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An American National Standard

Standard Practice for Radioscopy[1]

This standard is issued under the fixed designation E 1255; 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] provides application details for radioscopic examination using penetrating radiation. This includes dynamic radioscopy and for the purposes of this practice, radioscopy where there is no motion of the test object during exposure (referred to as static radioscopic imaging). Since the techniques involved and the applications for radioscopic 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 it's use. Refer to Guides E 94 and E 1000, Terminology E 1316, Practice E 747, Practice E 1025, 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 radioscopic systems. However, this document is written specifically for use with X-ray and gamma-ray systems. Other radioscopic 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:*

E 94 Guide for Radiographic Testing[3]

E 747 Practice for Design, Manufacture and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology[3]

E 1000 Guide for Radioscopy[3]

E 1025 Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology[3]

E 1316 Terminology for Nondestructive Examinations[3]

2.2 *ASNT Standard:*

SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing[4]

ANSI/ASNT CP-189 Standard for Qualification and Certification of Nondestructive Testing Personnel[4]

2.3 *Federal Standards:*

21 CFR 1020.40 Safety Requirements of Cabinet X-Ray Systems[5]

29 CFR 1910.96 Ionizing Radiation[5]

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[6]

3. Summary of Practice

3.1 Manual evaluation as well as computer-aided automated radioscopic examination systems are used in a wide variety of penetrating radiation examination applications. A simple manual evaluation radioscopic examination system might consist of a radiation source and a directly viewed fluorescent screen, suitably enclosed in a radiation protective enclosure. At the other extreme, a complex automated radioscopic examination system might consist of an X-ray source, a robotic test part manipulator, a radiation protective enclosure, an electronic image detection system, a closedcircuit television image transmission system, a digital image processor, a video 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 E 1000 lists many different system configurations.

3.2 This practice provides details for applying radioscopic examination techniques, however, supplemental requirements are necessary to address areas that are application and performance specific. Annex A1 and Annex A2 provide the detailed

[1] This practice is under the jurisdiction of ASTM Committee E-7 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.01 on Radiology (X and Gamma) Method.

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[2] For *ASME Boiler and Pressure Vessel Code* applications see related Practice SE-1255 in Section II of that code.

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

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

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

[6] Available from NCRP Publications, 7010 Woodmont Ave., Suite 1016, Bethesda, MD 20814.

supplemental requirements for government contracts (Annex A1) and nongovernment contracts (Annex A2).

4. Significance and Use

4.1 As with conventional radiography, radioscopic examination is broadly applicable to any material or test object through which a beam of penetrating radiation may be passed and detected including metals, plastics, ceramics, composite, and other nonmetallic materials. In addition to the benefits normally associated with radiography, radioscopic examination may be either a dynamic, filmless technique allowing the test part to be manipulated and imaging parameters optimized while the test object is undergoing examination, or a static, filmless technique wherein the test part is stationary with respect to the X-ray beam. Recent technology advances in the area of projection imaging, detectors, and digital image processing provide acceptable sensitivity for a wide range of applications.

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 test 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 test object within the radiation beam, in the case of dynamic radioscopy, and a detection system. The system may be as simple as a directly 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 A microfocus X-ray system to facilitate high-resolution projection imaging,

5.1.2.2 A multiple axis test part manipulation system to provide dynamic, full volumetric test part manipulation under operator joystick or automated program control, for dynamic radioscopy,

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

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

5.1.2.5 An archival quality image recording system, and

5.1.2.6 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 test results must be carefully selected.

5.2 *Practice*:

5.2.1 The purchaser and supplier for radioscopic examination services shall mutually agree upon a written procedure using the applicable annex of supplemental requirements 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.

5.2.1.2 *Test Object Scan Plan for Dynamic Radioscopy*—A listing of test object orientations, ranges of motions, and manipulation speeds through which the test 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, 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 fine detail detectability in the test 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 video image display as to brightness, contrast, focus, and linearity.

5.2.1.6 *Accept-Reject Criteria*—A listing of the expected kinds of test 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 *Operator Qualifications*—Nondestructive testing (NDT) personnel shall be qualified in accordance with a nationally recognized NDT personnel qualification practice or a standard such as ANSI/ASNT-CP-189, SNT-TC, MIL STD-410, or a similar document, to the level appropriate for the performance of the listed radioscopic examination.

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 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 test objects.

6.1.1.2 Conventional focal spots of 1.0 mm and larger are useful at low geometric magnification values close to 1×. Fractional focal spots ranging from 0.4 mm up to 1.0 mm are useful at geometric magnifications of up to approximately 2×. Minifocus spots in the range from 0.1 mm up to 0.4 mm are useful at geometric magnifications up to about 6×. 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 10 micrometres (10^{-8} metres) and are useful for geometric magnifications of more than 100×.

6.1.2 *Manipulation System for Dynamic Radioscopy*—The test part manipulation system has the function of holding the test object and providing the necessary degrees of freedom, ranges of motion, and speeds of travel to position the test 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 test 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 test part information, into a corresponding optical or electronic output signal while preserving the maximum amount of test object information. The detector may be of one-dimensional design, providing test part information one line at a time, or may be a two-dimensional area detector providing an area field of view.

6.1.4 *Information Processing of 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 optics, electronics, and interfaces after the detection system to and including the image display and automatic evaluation system. Information system components include such devices as lenses, fiber optic couplings, light amplifiers, video cameras, 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 exam, 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 test object conditions must be carefully determined under actual operating conditions. The potential for rejecting good test objects and accepting defective test 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 test object to the system operator. For manual evaluation systems, the displayed image is used as the basis for accepting or rejecting the test 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, 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 6.1.7-6.1.7.10. 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.

