



Designation: E1255 – 09

## Standard Practice for Radioscopy<sup>1</sup>

This standard is issued under the fixed designation E1255; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

### 1. Scope

1.1 This practice<sup>2</sup> provides application details for radiosopic examination using penetrating radiation. This includes dynamic radioscopy and for the purposes of this practice, radioscopy where there is no motion of the object during exposure (referred to as static radiosopic imaging) both using an analog component such as an electro-optic device or analog camera. Since the techniques involved and the applications for radiosopic examination are diverse, this practice is not intended to be limiting or restrictive, but rather to address the general applications of the technology and thereby facilitate its use. Refer to Guides E94 and E1000, Terminology E1316, Practice E747, Practice E1025, Test Method E2597, and Fed. Std. Nos. 21 CFR 1020.40 and 29 CFR 1910.96 for a list of documents that provide additional information and guidance.

1.2 The general principles discussed in this practice apply broadly to penetrating radiation radiosopic systems. However, this document is written specifically for use with X-ray and gamma-ray systems. Other radiosopic systems, such as those employing neutrons, will involve equipment and application details unique to such systems.

1.3 *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.* For specific safety statements, see Section 8 and Fed. Std. Nos. 21 CFR 1020.40 and 29 CFR 1910.96.

### 2. Referenced Documents

#### 2.1 ASTM Standards:<sup>3</sup>

E94 Guide for Radiographic Examination

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 Radiology

E1316 Terminology for Nondestructive Examinations

E1411 Practice for Qualification of Radioscopic Systems

E1742 Practice for Radiographic Examination

E2002 Practice for Determining Total Image Unsharpness in Radiology

E2597 Practice for Manufacturing Characterization of Digital Detector Arrays

#### 2.2 ASNT Standard:<sup>4</sup>

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

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

#### 2.3 Federal Standards:<sup>5</sup>

21 CFR 1020.40 Safety Requirements of Cabinet X-Ray Systems

29 CFR 1910.96 Ionizing Radiation

#### 2.4 National Council on Radiation Protection and Measurement (NCRP) Standard:

NCRP 49 Structural Shielding Design and Evaluation for Medical Use of X Rays and Gamma Rays of Energies Up to 10 MeV<sup>6</sup>

#### 2.5 AIA Standard:

NAS-410 NAS Certification and Qualification of Nondestructive Test Personnel<sup>7</sup>

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.01 on Radiology (X and Gamma) Method.

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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Practice SE-1255 in Section II of that code.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>4</sup> Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.

<sup>5</sup> Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

<sup>6</sup> Available from NCRP Publications, 7010 Woodmont Ave., Suite 1016, Bethesda, MD 20814.

<sup>7</sup> Available from Aerospace Industries Association of America, Inc. (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3928, http://www.aia-aerospace.org.

### 3. Summary of Practice

3.1 Visual evaluation as well as computer-aided automated radioscopic examination systems are used in a wide variety of penetrating radiation examination applications. A simple visual evaluation radioscopic examination system might consist of a radiation source, a fluorescent screen viewed with an analog camera, suitably enclosed in a radiation protective enclosure and a video display. At the other extreme, a complex automated radioscopic examination system might consist of an X-ray source, a robotic examination part manipulator, a radiation protective enclosure, an electronic image detection system with a camera, a frame grabber, a digital image processor, an image display, and a digital image archiving system. All system components are supervised by the host computer, which incorporates the software necessary to not only operate the system components, but to make accept/reject decisions as well. Systems having a wide range of capabilities between these extremes can be assembled using available components. Guide **E1000** lists many different system configurations.

3.2 This practice provides details for applying radioscopic examination with camera techniques; however, supplemental requirements are necessary to address areas that are application and performance specific. **Annex A1** provides the detailed supplemental requirements for government contracts.

### 4. Significance and Use

4.1 As with conventional radiography, radioscopic examination is broadly applicable to any material or examination object through which a beam of penetrating radiation may be passed and detected including metals, plastics, ceramics, composites, and other nonmetallic materials. In addition to the benefits normally associated with radiography, radioscopic examination may be either a dynamic, filmless technique allowing the examination part to be manipulated and imaging parameters optimized while the object is undergoing examination, or a static, filmless technique wherein the examination part is stationary with respect to the X-ray beam. The differentiation to systems with digital detector arrays (DDAs) is the use of an analog component such as an electro-optic device or an analog camera. Recent technology advances in the area of projection imaging, camera techniques, and digital image processing provide acceptable sensitivity for a wide range of applications. If normal video rates are not adequate to detect features of interest then averaging techniques with no movement of the test object shall be used.

