications, or other applicable documents shall indicate the criteria by which the components are judged acceptable. Complex components may be divided into zones and separate criteria assigned to each zone in accordance with its design requirements. When used, direct references to ASTM reference radiographic standards shall include the grade level for each type of discontinuity permitted for each part or zone.

NOTE 3—Information on reference radiographs can be obtained from the *Annual Book of ASTM Standards*, Vol 03.03 or from ASTM Headquarters.

6.3 *Surface Preparation*—Components may be examined without surface preparation or conditioning except as required to remove surface conditions that may interfere with proper interpretation of radiographs.

6.3.1 Castings, forgings, and weldments may be radiographed in the as-cast, as-forged, or as-welded conditions provided the following requirements are met.

6.3.1.1 For castings and forgings, the surface condition shall not interfere with evaluation.

6.3.1.2 Accessible surfaces of welds shall be prepared in accordance with A2.1.

6.4 *Radiographic Identification*—Each radiograph shall carry the identification or serial number of the component and view number, when multiple views are taken. Each radiograph shall also carry the identification of the NDT facility inspecting the component and the date of the examination. Radiographs of a repair area shall be identified with *R1, R2, R3*, and so forth, indicating the number of times that repairs were attempted. For explosives and propellants, the conditioning temperature shall be identified on each X-ray film if the ordnance has been conditioned to a temperature other than facility ambient for purposes of examination.

6.5 *Examination and Coverage*—The number of parts examined, and the radiographic coverage of each part shall be as specified by drawings, radiographic techniques, radiographic manuals, handbooks for aircraft technical orders, or other specifications, as applicable. Areas to be examined shall be identified on the drawing by using the symbols in accordance with ANSI/AWS A2.4 or other systems of designations that are easily identified on the drawing. If the number of parts to be examined and the amount of coverage of each part is not specified, all parts shall be examined and shall receive 100 % radiographic coverage.

6.6 *Examination Sequence*—The sequence for radiographic examination in the production operation should be specified in the manufacturing or assembly process specification, contract, or purchase order. If not specified, radiographic examination shall be performed at a stage in the process of manufacturing or assembly at which discontinuities can be detected. Radiographic examination may be performed before heat treatment, provided liquid penetrant or magnetic particle examinations are performed after heat treatment.

6.7 *Nonfilm Techniques*—When permitted by purchase order, contract, or specification, radioscopic examination shall be in accordance with Practice E 1255 and appropriate annex. Qualification of radioscopic systems shall be in accordance with Practice E 1411. Prior approval of the detailed examination, evaluation, and quality control procedures shall be obtained from the Level III radiographer of the cognizant engineering organization (see 5.1.1).

6.8 *Multi-Film Techniques*—Film techniques with two or more films of the same or different speeds in the same film holder, to be used in either single or superimposed film viewing, shall be permitted provided that the applicable radiographic quality level, and film density requirements (see 6.9 and 6.10), are achieved for the area of interest.

6.9 *Radiographic Quality Levels*—The five quality levels listed in Table 3 may be assigned on the basis of IQI thickness and the perceptibility of one, two, or three holes in the hole-type IQI image on the radiograph. If the quality level is not specified on the drawing or other applicable documents, it shall be Level 2–2T. Unless otherwise specified by the cognizant engineering organization, hole-type IQIs used for examination of material 0.25 in. or less in thickness shall be 0.005-in. minimum thickness.

6.10 *Film Density*—For single-film viewing, the density shall be in the range from 1.5 to 4.0 (inclusive) in the area of interest. Where superimposed film viewing is used, the density of the superimposed films shall be in the range from 2.0 to 4.0 (inclusive) in the area of interest, and each individual film shall not have a density below 1.0 in the area of interest. Film densities above 4.0 are permitted when agreed upon between the cognizant engineering organization and the NDT facility. For single-film viewing, densities less than 1.5 are permitted only when items not requiring an IQI (see 6.18) are inspected.

6.11 *Processing Radiographs*—Radiographs shall be free from blemishes which may interfere with film interpretation.

6.12 *IQI Selection*—The IQI thickness shall be based on a thickness not greater than the nominal thickness to be radiographed. For double-wall exposures and double-wall viewing techniques, the IQI shall be based on the double-wall thickness of the component. The IQI thicknesses that are in between, or smaller than, the thickness increments in Fig. 1 (for example, a hole-type IQI that is 0.0025 or 0.006 in. thick) may be used but are not mandatory. For double-wall exposures and single-wall viewing techniques, the IQI shall be based on the single-wall thickness of the component. In no case shall the IQI thickness be based on a thickness greater than the thickness to be radiographed. For fabrication welds the IQI shall be selected in accordance with Annex A2. For explosive/propellants, rocket motors, and their components, IQI selection shall be as specified in accordance with Annex A3.

6.13 *Placement of IQI's*—An IQI shall be placed on each part radiographed for the duration of exposure, unless a number of identical parts are simultaneously exposed on a single film. In such a case, a single IQI shall be placed upon the source side of a part at the outer edge of the cone of radiation or farthest extremity of the exposure setup (that is, farthest from the radiation beam centerline). For examination of irregular objects, the IQI shall be placed on the area of the part

TABLE 3 Quality Levels of Examination

IQI Designation	Radiographic Quality Level	Maximum IQI Thickness, %[A]	Minimum Hole Diameter[B]	Equivalent IQI Sensitivity, %[C]
00	1–1T	1	1T	0.7
0	1–2T	1	2T	1.0
1	2–1T	2	1T	1.4
2	2–2T	2	2T	2.0
3	2–4T	2	4T	2.8

[A] Expressed as a percentage of material thickness.
[B] Expressed as 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.

farthest from the film. The IQI's shall be placed adjacent to the area of interest, since accept/reject decisions cannot be made in the area directly beneath the IQI. Where it is not practicable to place the IQI on the part, the separate block technique in 6.13.1, or the film-side technique in 6.13.2, may be used as applicable.