6.1.7.1 Film or paper radiograph of the test object made under the same conditions as the radioscopic examination image,

6.1.7.2 Spot film camera used to photograph the examination image directly from the output of an X-ray image intensifier without the intervening television chain limitations,

6.1.7.3 Photograph of the actual image display,

6.1.7.4 Multi-format camera used to make a photograph of the examination image from the video signal,

6.1.7.5 Video hard copy device used to create a paper facsimile image from the video signal,

6.1.7.6 Laser print hard copy device used to create a film image from the scanned detector output.

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

6.1.7.8 Digital recording on magnetic disk or tape used to store the image of the test object digitally; characterized by limited storage capacity at video frame rates, therefore limiting the ability to capture test part motion in dynamic radioscopic systems,

6.1.7.9 Digital recording on optical disk used to store the image of the test object digitally; offers larger storage capacity than magnetic disk or tape; consideration should be given to the type of optical storage because there are fundamentally two different types: magneto-optical where radiological data can be erased or altered; and write once read many times (WORM) where a common format is CD ROM and the radiological data cannot be erased or altered after the disk is created.

6.1.7.10 Electronic digital memory, such as ROM (read only memory) or EPROM (erasable programmable read only memory); characterized by relatively limited capacity, and

6.1.7.11 Hologram used to store high-density digital image data on film at high-information density.

6.1.8 *Examination Record Data*—The examination record should contain sufficient information to allow the radioscopic examination test to be reevaluated or duplicated. Examination record data should be recorded contemporaneously with the 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, test date, operator identification, operating turn or shift, and other pertinent test and customer data,

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

6.1.8.3 Test part orientation and examination site information by manipulation system coordinate data or by reference to unique test 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 6.2.1 for system performance monitoring.

6.2 *Performance Measurement*—Radioscopic examination system performance parameters must be determined initially and monitored regularly to ensure consistent results. The best measure of total radioscopic examination system performance can be made with the system in operation, utilizing a test object similar to the test part under actual operating conditions. This indicates the use of an actual or simulated test object or calibration block containing actual or simulated features that must be reliably detected. Such a calibration block will provide a reliable indication of the radioscopic examination system's capabilities. Conventional wire- or plaque-type IQIs may be used in place of, or in addition to, the simulated test object or calibration block. Performance measurement methods are a matter of agreement between the provider and user of radioscopic examination services.

6.2.1 *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.

6.2.2 *Measurement with IQIs*—Radioscopic examination system performance measurement using IQIs shall be in accordance with accepted industry standards describing the use of IQIs. The IQIs should be placed on the test object as close as possible to the region of interest. The use of wire-type IQIs should also take into account the fact that the radioscopic examination system may exhibit asymmetrical sensitivity, in which case the wire diameter axis shall be oriented along the system's axis of least sensitivity. Selection of IQI thickness should be consistent with the test part radiation path length thickness.

6.2.3 *Measurement with a Calibration Block*—The calibration block may be an actual test object with known features that are representative of the range of features to be detected, or may be fabricated to simulate the test object with a suitable range of representative features. Alternatively, the calibration block may be a one-of-a-kind or few-of-a-kind reference test object containing known imperfections that have been verified independently. Calibration blocks containing known, natural defects are useful on a single-task basis, but are not universally applicable. Where standardization among two or more radioscopic examination systems is required, a duplicate manufactured calibration block should be used. The calibration blocks should approximate the test object as closely as is practical, being made of the same material with similar dimensions and features in the radioscopic examination region of interest.

Manufactured calibration blocks should include features at least as small as those that must be reliably detected in the actual test objects in locations where they are expected to occur in the actual test object. Where features are internal to the test object, it is permissible to produce the calibration block in sections. Calibration block details are a matter of agreement between the user and supplier of radioscopic examination services.

6.2.3.1 *Use of a Calibration Block*—The calibration block should be placed into the radioscopic examination system in the same position as the actual test 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 test object so as to maximize the radioscopic examination system's response to the simulated imperfection.

6.2.3.2 *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 calibration block shall be identical to those used for the actual examination of the test object.

6.2.4 *Use of Calibrated Line Pair Test Pattern and Step Wedge*:

6.2.4.1 A calibrated line pair test pattern and step wedge may be used, if so desired, to determine and track radioscopic system performance in terms of spatial resolution and contrast sensitivity. The line pair test pattern is used without an additional absorber to evaluate system spatial resolution. The step wedge is used to evaluate system contrast sensitivity.

6.2.4.2 The step wedge must be made of the same material as the test part with steps representing 100 %, 99 %, 98 %, and 97 % of both the thickest and the thinnest material sections to be examined. The thinner steps shall be contiguous to their respective 100 % section thicknesses in order to facilitate discerning the minimum visible thickness step. Other thickness steps are permissible upon agreement between the provider and the user of radioscopic services.

6.2.4.3 The line pair test pattern and the step wedge tests shall be conducted in a manner similar to the performance measurements for the IQI or the calibration block set forth in 6.2.2 and 6.2.3. It is permissible to adjust the X-ray energy and intensity to obtain a usable line pair test pattern image brightness. In the case of a radioisotope or X-ray generating system where the energy or intensity may not be adjusted, additional filtration may be added at the radiation source to reduce the brightness to a useful level. Contrast sensitivity shall be evaluated at the same energy and intensity levels as are used for the radioscopic technique.

6.2.4.4 A system that exhibits a spatial resolution of 3 line pairs/mm, a thin section contrast sensitivity of 3 %, and a thick section contrast sensitivity of 2 % may be said to have an equivalent performance level of 3 % − 2 % − 3 lp/mm.

6.2.4.5 The line pair test pattern and the step wedge may be used to make more frequent periodic system performance checks than required in accordance with 6.2.1. Resolution and contrast sensitivity checks must be correlated with IQI or calibration block performance measurements. This may be done by first evaluating system measurement in accordance with 6.2.2 or 6.2.3 and immediately thereafter determining the equivalent spatial resolution and contrast sensitivity values.

6.2.5 *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 manual evaluation radioscopic 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 radioscopic examination images.

7. Radioscopic Examination Interpretation and Acceptance Criteria

7.1 *Interpretation*—Interpretation may be done either by an operator in a manual evaluation radioscopic environment, or by means of a computer and appropriate software in the case of an automated radioscopic 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. Recommended Practice SNT-TC-1A sets forth three levels of nondestructive testing personnel qualifications that the radioscopic 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 radioscopic 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 carried out 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

ANNEXES

(Mandatory Information)

A1. DEPARTMENT OF DEFENSE CONTRACTS, SUPPLEMENTAL REQUIREMENTS

A1.1 Scope

A1.1.1 *Purpose*—This annex is to be used in conjunction with Practice E 1255 and MIL-STD-453. It permits the use of and gives guidance on the implementation of radioscopic examination for materials, components, and assemblies, when specified in the contract documents. The radioscopic requirements described herein allow the use of radioscopy for new applications as well as to replace radiography when inspection coverage, greater throughput, or improved inspection economics can be obtained, provided a satisfactory level of image quality can be demonstrated.