### 5. Equipment and Procedure

5.1 *System Configuration*—Many different radioscopic examination systems configurations are possible, and it is important to understand the advantages and limitations of each. It is important that the optimum radioscopic examination system be selected for each examination requirement through a careful analysis of the benefits and limitations of the available system components and the chosen system configuration. The provider as well as the user of the radioscopic examination services should be fully aware of the capabilities and limitations of the radioscopic examination system that is proposed for examination of the object. The provider and the user of radioscopic

examination services shall agree upon the system configuration to be used for each radioscopic examination application under consideration, and how its performance is to be evaluated.

5.1.1 The minimum radioscopic examination system configuration will include an appropriate source of penetrating radiation, a means for positioning the examination object within the radiation beam, in the case of dynamic radioscopy, and a detection system. The detection system may be as simple as a camera-viewed fluorescent screen with suitable radiation shielding for personnel protection that meets applicable radiation safety codes.

5.1.2 A more complex system might include the following components:

5.1.2.1 An Image Intensifier to intensify the photon detection from the fluorescent screen,

5.1.2.2 A micro- or mini-focus X-ray tube can be used with high magnification to facilitate higher-resolution projection imaging,

5.1.2.3 A multiple axis examination part manipulation system to provide dynamic, full volumetric examination part manipulation under operator manual control or automated program control, for dynamic radioscopy,

5.1.2.4 An electronic imaging system to display a bright, two-dimensional gray-scale image of the examination part at the operator's control console,

5.1.2.5 A digital image processing system to perform image enhancement and image evaluation functions,

5.1.2.6 An archival quality image recording or storage system, and

5.1.2.7 A radiation protective enclosure with appropriate safety interlocks and a radiation warning system.

5.1.3 Whether a simple or a complex system is used, the system components and configuration utilized to achieve the prescribed examination results must be carefully selected.

#### 5.2 *Practice:* 3-b15e74385a10/astm-e1255-09

5.2.1 The purchaser and supplier for radioscopic examination services shall mutually agree upon a written procedure and also consider the following general requirements.

5.2.1.1 *Equipment Qualifications*—A listing of the system features that must be qualified to ensure that the system is capable of performing the desired radioscopic examination task. System features are described in Guide **E1000**.

5.2.1.2 *Examination Object Scan Plan for Dynamic Radioscopy*—A listing of object orientations, ranges of motions, and manipulation speeds through which the object must be manipulated to ensure satisfactory examination.

5.2.1.3 *Radioscopic Parameters*—A listing of all the radiation source-related variables that can affect the examination outcome for the selected system configuration such as: source energy, intensity, focal spot size, filter in the X-ray beam, collimators, range of source to object distances, range of object to image plane distances, and source to image plane distances.

5.2.1.4 *Image Processing Parameters*—A listing of all the image processing variables necessary to enhance flaw detectability in the object and to achieve the required sensitivity level. These would include, but are not limited to, techniques such as noise reduction, contrast enhancement, and spatial filtering. Great care should be exercised in the selection of

directional image processing parameters such as spatial filtering, which may emphasize features in certain orientations and suppress them in others. The listing should indicate the means for qualifying image processing parameters.

5.2.1.5 *Image Display Parameters*—A listing of the techniques and the intervals at which they are to be applied for standardizing the image display as to brightness, contrast, focus, and linearity.

5.2.1.6 *Accept-Reject Criteria*—A listing of the expected kinds of object imperfections and the rejection level for each.

5.2.1.7 *Performance Evaluation*—A listing of the qualification tests and the intervals at which they are to be applied to ensure that the radioscopic examination system is suitable for its intended purpose.

5.2.1.8 *Image Archiving Requirements*—A listing of the requirements, if any, for preserving a historical record of the examination results. The listing may include examination images along with written or electronically recorded alphanumeric or audio narrative information, or both, sufficient to allow subsequent reevaluation or repetition of the radioscopic examination.

5.2.1.9 *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/ASNT CP-189, SNT-TC-1A, NAS-410, 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.