6.13.1 *Shim, Separate Block, or Like-Section IQI Technique*—Where it is impractical to place the IQI upon the part radiographed, the IQI may be placed on the source side of a separate shim, block, or like section, from the same material group (or material that is radiographically similar, see 5.5.2). The shim, block, or like section and IQI shall be placed on the outer edge of the cone of radiation. The shim, block, or like section shall exceed the IQI dimensions so that at least three sides of the IQI shall be visible on the radiograph. If required, the shim shall be placed on a low absorptive material (such as polystyrene plastic or its equivalent) to ensure that the IQI shall not be any closer to the film than the source side of the part, or area of interest being evaluated.

6.13.2 *Film-Side IQI Placement*—When examining double-walled parts such as tubing or hollow castings, and it is not practical to place an IQI on the source side of the part, IQI's may be placed on the film side of the part as specified in 6.13.2.1 and 6.13.2.2. A letter "*F*" shall be placed adjacent to the IQI.

6.13.2.1 *Film-Side IQI's (Double Wall-Double Image)*—When performing double-wall radiography in which both walls are viewed for acceptance, the film-side radiographic technique shall be demonstrated on an exposure of a like section in which the required IQI shall be placed on the source side, and sets of wire IQI's, (or a series of hole-type IQI's) ranging in thickness from that of the required IQI to one fourth that thickness shall be placed on the film side. If the required IQI on the source side indicates the specified radiographic quality level, then the image of either the smallest IQI hole in the thinnest IQI, or the image of the smallest wire, visible on the film side, shall be used to determine the proper film-side IQI to be used for production radiographs.

6.13.2.2 *Film-Side IQI's (Double Wall-Single Image)*—When performing double-wall radiography in which only the wall portion next to the film is viewed for acceptance, the film-side radiographic technique shall be demonstrated on an exposure of a like section in which the required IQI is placed on the inside of the part and a set of IQI's, as specified in 6.13.2.1, are placed on the film side. If the IQI on the inside indicates the required radiographic quality level, then the image of either the smallest IQI hole in the thinnest IQI, or the image of the smallest wire, visible on the film side, shall be used to determine the proper film-side IQI to be used for production radiographs.

6.13.3 *IQI Qualification Exposure*—When included in the written procedure and approved by the Level III radiographer of the cognizant engineering organization, a single exposure with the applicable IQI may be made to qualify the examination process.

6.13.3.1 *Qualification Exposure*—When it is impractical to continually place IQIs on a part requiring more than one exposure, a single exposure of the IQI may be made to qualify the examination process. As long as the radiographic technique is not changed, subsequent exposures may be performed without an IQI. A new qualification exposure with an IQI shall be made daily, or whenever any of the following parameters are changed:

(1) Energy level (kilovolts or Megavolts),
(2) Exposure (milliampere × time),
(3) Source to film distance,
(4) Screens, collimation, masking, or filters,
(5) Film type, or
(6) Film processing parameters.

6.13.3.2 *Subsequent Exposures*—Subsequent exposures shall be positively tied to the qualification exposure by serialization or other methods. A copy of the qualification shall be provided to all parties with review authority.

6.13.4 *Re-radiography*—Whenever there is a reasonable doubt as to the interpretation or clarity of the radiograph because of film artifacts or improper technique, re-radiography is required.

6.14 *Masking*—Shot, masking solutions, sheet lead and foils, polytetrafluoroethylene (PTFE), plastic, or other low-density, nonmetallic absorbers may be used as masking to minimize the effects of scattered radiation or undercutting. The shot may be a mixture of many diameters to provide a uniform density. Heavy chemical solutions used for masking may be toxic; the proper health and safety precautions and markings shall be used.

6.15 *Filters*—Filters may be used whenever the contrast reductions caused by low-energy scattered radiation occurring on production radiographs are of significant magnitude to cause difficulty in meeting the radiographic quality level or radiographic coverage requirements as specified in the contract, purchase order, or drawing.

6.16 *Multiple-Film-Cassette Exposure*— Where more than one film cassette is used to cover the area of interest in a single exposure, an IQI image shall appear on at least one radiograph at the edge of the film most distant from the center of the radiation beam. When the source is placed on the axis of the object, and the complete circumference is radiographed with a single exposure, at least three equally spaced IQI's are to be used if possible.

6.17 *Applicable IQI Area of Interest*— When placed directly on the component, one IQI shall represent an area within which radiographic densities do not vary more than +30 to −15 % from the density measured through the body of the IQI. At least one IQI per radiograph shall be used, except as specified in 6.17.1 and 6.18. Accept/reject decisions shall not be made directly beneath the IQI shim combination.

6.17.1 *Radiograph Qualification Using Two IQI's*—When the film density varies by more than is specified in 6.17, two IQI's used in the following manner are acceptable. If one IQI shows an acceptable sensitivity in the most dense portion of the radiograph, and the second IQI shows an acceptable sensitivity in the least dense portion of the radiograph, the two IQI's shall serve to qualify the radiograph within these density limits. Additional pairs of IQI's may be used, as necessary in subsequent exposures, to cover the entire thickness range of the object. For components such as castings and forgings, where