Designation: E2033 – 17

Standard Practice for Radiographic Examination Using Computed Radiography (Photostimulable Luminescence Method)[1]

This standard is issued under the fixed designation E2033; 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 establishes the minimum requirements for computed radiographic (CR) examination for metallic and nonmetallic materials using X-ray or gamma radiation.

1.2 *Applicability*—The requirements in this practice are intended to control the quality of computed radiographic examinations and are not intended to establish acceptance criteria for parts or materials.

1.3 *Basis of Application*—The requirements of this practice, Practice E2445 and E2446 shall be used together. The requirements of Practice E2445 will provide the baseline performance evaluation and long term stability test procedures for the CR system. Practice E2446 CR performance levels are recommended in Table 1. The user of the CR system shall establish a written procedure that addresses the specific requirements and tests to be used in their application and shall be approved by the Cognizant Radiographic Level 3 before examination of production hardware. The items that shall be determined and addressed in the written procedure are:

(a) Personnel qualification and certification.

(b) Minimum effective pixel coverage appropriate to the acceptance criteria and to meet the radiographic image quality level requirements of Table 1.

(c) Additional tests per Practice E2445 deemed appropriate.

(d) Organizations using a gamma source or radiation energy above 320 kV may need to modify the E2445 tests, gauges, or both.

(e) Maximum allowed unsharpness when other than Table 1.

(f) The method used to provide image traceability to the part and the examination facility.

1.3.1 This practice also requires the user to perform a system qualification suitable for its intended purpose and to issue a system qualification report (see subsection 7.1). Additionally, the user shall develop part specific inspection procedures (see subsections 5.5 and 7.5).

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

1.5 *Compliance*—Systems, equipment and materials that do not comply with this practice shall require a waiver from the Cognizant Engineering Organization (CEO).

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E746 Practice for Determining Relative Image Quality Response of Industrial Radiographic Imaging Systems

E747 Practice for Design, Manufacture and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology

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

E1030 Practice for Radiographic Examination of Metallic Castings

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

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

TABLE 1 Total Image Unsharpness, Maximum

Material Thickness	Maximum Allowed Image Unsharpness ($U_T^{20\%}$ or U_{Im})	Recommended CR Performance Level per E2446
≤ 0.5 inch [≤ 12.7 mm]	0.010 inch [0.254 mm]	CR level I or Higher
> 0.5 through 1 inch [> 12.7 through 25.4 mm]	0.015 inch [0.381 mm]	CR level I or Higher
> 1 through 2 inches [> 25.4 through 50.8 mm]	0.020 inch [0.508 mm]	CR level II or Higher
> 2 through 4 inches [> 50.8 through 101.6 mm]	0.030 inch [0.762 mm]	CR level II or Higher
> 4 inches [> 101.6 mm]	0.040 inch [1.016 mm]	CR level II or Higher

E1032 Test Method for Radiographic Examination of Weldments
E1114 Test Method for Determining the Size of Iridium-192 Industrial Radiographic Sources
E1161 Practice for Radiologic Examination of Semiconductors and Electronic Components
E1165 Test Method for Measurement of Focal Spots of Industrial X-Ray Tubes by Pinhole Imaging
E1316 Terminology for Nondestructive Examinations
E1647 Practice for Determining Contrast Sensitivity in Radiology
E1735 Test Method for Determining Relative Image Quality of Industrial Radiographic Film Exposed to X-Radiation from 4 to 25 MeV
E1742 Practice for Radiographic Examination
E1817 Practice for Controlling Quality of Radiological Examination by Using Representative Quality Indicators (RQIs)
E2002 Practice for Determining Total Image Unsharpness and Basic Spatial Resolution in Radiography and Radioscopy
E2339 Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE)
E2445 Practice for Performance Evaluation and Long-Term Stability of Computed Radiography Systems
E2446 Practice for Manufacturing Characterization of Computed Radiography Systems
E2736 Guide for Digital Detector Array Radiology
E2738 Practice for Digital Imaging and Communication Nondestructive Evaluation (DICONDE) for Computed Radiography (CR) Test Methods
E2903 Test Method for Measurement of the Effective Focal Spot Size of Mini and Micro Focus X-ray Tubes

2.2 *ASNT Standards:*[3]
ANSI/ASNT-CP-189 Standard for Qualification and Certification of Nondestructive Testing Personnel
SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing

2.3 *Aerospace Industries Association of America Document:*[4]
NAS-410 Certification and Qualification of Nondestructive Testing Personnel