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

## 6. Radioscopic Examination System Performance Considerations and Measurement

6.1 *Factors Affecting System Performance*—Total radioscopic examination system performance is determined by the combined performance of the system components that includes the radiation source, manipulation system (for dynamic radioscopy), detection system, information processing system, image display, automatic evaluation system, and examination record archiving system.

6.1.1 *Radiation Sources*—While the radioscopic examination systems may utilize either radioisotope or X-ray sources, X-radiation is used for most radioscopic examination applications. This is due to the energy spectrum of the X-radiation that contains a blend of contrast enhancing longer wavelengths, as well as the more penetrating, shorter wavelengths. X-radiation is adjustable in energy and intensity to meet the radioscopic examination test requirements, and has the added safety feature of discontinued radiation production when switched off. A radioisotope source has the advantages of small physical size, portability, simplicity, and uniformity of output.

6.1.1.1 X-ray machines produce a more intense X-ray beam emanating from a smaller focal spot than do radioisotope sources. X-ray focal spot sizes range from a few millimetres down to a few micrometres. Reducing the source size reduces geometric unsharpness, thereby enhancing detail sensitivity. X-ray sources may offer multiple or variable focal spot sizes. Smaller focal spots produce higher resolution when using geometrical magnification and provide reduced X-ray beam intensity, while larger focal spots provide higher X-ray intensity and produce lower resolution. Microfocus X-ray tubes are available with focal spots that may be adjusted to as small as a few micrometres in diameter, while still producing an X-ray beam of sufficient intensity so as to be useful for the radioscopic examination of finely detailed objects.

6.1.1.2 Conventional focal spots of 1.0 mm and larger are useful at low geometric magnification values close to 1 $\times$ . Fractional focal spots ranging from 0.4 mm up to 1.0 mm are useful at geometric magnifications of up to approximately 2 $\times$ . Minifocus spots in the range from 0.1 mm up to 0.4 mm are useful at geometric magnifications up to about 6 $\times$ . Greater magnifications suggest the use of a microfocus spot size of less than 0.1 mm in order to minimize the effects of geometric unsharpness. Microfocus X-ray tubes are capable of focal spot sizes of less than 1 micrometre (10<sup>-6</sup> metre) and are useful for geometric magnifications of more than 100 $\times$ .

6.1.2 *Manipulation System for Dynamic Radioscopy*—The examination part manipulation system has the function of holding the examination object and providing the necessary degrees of freedom, ranges of motion, and speeds of travel to position the object areas of interest in the radiation beam in such a way so as to maximize the radioscopic examination system's response. In some applications it may be desirable to manipulate the radiation source and detection system instead of, or in addition to, the object. The manipulation system must be capable of smooth well-controlled motion, especially so for high-magnification microfocus techniques, to take full advantage of the dynamic aspects of the radioscopic examination.

6.1.3 *Detection System*—The detection system is a key element. It has the function of converting the radiation input signal containing part information, into a corresponding electronic output signal while preserving the maximum amount of object information. The detector may be a two-dimensional area detector providing an area field of view.

6.1.3.1 A simple detection system may consist of a fluorescent screen viewed directly by an analog camera. Advantages include a selectable resolution and low component costs. The disadvantages include noisy imagery due to inefficient light capture from the fluorescent screen and pin cushion distortion.

6.1.3.2 Most radioscopic systems use image intensifiers that increase the capture efficiency from a fluorescent screen, intensify and reduce the image to an output phosphor that is then captured by a standard analog or digital TV/CCD camera, or equivalent. The image intensifier enables increased frame rates, or higher examination throughputs in relation to the use of a fluorescent screen alone. This enables the use of a standard low cost camera resulting in much higher SNR than if the

image intensifier were not used. Disadvantages of the image intensifier include image blooming, pin cushion distortion and a limited spatial resolution of about 100 to 400  $\mu\text{m}$ .<sup>8</sup>

6.1.3.3 Cameras in combination with image intensifiers may use analog or digital readout circuitry. Analog cameras may produce video signals and may be used with TV displays; digital cameras need computing devices for displaying the images. Digital cameras may be selected out of a wide range of options in spatial resolution, image size, sensitivity and frame rate.

#### 6.1.4 *Information Processing System:*

6.1.4.1 The function of the information processing system is to take the output of the detection system and present a useful image for display and operator interpretation, or for automatic evaluation. The information processing system may take many different forms, and may process analog or digital information, or a combination of the two.