A1.1.2 *Application*— This annex provides guidelines for a written practice as required in 3.2 and 5.2.1 of Practice E 1255. Should the requirements in this annex conflict with any other requirements of Practice E 1255, then Annex A1 takes precedence. The requirements of this annex are intended to control the quality of the radioscopic examination and not to specify the accept/reject criteria for the test object. Accept/reject criteria are provided in other contract documents.

A1.2 Referenced Documents

A1.2.1 In addition to those documents referenced in Practice E 1255, the following standards are applicable to the extent specified herein.

A1.2.2 *ASTM Standards:*

E 1411 Practice for Qualification of Radiographic Systems[3]

E 1453 Guide for Storage of Media that Contains Analog or Digital Radiographic Data[3]

A1.2.3 *Military Standards:*

MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification[5]

MIL-STD-453 Inspection, Radiographic[5]

DOD-STD-2167 Defense System Software Development[5]

A1.2.4 *American Welding Society Standard:*

ANSI/AWS A3.0 Welding Terms and Definitions[7]

A1.3 *Government Standards*—Unless otherwise stated, the issues of these documents are those listed in the Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the contract document.

A1.4 *Order of Precedence*—In the event of conflict between the text of this document and the references listed in A1.2.2, this document shall take precedence. However, nothing in this document shall supersede applicable laws and regulations unless a specific exemption has been obtained from the cognizant authorities.

A1.5. Terminology

A1.5.1 *component*—the test part or parts described, assembled, or processed to the extent specified by the drawing.

A1.5.2 *contracting agency*—a prime contractor, subcontractor, or government agency that procures radioscopic examination services.

A1.5.3 *contract documents*—the procuring contract and all drawings, specifications, standards, and other information included with or referred to by the procuring contract.

A1.5.4 *mandatory radioscopic examination*—those radioscopic examinations which are a part of the required radiographic examinations specified in the contract documents.

A1.5.5 *NDT facility*—the organization that is responsible for the providing of nondestructive examination services.

A1.5.6 *optional radioscopic examination*—those radioscopic examinations which are conducted for process verification or information only and are not a part of the required radiographic examination specified in the contract documents.

A1.5.7 *prime contractor*—a contractor having responsibility for the design control and delivery to the department of defense for system/equipment such as aircraft, engines, ships, tanks, vehicles, guns and missiles, ground communications and electronic systems, ground support, and test equipment.

A1.5.8 *test object*—the material, component or assembly that is the subject of the radioscopic examination.

A1.5.9 *written procedure*—in radioscopy, a series of steps that are to be followed in a regular definite order. The radioscopic system operator follows the written procedure to consistently obtain the desired results and image quality level when performing radioscopic examination. The development of a radioscopic technique usually precedes the preparation of a written procedure.

A1.5.10 Other definitions not given herein shall be as specified in Terminology E 1316.

A1.6 General Requirements

A1.6.1 *Equipment Qualification*—Radioscopic system qualification shall be in accordance with Practice E 1411 and can best be evaluated with IQIs similar to the flaw type being investigated. A common IQI is described in MIL-STD-453.

A1.6.2 *Personnel Qualification*—Radioscopic personnel shall be qualified and certified in accordance with the general requirements of MIL-STD-410, until specific requirements for radioscopy are included. Radioscopic system qualification, the development of radioscopic examination test techniques, scan plans, and the overall implementation of radioscopic examination in accordance with this annex, shall be under the control and supervision of a qualified MIL-STD-410 Level III with additional radioscopy training and experience or in conjunction with an individual having the necessary training and experience in radioscopic examination.

A1.6.3 *Safety*—The performance or radioscopic examination shall present no hazards to the safety of personnel or property. Applicable Federal, state, and local radiation safety codes shall be adhered to. All radioscopic procedures shall be

[7] Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

performed in a safe manner, such that personnel in that area are not exposed to any radiation dosage and shall in no case exceed Federal, state, and local limits.

A1.6.4 *Archival Recording of Mandatory Radioscopic Examination*—When required by contractual agreement, the radioscopic examination record shall contain the results of mandatory radioscopic examinations. The radioscopic examination record shall be suitably archived for a period of time not less than five years from the examination date or as may otherwise be required in the contract documents. Efficient radioscopic examination record recall shall be available at any time over the record retention period. The radioscopic examination record shall be traceable to the test object (by serial number or other means) or to the batch or lot number, if tested in groups. Mandatory radioscopic examinations shall be specified in the contract documents. The optional radioscopic examinations are not specified in the contract documents.

A1.6.4.1 *Radioscopic Examination Record*—The recorded radioscopic examination record for mandatory examinations shall include the written results of the radioscopic examination and the radioscopic image, if an image is utilized in the accept/reject decision-making process. The recorded radioscopic image shall be provided with such additional information as may be required to allow the subsequent off-line review of the radioscopic examination results and, if necessary, the repeating of the radioscopic examination.

A1.6.4.2 *Image Recording Media*—The radioscopic image shall be recorded on a media that is appropriate to the radioscopic examination requirement. The recorded image shall reference the examination zones in such a way that the reviewer can confirm that all zones have been covered. The recorded radioscopic image shall provide an image quality, at least equal to that, for which the radioscopic system is qualified. The recording media shall be capable of maintaining the required image quality for the required record storage period or not less than five years from the recording date. The radioscopic image record shall be maintained in an operable condition for the duration of the record storage period, measured from the date when the last radioscopic image was recorded.

A1.6.4.3 *Recording Media Storage Conditions*—Media storage and handling shall be in accordance with Guide E 1453.