2.4 *Society of Motion Picture and Television Engineers (SMPTE):*[5]
RP133 Specifications for Medical Diagnostic Imaging Test Pattern for Television Monitors and Hard Copy Recording Cameras

2.5 *Government Documents:*[6]
NCRP 116 Limitation to Exposure to Ionizing Radiation
NCRP 147 Structural Shielding Design for Medical X-ray Imaging Facilities

2.6 *ISO Documents:*[7]
ISO 9712 Non-destructive Testing—Qualification and Certification of NDT Personnel
ISO 10012 Measurement Management Systems—Requirements for Measurement Processes and Measuring Equipment
ISO 17636-2 Non-destructive Testing of Welds—Radiographic Testing—Part 2: X- and Gamma-Ray Techniques with Digital Detectors
ISO 19232-1 Non-destructive Testing—Image Quality of Radiographs—Part 1: Determination of the Image Quality Value Using Wire-type Image Quality Indicators
ISO 19232-2 Non-destructive Testing—Image Quality of Radiographs—Part 2: Determination of the Image Quality Value Using Step/Hole-Type Image Quality Indicators

2.7 *EN Documents:*[8]
EN 4179 Aerospace Series—Qualification and Approval of Personnel for Non-destructive Testing
EN 12543-2 Non-destructive Testing—Characteristics of Focal Spots in Industrial X-ray Systems for Use in Non-destructive Testing—Part 2: Pinhole Camera Radiographic Method
EN 12543-5 Non-destructive Testing—Characteristics of Focal Spots in Industrial X-ray Systems for Use in Non-destructive Testing—Part 5: Measurement of the Effective Focal Spot Size of Mini and Micro Focus X-ray Tubes.

[3] Available from American Society for Nondestructive Testing, 1711 Arlingate Plaza, P.O. Box 28518, Columbus, OH 43228-0518.
[4] Available from Aerospace Industries Association of America, Inc., 1250 Eye St. NW, Washington, D.C. 20005.
[5] Available from Society of Motion Picture and Television Engineers, 3 Barker Ave, White Plains, NY 10601.
[6] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.
[7] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.
[8] Available from British Standards Institution (BSI), 389 Chiswick High Rd., London W4 4AL, U.K., http://www.bsigroup.com.

2.8 *ANSI Documents:*[9]
Z540–3 Requirements for the Calibration of Measuring and Test Equipment

3. Terminology

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

3.1.1 *1:1*—an image display scenario where a single pixel of the image is mapped to a single pixel on the image display monitor.

3.1.2 *Cognizant Radiographic Level 3*—the certified level 3 radiographer holding final technical responsibility for the radiographic facility and staff.

3.1.3 *Effective Pixel Size*—effective pixel size is equal to the basic spatial resolution of the detector ($SR_b^{detector}$).

3.1.4 *Fast Scan Direction*—the fast scan direction refers to the laser scan direction along an image line of the IP. This may also be referred to as "laser scan direction."

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

3.1.6 *Pixel Coverage*—for the purpose of this practice, the term "pixel coverage" refers to the minimum number of effective pixels required to cover a feature such as a critical flaw size or the IQI designated hole or essential wire size, whichever is smallest. Geometric magnification may be required to achieve adequate pixel coverage. Additional information on pixel coverage and geometric magnification can be found in Guide E2736.

3.1.7 *Slow Scan Direction*—Slow scan direction refers to the mechanical transport direction of the IP through the scanner. This may also be referred to as "IP transport direction."

4. Summary of Practice

4.1 *Apparatus*—This practice covers application details for computed radiography using a system that consists of a radiation source, a storage phosphor imaging plate (IP) and cassette, an IP scanner/digitizer, scan parameter settings, a workstation with software, an image display monitor, and a digital image archiving system.

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

5. Significance and Use

5.1 This practice establishes the basic parameters for the application and control of the CR examination method. This practice is written so it can be specified on the engineering drawing, specification, or contract.

5.2 *Weld Examination*—Additional information on weld examination may be found in Practice E1032, ISO 17636-2, or both.

5.3 *Casting Examination*—Additional information on casting examination may be found in Practice E1030.

5.4 *Electronic Components*—Radiographic examination of electronic components shall comply with Practice E1161.

5.5 *Part-Specific Examination Technique*—A detailed written procedure in the form of a part-specific examination technique (7.5) shall be documented for each part, or group of parts, and shall be approved by the Cognizant Radiographic Level 3.