6.1.4.2 The information processing system includes all of the electronics and interfaces after the detection system to and including the image display and automatic evaluation system. Information system components include such devices as frame grabbers, image processors, and in general any device that processes radioscopic examination information after the detection system.

6.1.4.3 The digital image processing system warrants special attention, since it is the means by which radioscopic examination information may be enhanced. Great care must be exercised in determining which image processing techniques are most beneficial for the particular application. Directional spatial filtering operations, for example, must be given special attention as certain feature orientations are emphasized while others are suppressed. While many digital image processing operations occur sufficiently fast to follow time-dependent radioscopic system variables, others do not. Some image processing operations require significant image acquisition and processing time, so as to limit the dynamic response of the radioscopic examination, in dynamic radioscopic systems.

6.1.5 *Automatic Evaluation System*—Some radioscopic examination applications can be fully automated including the accept/reject decision through computer techniques. The automatic evaluation system's response to various examination object conditions must be carefully determined under actual operating conditions. The potential for rejecting good objects and accepting defective objects must be considered. Automatic evaluation system performance criteria should be mutually determined by the provider and user of radioscopic examination services.

#### 6.1.6 *Image Display:*

6.1.6.1 The function of the image display is to convey radioscopic information about the examination object to the system operator. For visual evaluation systems, the displayed image is used as the basis for accepting or rejecting the object, subject to the operator's interpretation of the radioscopic

image. The image display performance, size, and placement are important radioscopic system considerations.

6.1.6.2 When employing a television image presentation with row interlacing from an analog camera, vertical and horizontal resolution are often not the same. Therefore, the effect of raster orientation upon the radioscopic examination system's ability to detect fine detail, regardless of orientation, must be taken into account.

6.1.7 *Radioscopic Examination Record Archiving System*—Many radioscopic examination applications require an archival quality examination record of the radioscopic examination. The archiving system may take many forms, a few of which are listed in 6.1.7-6.1.7.7. Each archiving system has its own peculiarities as to image quality, archival storage properties, equipment, and media cost. The examination record archiving system should be chosen on the basis of these and other pertinent parameters, as agreed upon by the provider and user of radioscopic examination services. The reproduction quality of the archival method should be sufficient to demonstrate the same image quality as was used to qualify the radioscopic examination system. To reduce storage capacity image compression may be used. Lossless compression provides no degradation or loss in quality; care should be taken when using lossy compression like JPEG or MPEG that the resulting quality is equivalent to the original image. Care shall be taken about the lifetime of the image storage media.

6.1.7.1 Video hard copy device used to create an image from the video signal,

6.1.7.2 Laser print hard copy device used to create a film image.

6.1.7.3 Analog video tape recorder used to record the video signal on magnetic tape; characterized by long recording time at video frame rates; useful for capturing part motion,

6.1.7.4 Digital recording on magnetic tape used to store the image of the object digitally; characterized by limited storage capacity at video frame rates, when using no image compression,

6.1.7.5 Digital recording on optical disk used to store the image of the object digitally; consideration should be given to the type of optical storage because there are fundamentally two different types: write once read many times (WORM) where common formats are CD ROM or DVD ROM, where the radiological data cannot be erased or altered after the disk is created, and rewritable disks, where radiological data can be erased, altered, or signed with R/W symbol.

6.1.7.6 Digital recording on magnetic hard disks may record several hours or even days on one hard drive. Care should be taken about the limited reliability of hard drives and about the fact that radiological data can be erased or altered easily.

6.1.7.7 Digital records can be stored in a digital network or on a multi-disk system when a backup-system is available. Care should be taken about the fact that radiological data can be erased or altered easily.

6.1.8 *Examination Record Data*—The examination record should contain sufficient information to allow the radioscopic examination to be reevaluated or duplicated. Examination record data should be recorded contemporaneously with the

<sup>8</sup> Note that some scientific CCD cameras, and amorphous silicon detectors that always provide digital imagery are now capable of reading fluorescent screens at fast frame rates without the need of an image intensifier. These devices are not covered by this standard.

radioscopic examination image, and may be in writing or a voice narrative, providing the following minimum data:

6.1.8.1 Radioscopic examination system designation, examination date, operator identification, operating turn or shift, and other pertinent examination and customer data,

6.1.8.2 Specific part data as to part number, batch, serial number, etc. (as applicable),

6.1.8.3 Examination part orientation and examination site information by manipulation system coordinate data or by reference to unique part features within the field of view, and

6.1.8.4 System performance monitoring by recording the results of the prescribed radioscopic examination system performance monitoring tests, as set forth in Section 5, at the beginning and end of a series of radioscopic examinations, not to exceed the interval set forth in 6.2.2 for system performance monitoring.