A1.6.5 *Image Quality Indicators*—Image quality indicators must be chosen with care to demonstrate the radioscopic system's ability to detect discontinuities or other features that are of interest. MIL-STD-453, Practice E 1025 plaque-type, and Practice E 747 wire-type IQIs and calibration blocks with real or simulated defects, to match the application, are all acceptable unless a particular IQI is specified in the contract documents. The selected IQI or calibration block shall be detailed in the written procedure. An IQI or calibration block may not be required for the following radioscopic examinations:

A1.6.5.1 When conducting radioscopy to check for adequate defect removal or grind-out, the final acceptance radioscopic examination shall include an IQI,

A1.6.5.2 Examinations to show material details or contrast between two or more dissimilar materials, in component parts or assemblies, including honeycomb areas for the detection of fabrication irregularities or the presence or absence of material,

A1.6.5.3 Examinations of electronic components for contamination, loose or missing elements, solder balls, broken or misplaced wires or connectors, and potted assemblies for broken internal components or missing potting compound,

A1.6.5.4 Optional radioscopic examinations, and

A1.6.5.5 Where the use of an IQI is impractical or ineffective, an alternate method may be used, subject to the approval of the contracting agency.

A1.6.6 *Classification of Test Object Zones for Radioscopy*—The classification of test objects into zones for various accept/reject criteria shall be determined from the contract documents.

A1.7 Detailed Requirements

A1.7.1 *Application Qualification*:

A1.7.1.1 *New Applications*—Radioscopy may be used where appropriate for new examination requirements, provided the required performance, including image quality, can be met.

A1.7.1.2 *Replacement of Existing Radiographic Applications*—When agreed to by the contracting officer, radioscopy may be used to replace or augment existing radiographic applications, provided that the radioscopic results correlate favorably with the results obtained with X-ray film produced in accordance with MIL-STD-453. Favorable correlation means that the radioscopic and film images show similar sensitivity to test object features that are of interest.

A1.7.2 *Written Procedure*—It shall be the responsibility of the NDE facility to develop a written radioscopic examination procedure to ensure the effective and repeatable radioscopic examination of the test object. A test object scan plan for dynamic radioscopic systems, meeting the requirements of Practice E 1255, (see 5.2.1.2) shall be included in the written procedure. Those portions of the contract document that specify and detail radioscopic examination shall become an appendix to the written procedure. The written procedure must be approved by the Level III of the NDE facility. Where required, the written procedure shall be approved by the contracting agency prior to use. The written procedure shall include as a minimum the following information:

A1.7.2.1 A drawing, sketch, or photograph of the component that shows the radiation beam axis, position(s) of the detector, and applicable IQI for each and all variations of the test object orientation and beam energy. This requirement may be expressed in coordinates for automated systems having calibrated manipulation systems,

A1.7.2.2 A physical description of the test object, including size, thickness, weight, and composition,

A1.7.2.3 Classification of the test object into zones for radioscopy,

A1.7.2.4 Test part masking, if used, for each required view,

A1.7.2.5 Added radiation source collimation, expressed in terms of the radiation field dimensions at the test object source side, for each required view,

A1.7.2.6 Detector field of view for each required view,

A1.7.2.7 Detector diaphragm settings, expressed in terms of field of view at the detector, for each required view,

A1.7.2.8 The allowable range of radiation energy and beam current or source intensity and the focal spot or source size for each required view,

A1.7.2.9 Added beam filtration, if used, for each required view,

A1.7.2.10 The inspection geometry and coverage for each required view,

A1.7.2.11 Type of IQI or calibration block used and the required quality level,

A1.7.2.12 All hardware and software settings that can be changed by the operator to affect the outcome of the radioscopic examination. Such settings include, but are not limited to, video camera and display settings and image processor variables, and

A1.7.2.13 The recording media and storage image format for mandatory radioscopic image storage.

A1.7.3 *Test Object Examination*—The number of test objects to be examined and the coverage required for each test object shall be specified in the contract documents. If not specified, all test objects shall receive 100 % radioscopic coverage as detailed in the written procedure.

A1.7.4 *Image Quality*— Unless otherwise specified in the contract documents, the required image quality level is 2-2T. Image quality assessment shall be performed using the same system parameters as in the inspection and as documented in the written procedure.

A1.7.4.1 The IQI may be placed on the test object or on a mounting block, at or near the test object location, following the requirements of MIL-STD-453. In the case of small radioscopic fields of view or other situations where it is not practical to place the IQI in the field of view with the test object and maintain it normal to the X-ray beam, the IQI may be imaged immediately before and after the test object examination. Batch quantities of similar parts need not have IQI images made between each part, at the discretion of the Level III. The radioscopic examination results shall be invalid, if the before and after IQI images fail to demonstrate the required sensitivity. The before and after IQI images shall be considered a part of the test object image for radioscopic image interpretation and archiving purposes.

A1.7.4.2 With written permission from the contracting agency, other IQI's or a calibration block with natural or artificial flaws may be used instead of the specified IQI.

A1.7.5 *Radioscopic System Qualification*—The radioscopic system, including mandatory radioscopic image archiving devices, shall be qualified to the image quality level required for test object examination. Radioscopic system initial qualification shall be in accordance with Practice E 1411.

A1.7.6 *Radioscopic System Requalification*—The radioscopic system, including mandatory image archiving devices, shall be periodically requalified at intervals frequent enough to ensure the required level of radioscopic system performance. Each requalification shall be carried out in accordance with Practice E 1411.

A1.7.7 *Inspection Image Control*—The radioscopic system shall be checked for performance before each day's production usage using the method and devices that were initially used to qualify the written procedure. A log shall be maintained to document any changes in system performance requiring changes in operating parameters and listing all equipment maintenance. System requalification shall be required whenever image quality requirements can no longer be met.

A1.7.8 *Repair of Radioscopic System*—Repair or replacement of key radioscopic system components including, but not limited to, the radiation source, image forming, image transmission, image processing, and image display sub-systems shall be cause for system requalification. In no case shall the interval between qualification tests exceed one year. The qualification statement shall be posted on the radioscopic system. The results of the qualification tests shall be maintained in the radioscopic system equipment file until the completion of the next qualification procedure or the expiration of the archival image retention period, whichever is longer.