5.6 *Personnel Qualification*—Personnel performing examinations to this practice shall be qualified in accordance with ISO 9712, NAS 410, EN 4179, ANSI/ASNT CP 189, or SNT-TC-1A and certified by the employer or certifying agency as applicable. Other equivalent qualification documents may be used when specified on the contract or purchase order. The applicable revision shall be the latest unless otherwise specified in the contractual agreement between parties.

5.7 *System Qualification*—All CR systems shall be qualified for their intended use. System qualification requirements are specified in subsection 7.1.

5.8 *Process Control*—All CR systems shall be monitored for long term stability (process control) as specified in subsection 7.1.4.

5.9 *Preventative Maintenance*—All CR systems and X-ray machines require periodic maintenance to ensure proper functionality. Preventative maintenance requirements are specified in subsection 6.2.

5.10 *Environmental Conditions*—CR systems should be operated within environmental conditions that are in compliance with manufacturer's stated acceptable environmental conditions, e.g., temperature and humidity. When CR systems are operated outside the specified manufacturer's environmental ranges, the system shall be qualified (7.1) for such conditions.

6. Equipment and Facilities

6.1 *Equipment:*

6.1.1 *X-Radiation Sources*—Selection of appropriate X-ray machine parameters (e.g., voltage, current, focal spot) is dependent upon the examination requirements for the specimen being examined (e.g., material type, geometry, acceptance criteria). The suitability of any X-ray machine and the examination technique parameters shall be demonstrated by attainment of the required radiographic quality level and compliance with all other requirements specified herein.

6.1.2 *Gamma Radiation Sources*—Selection of an appropriate isotope source (e.g., energy, source size) is dependent upon the examination requirements for the specimen being examined (e.g., material type, geometry, acceptance criteria). The suitability of any gamma ray source and the examination technique

[9] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

parameters shall be demonstrated by attainment of the required radiographic quality level and compliance with all other requirements specified herein.

6.1.3 *Computed Radiography Scanner*—Selection of an appropriate CR scanner is dependent upon the examination requirements for the specimen being examined (e.g., material type, geometry, acceptance criteria). The suitability of the CR scanner and the examination technique parameters shall be demonstrated by attainment of the required radiographic quality level and compliance with all other requirements specified herein.

6.1.3.1 The minimum acquisition bit depth of the CR scanner shall be 12.

6.1.3.2 *Discussion:* Guidance for appropriate CR scanner capability may be found in subsection 7.6 and Table 3 for radiographic quality level requirements, Table 1 for recommended CR performance levels, and subsection 7.5 for the examination technique requirements.

6.1.4 *Storage Phosphor Imaging Plate (IP)*—IPs selected for application to this practice shall meet the requirements of the CR scanner manufacturer.

6.1.4.1 *IP Storage and Handling*—IPs should be stored flat (not bent or curled) and in a manner that will not induce pressure marks (e.g., vertical storage or storage in non-crushable containers if stacked) when not in use. The IP storage area shall be free of radiation. IPs should be handled with care in order to prevent crimp marks or other surface flaws that will render image artifacts.

6.1.4.2 *IP Cleaning Materials*—Only manufacturer-approved IP cleaning materials shall be used. Care shall be taken to not over-clean IPs in such a way as to damage or remove the clear protective coating.

TABLE 3 Radiographic Quality Levels

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

[A]1/50th (2%) of specimen thickness, except the minimum thickness may be 0.005 in. [0.127 mm].
[B]The hole, expressed as a multiple thickness of the IQI that shall be clearly visible, except the minimum hole sizes may be 0.010 in. [0.254 mm], 0.020 in. [0.508 mm], and 0.040 in. [1.016 mm].
[C]Equivalent IQI (Penetrameter) Sensitivity (EPS) is the thickness of the IQI expressed as a percentage of specimen thickness at which a 2T hole would be clearly visible under the same radiographic conditions–see Practice E1025, Appendix X1.
[D]When using Wire Type IQIs, Table 4 of Practice E747 shall be used to determine equivalent wire size to corresponding 1T, 2T or 4T hole size.
[E]EPS values shown above are not applicable for material thicknesses below 0.500 inch [12.7 mm] when using standard Hole Type IQIs with minimum thickness and hole size (Note A & B).

6.1.4.3 *IP Artifacts*—When IPs are tested for artifacts, compliance with Practice E2445 shall be required. IPs with artifacts that interfere with interpretation in the Area of Interest (AOI) are not acceptable.

6.1.5 *IP Cassettes*—IP cassettes shall be clean, light tight, and constructed of materials that do not interfere with the quality of the radiographic image. Cassettes that exhibit light leaks shall be repaired or discarded.