6.2 *Performance Measurement*—Radioscopic examination system performance parameters shall 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, utilizing an object similar to the part under actual operating conditions. Tests with natural discontinuities are not sufficient as the only quality control measurement for the comparison of the actual system performance with its qualified state. The performance of the radioscopic system should be tested to its ability to image and recognize the typical and the critical discontinuities of a certain component. In addition to standardized IQIs, samples with the smallest or most difficult to detect natural discontinuities or simulated imperfections, for example, drilled holes, may be used as reference objects for a routine quality control of the overall system performance. In place of real samples, objects or reference blocks containing realistic or manufactured discontinuities can be used to check quality performance. Performance measurement methods shall be a matter of agreement between the provider and user of radioscopic examination services.

6.2.1 *System Performance Quality Parameter*—The quality of a radioscopic image is essentially determined by unsharpness, contrast, noise and linearity. The X-ray settings shall be the same as in production (energy, intensity, filter, FDD, FOD).

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

6.2.3 *Measurement with Reference Object and IQIs*— Radioscopic examination system performance measurement using IQIs shall be in accordance with Practices E747, E1025, or E1742. The IQIs should be placed at the source side of a reference object as close as possible to the region of interest. The use of wire-type IQIs (see Practice E747) should also take into account the fact that the radioscopic examination system may exhibit asymmetrical sensitivity, in which case the wire

axis shall be oriented along the system's axis of least sensitivity. Selection of IQI thickness should be consistent with the part radiation path length thickness. For more details the instructions in the referenced standards shall be followed. The reference object should be placed into the radioscopic examination system in the same position as the actual object and may be manipulated through the same range of motions through a given exposure for dynamic radioscopic systems as are available for the actual object so as to maximize the radioscopic examination system's response to the indications of the IQIs or simulated imperfection.

6.2.4 *Measurement with a Reference Block*—The reference block may be an actual object with known features that are representative of the range of features to be detected, or may be fabricated to simulate the object with a suitable range of representative features. Alternatively, the reference block may be a one-of-a-kind or few-of-a-kind reference object containing known imperfections that have been verified independently. Reference blocks containing known, natural discontinuities are useful on a single-task basis, but are not universally applicable. Where standardization among two or more radioscopic examination systems is required, a duplicate manufactured reference block should be used. The reference blocks should approximate the 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 reference blocks should include features at least as small as those that must be reliably detected in the actual objects in locations where they are expected to occur in the actual object. Where features are internal to the object, it is permissible to produce the reference block in sections. Reference block details are a matter of agreement between the user and supplier of radioscopic examination services.

6.2.4.1 *Use of a Reference Block*—The reference block should be placed into the radioscopic examination system in the same position as the actual object and may be manipulated through the same range of motions through a given exposure for dynamic radioscopic systems as are available for the actual object so as to maximize the radioscopic examination system's response to the simulated imperfection.

6.2.4.2 *Radioscopic Examination Techniques*— (radiation beam energy, intensity, focal spot size, enlargement, digital image processing parameters, manipulation scan plan for dynamic radioscopic systems, scanning speed, and other system variables) utilized for the reference block shall be identical to those used for the actual examination of the object.

6.2.5 *Measurement with Step Wedge Method*:

6.2.5.1 An unsharpness gauge and a step wedge with IQIs may be used, if so desired, to determine and track radioscopic system performance in terms of unsharpness and contrast sensitivity. The step wedge shall be placed into the radioscopic examination system in the same position as the actual object with the face of the IQIs to the source side. In minimum two views shall be recorded. Between both views the step wedge shall be rotated by 90° as radioscopic examination system may exhibit asymmetrical sensitivity.