A1.7.9 *Image Interpretation*:

A1.7.9.1 *Static Imaging*— Radioscopic system qualification in accordance with Practice E 1411 applies to static imaging conditions only where the test part is stationary with respect to the X-ray beam. Therefore, all performance measurements are based upon static image quality. All mandatory radioscopic examination accept/reject decisions shall be based upon the assessment of static images.

A1.7.9.2 *Dynamic Imaging*— Dynamic or in-motion imaging may be used to gain useful information about the test object. However, unless dynamic imaging is specified, the final assessment of image formation for mandatory radioscopic examinations shall be made in the static mode. When the contracting agency specifies dynamic inspection, all aspects of the procedure must be approved by MIL-STD-410 Level III personnel. For dynamic inspection, the image quality shall be measured under the same procedure as the inspection.

A1.7.10 *Feature Size Determination*—Where feature measurement from the radioscopic image is required, the written procedure shall include methodology for determining and maintaining the accuracy of the selected measurement method.

A1.7.10.1 *Feature Measurement by Test Object Displacement*—For those radioscopic systems with calibrated manipulation systems, the more accurate, and therefore preferred, method of measurement is to manipulate the extremities of the feature to be measured to a common central reference point within the radioscopic image field of view. The dimension may then be read from the manipulation system position display.

A1.7.10.2 *Feature Measurement by Comparison*—A second method involves comparing the test object feature with a known, observable dimension which must be wholly within the radioscopic field of view. Many digital image processors facilitate this type of measurement by counting pixels over the feature length. The pixel number is often converted to engineering units by comparison with a known length. However, the orientation and position along the X-ray beam (magnification) of both the feature and the calibrating reference length affect the accuracy of such measurements.

A1.7.11 *Gray Scale Range*—The gray scale range required to meet initial qualification contrast sensitivity requirements for image quality shall be recorded and monitored. For systems using human image assessment, it is particularly important that

the gray scale range and the number of gray scale steps be closely matched to the response of the human eye. The written procedure shall include a means for monitoring the required gray scale range using a contrast sensitivity gage, step wedge, or similar device made of the test object or IQI material.

A1.7.12 *Timing of Radioscopic Examination*—Radioscopic examination shall be performed at the time of manufacturing, assembly, or rework as required by the contract documents.

A1.7.13 *Identification*— A means shall be provided for the positive identification of the test object to the archival radioscopic inspection record. Archived radioscopic images shall be annotated to agree with the test object identification.

A1.7.14 *Locating the Radioscopic Examination Areas*— Whenever more than one image is required for a weldment or other test object, location markers shall be placed on the test object in order that the orientation of the test object and the location of test object features relative to the radioscopic field of view may be established. This requirement shall not apply to automated systems having programmed radioscopic examination sequences where coverage has been proven during the development of the scan plan. Also, this requirement does not apply to the radioscopic examination of simple or small shapes where the test part orientation is obvious and coverage is not in question.

A1.7.15 *Surface Preparation*—Test objects may be inspected without surface preparation, except when required to remove surface conditions that may interfere with proper interpretation of the radioscopic image or that may create a safety hazard.

A1.7.16 *Detailed Data*— The provider of radioscopic examination services shall keep the written procedure, qualification documentation, and the signed inspection reports or tabulated results, or both, for five years from the radioscopic examination date, unless otherwise specified in the contract documents. For software-based automated radioscopic systems using custom software, a copy of the source code and the related inspection parameters shall also be maintained on file for a like period of time. This requirement shall not apply to standard commercially available software packages or to traceable software documentation which complies with DOD-STD-2167 where a separate copy of the software is maintained.

A1.7.17 *Radioscopic Reexamination of Repairs*—When repair has been performed as the result of radioscopic examination, the repaired areas shall be reexamined using the same radioscopic technique to evaluate the effectiveness of the repair. Each repaired area shall be identified with R1, R2, R3, and so forth, to indicate the number of times repair was performed.

A1.7.18 *Retention of Radioscopic Examination Records*— Mandatory radioscopic examination records and associated radioscopic images shall be stored in a proper repository at the contractor's plant for five years from the date from which they were made. Special instructions, such as storage for other periods of time, making backup copies, copying the records to other media, or having the records destroyed shall be specified in the contract documents.

A1.7.19 *Rejection of Test Objects*—Test objects containing defects exceeding the permissible limits specified in the contract documents shall be separated from acceptable material, appropriately identified as discrepant, and submitted for material review when required by the contract documents.

A1.7.20 *Reexamination*— Where there is a reasonable doubt as to the ability to interpret the radioscopic results because of improper execution or equipment malfunction, the test object shall be reexamined using the correct procedure. If the problem is not resolved by reexamination, the procedure shall be reviewed by the Level III of the NDE facility and adjusted, if necessary. Reference exposures may be made using radiography if necessary. If the reexamination was caused by equipment malfunction, the equipment may not be returned to service until the malfunction is repaired and the equipment is requalified to the current qualification requirements in accordance with to Practice E 1411.

A1.7.21 *Test Object Marking*—The marking of test objects shall be as specified in MIL-STD-453.

A1.8 Notes

A1.8.1 This section contains information of a general or explanatory nature and is not mandatory.

A1.8.1.1 **Caution**—Active electronic components and some materials, such as tetrafluoroethylene, are subject to radiation damage if exposed to large doses of radiation. While normal radioscopic examinations should cause no problem, extended periods of radiation exposure should be avoided.

A1.8.1.2 *Human Factors*— The success of radioscopic examinations which involve human image interpretation are, like radiography, subject to human factors. Careful attention should be given to the human environment where image interpretation takes place, to make it as conducive to correct, consistent image interpretation as possible. Measures should also be implemented to ensure that fatigue does not interfere with correct and consistent radioscopic image interpretation.

A1.8.1.3 *Use of IQI(s)*— As with radiography, the achievement of the required IQI sensitivity does not guarantee the ability to find all defects down to the minimum defect size. This is due to the fact that many defects, especially those of a planar nature, are very orientation sensitive. When using dynamic radioscopic systems, care must be taken to see that the scan plan includes sufficient manipulation to maximize the possibility that orientation-sensitive defects will be found. It is for this reason that the use of calibration blocks with real or simulated defects may more accurately characterize the ability of the radioscopic system to find orientation-sensitive defects when using dynamic radioscopic systems.