6.1.6 *IP Cassette Screens*—Front or back metallic screens, or both, should be used with IPs whenever they improve radiographic image quality.

TABLE 2 Calibration and Process Control

Check	Method	Frequency	Subsection
Image Display Monitor:			
Brightness	Light Meter	Monthly	6.1.8.1
Contrast	Light Meter	Monthly	6.1.8.2
High Contrast Resolution	Visual	Daily[A]	6.1.8.3
Low Contrast Resolution	Visual	Daily[A]	6.1.8.4
Flicker	Visual	Daily[A]	6.1.8.5
Distortion	Visual	Daily[A]	6.1.8.5
Small Contrast Change	Visual	Daily[A]	6.1.8.6
Light Meter(s)	Calibration	6 months	6.1.10
Image Quality Indicators	Certified	When Procured	6.1.11
	Visual	Prior to Use[A]	6.1.11
Representative Quality Indicators	Visual	Prior to Use[A]	6.1.12
Relative Image Quality Indicators	Certified	When Procured	6.1.13
	Visual	Prior to Use[A]	6.1.13
RIQI Absorber Plate	Certified	When Procured	6.1.13.1
	Visual	Prior to Use[A]	6.1.14
Duplex Wire Gauge	Certified	When Procured	6.1.14
	Visual	Prior to Use[A]	6.1.14
CR Phantom	Certified	When Procured	6.1.15
	Visual	Prior to Use[A]	6.1.15
Reference Standard	Calibration	[B]	6.1.16
Measurement Tools	Calibration	[B]	6.1.17
Contrast Sensitivity Gauge	Certified	When Procured	6.1.18
	Visual	Prior to Use[A]	6.1.18
Miscellaneous Radiographic Tools	Visual	Prior to Use[A]	6.1.19
Background Ambient Light	Light Meter	6 months[C]	6.3.3.1

[A]Documentation of this check is not required.
[B]Calibrated and recorded in accordance with ANSI Z540-3 or ISO 10012, as applicable.
[C]Fixed viewing locations with acceptable and controlled ambient lighting conditions need not be re-verified as long as those conditions are maintained.

6.1.6.1 Screens shall be visibly free of any cracks, creases, scratches, or foreign materials that would create image artifacts.

6.1.6.2 *Discussion*—For the purpose of this practice, when a metallic screen is used inside the cassette in front of the IP, it shall be referred to as a screen, when used in front of the cassette it shall be referred to as a filter. Back screens, whether inside the cassette or outside the cassette are considered shielding for backscattered radiation.

6.1.7 *Filters*—Filters should be used at the radiation source whenever they improve radiographic image quality. Filters shall be free of any cracks, creases, scratches, or foreign materials that could create image artifacts.

6.1.8 *Image Display Monitor*—The image display monitor used for accept/reject evaluations shall be tested in accordance with Table 2 and shall meet the following minimum requirements:

6.1.8.1 *Brightness:* The minimum brightness at maximum Digital Driving Level (DDL) shall be 250 cd/m^2,

6.1.8.2 *Contrast:* The minimum contrast as determined by the ratio of the brightness at maximum DDL compared to the brightness at the minimum DDL shall be at least 250:1,

6.1.8.3 *High Contrast Resolution:* The image display monitor shall be capable of displaying linear patterns of alternating pixels at full contrast (modulation depth of 100%) without aliasing in both the horizontal and vertical directions at the display center and at each of the four corners,

6.1.8.4 *Low Contrast Resolution:* The image display monitor shall be capable of discriminating linear patterns of alternating pixels at low contrast (1% modulation patterns where white equals 51% DDL and black equals 50% DDL) in both the horizontal and vertical directions at the display center and each of the four corners,

6.1.8.5 *Flicker and Distortion:* The image display monitor shall be free of screen flicker and discernible geometric distortions, and,

6.1.8.6 *Small Contrast Changes:* The image display monitor shall be capable of displaying a 5% DDL block against a 0% DDL background while simultaneously displaying a 95% DDL block against a 100% background in a manner that is clearly perceptible to the user.

6.1.9 *Image Display Monitor Test Pattern*—The test pattern for measuring the image display monitor requirements of subsection 6.1.8 shall comply with SMPTE RP 133 and shall be configured to the image display monitors resolution and aspect ratio. The test pattern shall be viewed at 1:1 digital zoom. Alternate test patterns may be used when approved by the Cognizant Radiographic Level 3 provided they include the features described in SMPTE RP 133 required to perform the image display tests specified herein.