6.2.5.2 The step wedge shall be made of the same material as the test part with in minimum three steps. The thickest and

thinnest steps represent the thickest and the thinnest material sections to be examined. Other thickness steps are permissible upon agreement between the provider and the user of radioscopy services. As a minimum, an IQI each representing the required image quality shall be placed on the thinnest and thickest step of the stepwedge. Selection of the IQI shall be in agreement between the CEO and user of radioscopy system. If no quality level is defined 2-2T shall be taken for both, the thinnest and thickest step. See Guide E94 or Practice E1025 for more details about quality levels.

6.2.5.3 The total system unsharpness shall be checked with an IQI of the duplex wire type in accordance with Practice E2002. The duplex wire shall be placed on the second thinnest step of the step wedge tilted by about 5°. The step wedge shall be positioned horizontally and vertically to the lines of the detection system. The duplex wire IQI shall be read in the unsharper direction if any. When agreed between the CEO and the user of radioscopy services a calibrated line pair test pattern may be used instead of the Practice E2002 duplex wire. The line pair test pattern shall be placed on the thinnest step of the wedge. For systems with an image processing computer, the profile across the IQI shall be evaluated. For Practice E2002, the duplex wire pair for which the modulation depth is less than 20 % shall be documented, also noting the actual modulation measured. If using the line pair test pattern, the spatial resolution just before the lines are completely blurred shall be documented. For example where modulation is either just observed or measured, that spatial resolution shall be recorded. Note that with the use of a line pair gauge the lines can sometimes come back into focus at a higher frequency. This resolution is not to be recorded, as this represents an aliased, non-realistic definition of the spatial resolution of the system.

6.2.5.4 A system that exhibits an unsharpness of 320 μm, equivalent to a 160 μm effective pixel pitch, a thin-section contrast sensitivity of 2-4T, and a thick-section contrast sensitivity of 2-2T may be said to have an equivalent performance level of 2-4T – 2-2T – 320 μm. This may be converted to older definitions by: 320 μm ~ 3 lp/mm; 2-4T ~ 2.8 % equivalent IQI sensitivity; 2-2T ~ 2.0 % equivalent IQI sensitivity to an equivalent performance level of 3 % – 2 % – 3 lp/mm. For more details in converting the contrast levels refer to Practice E1742.

6.2.5.5 The step wedge with the IQIs may be used to make more frequent periodic system performance checks than required in accordance with 6.2.2. Unsharpness and contrast sensitivity checks shall be correlated with IQI readout of reference object performance measurements. This may be done by first evaluating system measurement in accordance with 6.2.3 and immediately thereafter determining the equivalent spatial resolution and contrast sensitivity values.

6.2.6 *Importance of Proper Environmental Conditions*—Environmental conditions conducive to human comfort and concentration will promote examination efficiency and reliability, and must be considered in the performance of visual evaluation radioscopy examination systems. A proper examination environment will take into account temperature, humidity, dust, lighting, access, and noise level factors. Proper reduced lighting intensity is extremely important to provide for high-contrast glare-free viewing of radioscopy examination images.

## 7. Radioscopic Examination Interpretation and Acceptance Criteria

7.1 *Interpretation*—Interpretation may be done either by an operator in a visual evaluation radioscopy environment, or by means of a computer and appropriate software in the case of an automated radioscopy examination system. A hybrid environment may also be utilized whereby the computer and software presents to the operator a recommended interpretation, which is then subject to the operator’s final disposition.

7.2 *Operator*—The supplier and user should reach an agreement as to operator qualifications including duty and rest periods. Nationally or internationally recognized NDT personnel qualification practices or standards such as ANSI/ASNT CP-189, SNT-TC-1A, NAS-410, or similar document sets forth three levels of nondestructive testing personnel qualifications that the radioscopy examination practitioner may find useful.

7.3 *Accept/Reject Criteria*—Accept/reject criteria is a matter of contractual agreement between the provider and the user of radioscopy examination services.

## 8. Records, Reports, and Identification of Accepted Material

8.1 Records and reports are a matter of agreement between the supplier and the user. If an examination record archiving requirement exists, refer to 6.1.8, which outlines the necessary information that should be a part of an archival examination record.

## 9. Safety Conditions

9.1 Radioscopic examination procedures shall be conducted under protective conditions so that personnel will not receive radiation dose levels exceeding that permitted by company, city, state, or national regulations. The recommendations of the National Committee on Radiation Protection should be the guide to radiation safety.

## 10. Keywords

10.1 analog; detector; digital; display; examination; image; manipulator; processor; radioscopy; source