A1.8.1.4 *Use of Image-Processing Techniques*—Care should be exercised in applying digital image-processing techniques to evaluate the overall effect upon image quality. For example, contrast enhancement techniques may emphasize contrast in one brightness range, while decreasing contrast in other brightness ranges. Some spatial filters have directional aspects, whereby features in one direction are emphasized while those in the orthogonal direction are deemphasized. Such cautions are intended to cause the careful evaluation of digital image-processing techniques and not to discourage their use.

A1.8.1.5 *Feature Size Determination*—As with radiography, great care must be exercised in trying to assess test part feature dimensions from a two-dimensional projected view.

A2. NONGOVERNMENT CONTRACT SUPPLEMENTAL REQUIREMENTS

A2.1 Scope

A2.1.1 *Purpose*—This annex is to be used in conjunction with Practice E 1255. This annex includes application-specific details as may be agreed upon by the purchaser and the supplier of radioscopic examination services.

A2.1.2 *Application*— This document satisfies the requirements of 3.2 and 5.2.1 of Practice E 1255. Should this annex conflict with any other requirements of Practice E 1255, this annex shall prevail. The requirements of this annex are intended to control the quality of the radioscopic examination and not to specify the accept/reject criteria for the test object. Accept/reject criteria are provided in other contract documents.

A2.2. Terminology

A2.2.1 *component*—the test part or parts described, assembled, or processed to the extent specified by the drawing.

A2.2.2 *contract documents*—the procuring contract and all drawings, specifications, standards, and other information included with or referred to by the procuring contract.

A2.2.3 *contractor*—a contractor having first level responsibility for the design, manufacture, and delivery of an end item. When radioscopic examination is required, the contractor is the user of radioscopic examination services.

A2.2.4 *mandatory radioscopic examination*—those radioscopic examinations which are a part of the required radiographic examinations specified in the contract documents.

A2.2.5 *NDE facility*—the organization that is responsible for providing nondestructive examination services.

A2.2.6 *optional radioscopic examination*—those radioscopic examinations that are conducted for process verification or information only and are not a part of the required radiographic examinations specified in the contract documents.

A2.2.7 *provider of radioscopic services*—a contractor, subcontractor or other entity that provides radioscopic examination services.

A2.2.8 *test object*—the material, component, or assembly that is the subject of the radioscopic examination.

A2.2.9 *user of radioscopic services*—a contractor, subcontractor, or other entity that procures radioscopic examination services. The provider and user of radioscopic examination services may be a part of the same organization or different organizations.

A2.2.10 *written procedure*—in radioscopy, a series of steps that are to be followed in a regular definite order. The radioscopic system operator follows the written procedure to consistently obtain the desired results and image quality level when performing radioscopic examination. The development of a radioscopic technique usually precedes the preparation of a written procedure.

A2.2.11 Other definitions not given herein shall be as specified in Terminology E 1316.

A2.3 General Requirements

A2.3.1 *Equipment Qualification*—Radioscopic system qualification shall be in accordance with Practice E 1411, using Practice E 747 and Practice E 1025 image quality indicators or a calibration block containing actual or simulated defects.

A2.3.2 *Personnel Qualification*—Radioscopic personnel shall be qualified and certified in accordance with the requirements of SNT-TC-1A or ANSI/ASNT CP-189. Radioscopic system qualification, the development of radioscopic examination test techniques, scan plans, and the overall implementation of radioscopic examination in accordance with this annex shall be under the control and supervision of a qualified Level III with additional radioscopy training and experience or, in conjunction with an individual having the necessary training and experience in radioscopic examination. Operation of the radioscopic system, including interpretation of the radioscopic image, shall be made by qualified Level II personnel.

A2.3.3 *Safety*—The performance of radioscopic examination shall present no hazards to the safety of personnel or property. Applicable Federal, state, and local radiation safety codes shall be adhered to. All radioscopic procedures shall be performed so that personnel shall receive the minimum dosage and in no case exceed Federal, state, and local limits.

A2.3.4 *Archival Recording of Mandatory Radioscopic Examinations*—The radioscopic examination record shall contain the results for mandatory radioscopic examinations. The radioscopic examination record shall be suitably archived for a period of one year after the date of radioscopic examination or for a longer time if specified in the contract documents. Efficient radioscopic examination record recall shall be available at any time over the record retention period. The radioscopic examination record shall be traceable to the test object by serial number or other means. This requirement will not apply to optional radioscopic examinations that are not specified in the contract documents.

A2.3.4.1 *Radioscopic Examination Record*—The recorded radioscopic examination record for mandatory examinations shall include the written results of the radioscopic examination and the radioscopic image, if an image is utilized in the accept/reject decision-making process. The recorded radioscopic image shall be provided with such additional information as may be required to allow the subsequent off-line review of the radioscopic examination results and, if necessary, the repeating of the radioscopic examination.

A2.3.4.2 *Image Recording Media*—The radioscopic image shall be recorded on a media that is appropriate to the radioscopic examination requirement. The recorded image shall reference the examination zones in such a way that the reviewer can confirm that all zones have been covered. The recorded radioscopic image shall provide an image quality at least equal to that for which the radioscopic system is qualified. The recording media shall be capable of maintaining the required image quality for the required record storage period or not less than five years from the recording date. The recorded radioscopic image playback shall be maintained in an operable condition for the duration of the record storage period measured from the date when the last radioscopic image was recorded.

A2.3.4.3 *Recording Media Storage Conditions*—Media

storage and handling shall be in accordance with Guide E 1453.

A2.3.4.4 *Other Recording*— Where the recording of the radioscopic examination record is not in fulfillment of mandatory archival recording requirements, other recording methods and media may be used.

A2.3.5 *Image Quality Indicators*—An IQI must be chosen with care to demonstrate the radioscopic system's ability to detect discontinuities, or other features of interest. Practice E 1025 plaque-type and Practice E 747 wire-type IQIs and calibration blocks with real or simulated defects that match the application are all acceptable unless a specific IQI is specified in the contract documents. The selected IQI or calibration block shall be detailed in the written procedure. An IQI or calibration block may not be required for the following radioscopic examinations:

A2.3.5.1 Examining assemblies for debris or foreign objects.