6.1.10 *Light Meters:*

6.1.10.1 *Luminance*—A calibrated light meter shall be used to measure image display monitors for brightness and contrast and shall measure luminance in candelas per square meter (cd/m^2) or foot-lamberts.

6.1.10.2 *Illuminance*—A calibrated light meter shall be used to measure ambient background lighting and shall measure illuminance in lux [lumens/m^2] or in foot candles (fc).

6.1.10.3 Calibration frequency for light meters is listed in Table 2.

6.1.11 *Image Quality Indicators (IQIs)*—A Certificate of Compliance (COC) is required to verify material type and dimensional accuracy. A means to trace COCs to individual IQIs shall be provided. Users shall visually inspect IQIs for damage and cleanliness in accordance with Table 2.

6.1.11.1 *Hole-Type IQIs*—Hole-type IQIs shall comply with Practice E1025, Practice E1742 Annex A1, or ISO 19232-2, however, the minimum thickness may be 0.005 in. [0.127 mm] and the minimum hole sizes may be 0.010 in. [0.254 mm], 0.020 in. [0.508 mm] and 0.040 in. [1.016 mm].

6.1.11.2 *Wire-Type IQIs*—Wire-type IQIs shall comply with Practice E747 or ISO 19232-1 and shall be correlated to hole-type radiographic quality levels.

6.1.11.3 *IQI and Shim Material*—IQIs and shims shall be of the same material group as the specimen being examined. When IQIs and shims of the same material group are not available, radiographically similar IQIs and shims as defined in Practice E1025 may be used. IQIs and shims of radiographically less dense material than the subject shall be allowed.

6.1.11.4 *IQI Shims*—Shims used with IQIs shall exceed the IQI dimensions such that the pertinent features of the IQI are visible in the image.

6.1.12 *Representative Quality Indicators (RQIs)*—When used, RQIs shall comply with the requirements of Practice E1817. Users shall visually inspect RQIs for damage and cleanliness in accordance with Table 2.

6.1.13 *Relative Image Quality Indicators (RIQIs)*—All RIQIs shall comply with the requirements of Practices E746 or E1735 as applicable, except the material type may be of any material deemed appropriate by the Cognizant Radiographic Level 3. A COC is required to verify material type and dimensional accuracy. Users shall visually inspect RIQIs for damage and cleanliness in accordance with Table 2.

6.1.13.1 *RIQI Absorber Plate*—The absorber plate shall be of the same material group or radiographically similar material as the RIQIs. Dimensions and surface finish shall comply with Practice E746 or E1735 as applicable. Other thicknesses may be used when approved by the Cognizant Radiographic Level 3. A COC is required to verify material type and dimensional accuracy and surface finish. Users shall visually inspect the RIQI absorber plate for damage and cleanliness in accordance with Table 2.

6.1.14 *Duplex Wire Gauge (DWG)*—Spatial resolution and unsharpness measurements shall be performed using a DWG that complies with Practice E2002. A COC is required to verify dimensional accuracy. Users shall visually inspect the DWG for damage and cleanliness in accordance with Table 2.

6.1.15 *CR Test Phantom*—The CR test phantom shall comply with Practice E2445. Either the Type I or the Type II CR test phantom is acceptable for compliance to this practice. A COC is required to verify dimensional accuracy and compliance to E2445. Users shall visually inspect the CR test phantom for damage and cleanliness in accordance with Table 2.

6.1.15.1 In the event an E2445 compliant CR test phantom is not available, other types of gauges or phantoms may be

used when approved by the Cognizant Radiographic Level 3 and when applicable, COCs are available to verify dimensional accuracy.

6.1.16 *Reference Standard*—When image features are measured for accept/reject evaluations, a calibrated physical standard shall be used when calibrating the software measurement tool. Users shall visually inspect the reference standard to ensure the calibration is current and for damage and cleanliness in accordance with Table 2. A dimensional calibration of the measuring function based upon a verifiable scanned pixel size may also be used.

6.1.17 *Measurement Tools*—As an alternative to the reference standard, a feature or item included in the image, such as the IQI, may be measured with a calibrated measurement tool (e.g., calibrated dial caliper) to establish software calibration. Users shall ensure the calibration is current in accordance with Table 2. A dimensional calibration of the measuring function based upon a verifiable scanned pixel size may also be used.

6.1.18 *Contrast Sensitivity Gauge*—Contrast sensitivity gauges shall comply with Practice E1647. A COC is required to verify material type and dimensional accuracy. Users shall visually inspect contrast sensitivity gauges for damage and cleanliness in accordance with Table 2.