A2.3.5.2 Conducting radioscopy for adequate defect removal or grind-out. However, the final acceptance radioscopic examination shall include an IQI.

A2.3.5.3 Examinations to show material details or contrast between two or more dissimilar materials in component parts or assemblies including honeycomb areas for the detection of fabrication irregularities or the presence or absence of material.

A2.3.5.4 Examining electronic components for contamination, loose or missing elements, solder balls, broken or misplaced wires, or connectors and potted assemblies for broken internal components or missing potting compound.

A2.3.5.5 Optional radioscopic examinations.

A2.3.5.6 Where the use of an IQI is impractical or ineffective, an alternate method may be used, subject to the approval of the contracting agency.

A2.3.6 *Classification of Test Object Zones for Radioscopy*—The classification of test objects into zones for various accept/reject criteria shall be determined from the contract documents. In cases where no accept/reject criteria is specified, the Level III of the NDE facility shall document those anomalies considered critical and indicate in writing that no formal accept/reject criteria was provided.

A2.4 Detailed Requirements

A2.4.1 *Application Qualification*—Radioscopy may be used where appropriate for new as well as existing radiographic examination requirements provided that the required performance, including image quality, can be met. Where radioscopy is used to replace or augment existing radiographic applications, the radioscopic results should correlate favorably with the results obtained with radiographic film-produced techniques. Favorable correlation means that the radioscopic and film images show similar sensitivity to test object features which are of interest.

A2.4.2 *Written Procedure*—It shall be the responsibility of the NDE facility to develop a written radioscopic examination procedure to ensure the effective and repeatable radioscopic examination of the test object. When a dynamic radioscopic system is used, a test object scan plan meeting the requirements of Practice E 1255 (see 5.2.1.2) shall be included in the written procedure. Those portions of the contract document that specify and detail radioscopic examination shall become an appendix to the written procedure. The written procedure must be written or approved by the Level III of the NDE facility. Where required, the written procedure shall be approved by the contracting agency prior to use. The written procedure shall include as a minimum the following information:

A2.4.2.1 A drawing, sketch, or photograph of the component that shows the radiation beam axis, position(s) of the detector and applicable IQI for each and all variations of the test object orientation, and beam energy. This requirement may be expressed in coordinates for automated systems having calibrated manipulation systems.

A2.4.2.2 A physical description of the test object including size, weight, and composition.

A2.4.2.3 Classification of test object into zones for radioscopy.

A2.4.2.4 Test part masking, if used, for each required view.

A2.4.2.5 Added radiation source collimation, expressed in terms of the radiation field dimensions at the test object source side for each required view.

A2.4.2.6 Detector field of view for each required view.

A2.4.2.7 Detector diaphragm settings, expressed in terms of field of view at the detector for each required view.

A2.4.2.8 The allowable range of radiation energy and beam current or source intensity and the focal spot or source size for each required view.

A2.4.2.9 Added beam filtration, if used, for each required view.

A2.4.2.10 The inspection geometry and coverage for each required view.

A2.4.2.11 Type of IQI or calibration block used and the required quality level.

A2.4.2.12 All hardware and software settings which can be changed by the operator to affect the outcome of the radioscopic examination. Such settings include, but are not limited to, video camera, display settings, and image processor variables.

A2.4.2.13 The recording media and stored image format for mandatory radioscopic image storage.

A2.4.3 *Test Object Examination*—The number of test objects to be examined and the coverage required for each test object shall be specified in the contract documents. If not specified, all test objects shall receive 100 % radioscopic coverage as detailed in the written procedure.

A2.4.4 *Image Quality*— Unless otherwise specified in the contract documents, the required image quality level is 2-2T. Image quality assessment shall be made in the same mode as that used for the inspection.

A2.4.4.1 The IQI may be placed on the test object or on a mounting block at or near the test object location. In the case of small radioscopic fields of view or other situations where it is not practical to place the IQI in the field of view with the test object and maintain it normal to the X-ray beam, the IQI may be imaged immediately before and after the test object examination or batch of test objects if they are similar. The radioscopic examination results shall be invalid if the before and after IQI images fail to demonstrate the required sensitivity. Before and after IQI images shall be considered a part of

the test object image for radioscopic image interpretation and archiving purposes.

A2.4.5 *Radioscopic System Qualification*—The radioscopic system including mandatory radioscopic image archiving devices shall be qualified to the image quality level required for test object examination. Radioscopic system initial qualification and periodic requalification shall be in accordance with Practice E 1411.

A2.4.6 *Radioscopic System Requalification*—The radioscopic system, including mandatory image archiving devices, shall be periodically requalified at intervals frequent enough to ensure the required level of radioscopic system performance.

A2.4.7 *Inspection Image Control*—The radioscopic system shall be checked for performance before each day's production usage using the method and devices that were initially used to qualify the written procedure. A log shall be maintained to document any changes in system performance requiring changes in operating parameters and listing all equipment maintenance. System requalification shall be required whenever image quality requirements can no longer be met.

A2.4.8 *Repair of Radioscopic System*—Repair or replacement of key radioscopic system components including but not limited to the radiation source, image forming, image transmission, image processing, and image display sub-systems shall be cause for system requalification. In no case shall the interval between qualification tests exceed one year. The qualification statement shall be posted on the radioscopic system. The results of the qualification tests shall be maintained in the radioscopic system equipment file at least until completion of the next qualification procedure or the expiration of the archival image retention period, whichever is longer.

A2.4.9 *Image Interpretation*:

A2.4.9.1 *Static Imaging*— Radioscopic system qualification in accordance with Practice E 1411 applies to static imaging conditions, only where the test part is stationary with respect to the X-ray beam. Therefore, all performance measurements are based upon static image quality. All mandatory radioscopic examination accept/reject decisions shall be based upon the assessment of static images.

A2.4.9.2 *Dynamic Imaging*— Dynamic or in-motion imaging may be used to gain useful information about the test object. However, the final assessment of image information for mandatory radioscopic examinations shall be made in the static mode.