6.1.19 *Miscellaneous Radiographic Tools*—Holding fixtures, tooling, and other miscellaneous radiographic aids may be used to aid the radiographic set-up, and shall not interfere with the radiographic image clarity in the AOI or the image of the IQI. Devices used as radiographic set-up aids shall be examined for damage and cleanliness prior to use.

6.2 *CR System Preventative Maintenance (PM)*—Preventative maintenance shall be performed to ensure the system generates uniform images free of artifacts that would interfere with image interpretation and evaluation in the AOI. Preventative maintenance requirements shall be as stated by the system manufacturer. After PM or repairs, retesting to Practice E2445 is required.

6.3 *Facilities*—Facilities shall be kept clean and equipped so that acceptable radiographic images are produced in accordance with this practice.

6.3.1 *Cleanliness*—Environmental conditions involving dust, dirt, or debris shall be controlled to prevent introduction of artifacts to the images and to minimize wear on the CR system hardware.

6.3.2 *CR IP Loading and Scanning Area:*

6.3.2.1 The surface of the IP loading and scanning area shall be kept visibly clean and free of dust and dirt particles so that contamination is not introduced into the IP cassette or CR scanner

6.3.2.2 Exposed IPs should be handled in conditions of subdued background lighting. It is recommended that exposed IPs be subjected to no more than 2500 *lux* × *seconds* of visible light prior to scanning.

6.3.2.2.1 *Discussion*—The overall exposure to background lighting determines the signal loss and radiographic image quality degradation. Exposure is equal to the lighting intensity multiplied by time.

6.3.3 *Image Viewing Area*—The image viewing area shall be an area with subdued background lighting with the equipment arranged in such a manner to prevent reflective glare from the surface of the image display monitor. Subdued lighting, rather than total darkness, is required in the image viewing area.

6.3.3.1 *Background Ambient Light Level*—Background ambient light levels shall not exceed 30 lux (3 fc) at the image display monitor used for image analysis and final disposition. Background ambient light levels shall be measured at the surface of the image display monitor with the monitor off and recorded in accordance with Table 2.

6.3.4 *Environmental Conditions*—Humidity and temperature shall be maintained within the limits stated by the equipment and IP manufacturer.

6.4 *Software*—All software shall be revision controlled. The following software features and tools are required:

6.4.1 *Line Profile*—A line profile function capable of displaying the pixel values (PVs) along a user defined line as a graph. The line profile tool should also be capable of adjusting the line width where the values of the line profile are averaged across the line width.

6.4.2 *Region of Interest Tool*—A histogram type tool capable of displaying the PVs of a user-defined Region of Interest (ROI) as a graph. The ROI tool shall also display the size of the ROI (e.g., *x* pixels by *y* pixels), and as a minimum, the statistical mean and standard deviation of the ROI PVs.

6.4.3 *Negative/Positive Image Display*—Display images in either negative or positive gray scale (negative or inverse).

6.4.4 *Linearized Pixel Values*—The software shall be capable of performing calculations using linearized pixel values.

6.4.4.1 *Discussion*—Linearized pixel values, which are directly proportional to the exposure dose, are required for measuring values such as normalized signal to noise ratio (SNR_N). The linear pixel value is zero if the radiation dose is zero.

6.4.5 *Digital Image Magnification (Zoom)*—Adjust and display the digital magnification level, as well as display the image at 1:1 pixel mapping (i.e., each pixel of the image is mapped to an image display monitor pixel).

6.4.6 *Image Pan*—Capability to pan the image.

6.4.7 *Window Width and Window Level (Window/Level)*—Adjust window width (contrast) and window level (brightness).

6.4.8 *Size Measurement Tool*—Perform measurements for distance or sizing of discontinuities. The software shall be capable of calibrating the measuring tool to a reference standard.

6.4.8.1 *Software Calibration*—When the system software is capable of self-calibration, such as using pixel size and set up geometry, a reference standard (6.1.17) may not be required when the software has been validated during system qualification (7.1).

6.4.9 *DICONDE Compliance*—Compliance with Practice E2339 and E2738 is recommended.

6.4.10 *Image Format*—Lossy compression shall not be allowed for images that are used for final product disposition. For systems that are not DICONDE compliant, TIFF images are recommended.

6.4.11 *Image Processing Software*—Image processing used for final product disposition shall be verified by adequately displaying the pertinent IQI or RQI features. The software shall