A2.4.10 *Feature Size Determination*—Where feature measurement from the radioscopic image is required, the written procedure shall include methodology for determining and maintaining the accuracy of the selected measurement method.

A2.4.10.1 *Feature Measurement by Test Object Displacement*—For those radioscopic systems with calibrated manipulation systems, the more accurate and therefore preferred method of measurement is to manipulate the extremities of the feature to be measured to a common central reference point within the radioscopic image field of view. The dimension may then be read from the manipulation system position display.

A2.4.10.2 *Feature Measurement by Comparison*—A second method involves comparing the test object feature with a known, observable dimension which must be wholly within the radioscopic field of view. Many digital image processors facilitate this type of measurement by counting pixels over the feature length. The pixel number is often converted to engineering units by comparison with a known length. However, the orientation and position along the X-ray beam (magnification) of both the feature and the calibrating reference length affect the accuracy of such measurements.

A2.4.11 *Gray Scale Range*—The gray scale range required to meet initial qualification contrast sensitivity requirements for image quality shall be recorded and monitored. For systems using human image assessment, it is particularly important that the gray scale range and the number of gray scale steps be closely matched to the response of the human eye. The written procedure shall include a means for monitoring the required gray scale range using a contrast sensitivity gage, step wedge, or similar device made of the test object or IQI material.

A2.4.12 *Timing of Radioscopic Examination*—Radioscopic examination shall be performed at the time of manufacturing, assembly, or rework as required by the contract documents.

A2.4.13 *Identification*— A means shall be provided for the positive identification of the test object to the archival radioscopic inspection record. Archived radioscopic images shall be annotated to agree with the test object identification.

A2.4.14 *Locating the Radioscopic Examination Areas*—Whenever more than one image is required for a weldment or other test object, location markers shall be placed on the test object in order that the orientation of the test object and the location of test object features relative to the radioscopic field of view may be established. This requirement shall not apply to automated systems having programmed radioscopic examination sequences where coverage has been proven during the development of the scan plan. Also, this requirement does not apply to the radioscopic examination of simple or small shapes where the test part orientation is obvious and coverage is not in question.

A2.4.15 *Surface Preparation*—Test objects may be inspected without surface preparation except as may be required to remove surface conditions which may interfere with proper interpretation of the radioscopic image or create a safety hazard.

A2.4.16 *Detailed Data*— The provider of radioscopic examination services shall keep the written procedure, qualification documentation, and the signed inspection reports or tabulated results for five years from the radioscopic examination date unless otherwise specified in the contract documents. For software-based automated radioscopic systems using custom software, a copy of the source code and the related inspection parameters shall also be maintained on file for a like period of time. This requirement shall not apply to standard commercially available software packages where a separate copy of the software is maintained.

A2.4.17 *Radioscopic Reexamination of Repairs*—When repair has been performed as the result of radioscopic examination, the repaired areas shall be reexamined using the same radioscopic technique to evaluate the effectiveness of the repair. Each repaired area shall be identified with R1, R2, R3,

and so forth, to indicate the number of times repair was performed.

A2.4.18 *Retention of Radioscopic Examination Record*—Mandatory radioscopic examination records and associated radioscopic images shall be stored in a proper repository at the contractor's plant for one year from the date from which they were made. Special instructions, such as storage for other periods of time, making backup copies, copying the records to other media, or having the records destroyed shall be specified in the contract documents.

A2.4.19 *Rejection of Test Objects*—Test objects containing defects exceeding the permissible limits specified in the contract documents shall be separated from acceptable material, appropriately identified as discrepant, and submitted for material review when required by the contract documents.

A2.4.20 *Reexamination*— Where there is an inability to interpret the radioscopic results because of improper execution or equipment malfunction, the test object shall be reexamined using the correct procedure. If the problem is not resolved by reexamination, the procedure shall be reviewed by the Level III of the NDE facility and adjusted, if necessary. Reference exposures may be made using radiography if necessary. If the reexamination was caused by equipment malfunction, the equipment may not be returned to service until the malfunction is repaired and the equipment is requalified to the current qualification requirements in accordance with Practice E 1411.

A2.4.21 *Test Object Disposition*—Test objects that have undergone radioscopic examination shall be marked or physically separated in such a manner so as to minimize the possibility of rejected or questionable test objects being confused with acceptable ones.

A2.5 Notes

A2.5.1 This section contains information of a general or explanatory nature and is not mandatory.

A2.5.1.1 *Caution*—Active electronic components and some materials, such as tetrafluoroethylene, are subject to radiation damage if exposed to large doses of radiation. While normal radioscopic examinations should cause no problem, extended periods of radiation exposure should be avoided.

A2.5.1.2 *Human Factors*— The success of radioscopic examinations which involve human image interpretation are, like radiography, subject to human factors. Careful attention should be given to the human environment where image interpretation takes place, to make it as conducive to correct, consistent image interpretation as possible. Measures should also be implemented to ensure that fatigue does not interfere with correct and consistent radioscopic image interpretation.

A2.5.1.3 *Use of IQI*— As with radiography, the achievement of the required IQI sensitivity does not guarantee the ability to find all defects down to the minimum defect size. This is due to the fact that many defects, especially those of a planar nature, are very orientation sensitive. When a dynamic radioscopic system is used, care must be taken to see that the scan plan includes sufficient manipulation to maximize the possibility that orientation-sensitive defects will be found. It is for this reason that the use of calibration blocks with real or simulated defects may more accurately characterize the ability of the radioscopic system to find orientation-sensitive defects.

A2.5.1.4 *Use of Image-Processing Techniques*—Care should be exercised in applying digital image-processing techniques to evaluate the overall effect upon image quality. For example, contrast enhancement techniques may emphasize contrast in one brightness range while decreasing contrast in other brightness ranges. Some spatial filters have directional aspects whereby features in one direction are emphasized while those in the orthogonal direction are deemphasized. Such cautions are intended to cause the careful evaluation of digital image-processing techniques and not to discourage their use.

A2.5.1.5 *Feature Size Determination*—As with radiography, great care must be exercised in trying to assess test part feature dimensions from a two-dimensional projected view.