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Standard Guide for Computed Radiography¹

This standard is issued under the fixed designation E2007; 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 guide provides general tutorial information regarding the fundamental and physical principles of computed radiography (CR), definitions and terminology required to understand the basic CR process. An introduction to some of the limitations that are typically encountered during the establishment of techniques and basic image processing methods are also provided. This guide does not provide specific techniques or acceptance criteria for specific end-user inspection applications. Information presented within this guide may be useful in conjunction with those standards of 1.2.

1.2 CR techniques for general inspection applications may be found in Practice E2033. Technical qualification attributes for CR systems may be found in Practice E2445. Criteria for classification of CR system technical performance levels may be found in Practice E2446. Reference Images Standards E2422, E2660, and E2669 contain digital reference acceptance illustrations.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only.

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

1.5 *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 Recom-*

mendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 ASTM Standards:²

- E94 Guide for Radiographic Examination Using Industrial Radiographic Film
- 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 Radiography
- E1316 Terminology for Nondestructive Examinations
- E1453 Guide for Storage of Magnetic Tape Media that Contains Analog or Digital Radioscopic Data
- E2002 Practice for Determining Image Unsharpness and Basic Spatial Resolution in Radiography and Radioscopy
- E2033 Practice for Radiographic Examination Using Computed Radiography (Photostimulable Luminescence Method)
- E2339 Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE)
- E2422 Digital Reference Images for Inspection of Aluminum Castings
- E2445 Practice for Performance Evaluation and Long-Term Stability of Computed Radiography Systems
- E2446 Practice for Manufacturing Characterization of Computed Radiography Systems
- E2660 Digital Reference Images for Investment Steel Castings for Aerospace Applications

¹ This guide 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.

E2669 Digital Reference Images for Titanium Castings

2.2 SMPTE Standard:

RP-133 Specifications for Medical Diagnostic Imaging Test Pattern for Television Monitors and Hard-Copy Recording Cameras³

3. Terminology

3.1 Unless otherwise provided within this guide, terminology is in accordance with Terminology E1316.

3.2 Definitions:

3.2.1 *aliasing*—artifacts that appear in an image when the spatial frequency of the input is higher than the output is capable of reproducing. This will often appear as jagged or stepped sections in a line or as moiré patterns.

3.2.2 *basic spatial resolution (SR_b)*—terminology used to describe the smallest degree of visible detail within a digital image that is considered the effective pixel size.

3.2.2.1 *Discussion*—The concept of basic spatial resolution involves the ability to separate two distinctly different image features from being perceived as a single image feature. When two identical image features are determined minimally distinct, the single image feature is considered the effective pixel size. If the physical sizes of the two distinct features are known, for example, widths of two parallel lines or bars with an included space equal to one line or bar, then the effective pixel size is considered $\frac{1}{2}$ of their sums. Example: A digital image is determined to resolve five line pairs per mm or a width of line equivalent to five distinct lines within a millimetre. The basic spatial resolution is determined as $1/[2 \times 5 \text{ LP/mm}]$ or 0.100 mm.

3.2.3 *binary/digital pixel data*—a matrix of binary (0's, 1's) values resultant from conversion of PSL from each latent pixel (on the IP) to proportional (within the bit depth scanned) electrical values. Binary digital data value is proportional to the radiation dose received by each pixel.

3.2.4 *bit depth*—the number “2” increased by the exponential power of the analogue-to-digital (A/D) converter resolution. Example 1) In a 2-bit image, there are four (2^2) possible combinations for a pixel: 00, 01, 10 and 11. If “00” represents black and “11” represents white, then “01” equals dark gray and “10” equals light gray. The bit depth is two, but the number of gray scales shades that can be represented is 2^2 or 4. Example 2): A 12-bit A/D converter would have 4096 (2^{12}) gray scales shades that can be represented.

3.2.5 *blooming or flare*—an undesirable condition exhibited by some image conversion devices brought about by exceeding the allowable input brightness for the device, causing the image to go into saturation, producing an image of degraded spatial resolution and gray scale rendition.

3.2.6 *computed radiographic system*—all hardware and software components necessary to produce a computed radiograph. Essential components of a CR system consisting of: an imaging plate, an imaging plate readout scanner, electronic

image display, image storage and retrieval system and interactive support software.

3.2.7 *computed radiographic system class*—a group of computed radiographic systems characterized with a standard image quality rating. Practice E2446, Table 1, provides such a classification system.

3.2.8 *computed radiography*—a radiological nondestructive testing method that uses storage phosphor imaging plates (IP's), a PSL stimulating light source, PSL capturing optics, optical-to-electrical conversion devices, analogue-to-digital data conversion electronics, a computer and software capable of processing original digital image data and a means for electronically displaying or printing resultant image data.

3.2.9 *contrast and brightness*—an application of digital image processing used to “re-map” displayed gray scale levels of an original gray scale data matrix using different reference lookup tables.

3.2.9.1 *Discussion*—This mode of image processing is also known as “windowing” (contrast adjustment) and “leveling” (brightness adjustment) or simply “win-level” image processing.

3.2.10 *contrast-to-noise ratio (CNR)*—quotient of the digital image contrast (see 3.2.13) and the averaged standard deviation of the linear pixel values.

3.2.10.1 *Discussion*—CNR is a measure of image quality that is dependent upon both digital image contrast and signal-to-noise ratio (SNR) components. In addition to CNR, a digital radiograph must also possess adequate sharpness or basic spatial resolution to adequately detect desired features.

3.2.11 *digital driving level (DDL)*—terminology used to describe displayed pixel brightness of a digital image on a monitor resultant from digital mapping of various gray scale levels within specific look-up-table(s).

3.2.11.1 *Discussion*—DDL is also known as monitor pixel intensity value; thus, may not be the PV of the original digital image.

3.2.12 *digital dynamic range*—maximum material thickness latitude that renders acceptable levels of specified image quality performance within a specified pixel intensity value range.

3.2.12.1 *Discussion*—Digital dynamic range should not be confused with computer file bit depth.

3.2.13 *digital image contrast*—pixel value difference between any two areas of interest within a computed radiograph.

3.2.13.1 *Discussion*—Digital contrast = $PV2 - PV1$ where PV2 is the pixel value of area of interest “2” and PV1 is the pixel value of area of interest “1” on a computed radiograph. Visually displayed image contrast can be altered via digital re-mapping (see 3.2.11) or re-assignment of specific gray scale shades to image pixels.

3.2.14 *digital image noise*—imaging information within a computed radiograph that is not directly correlated with the degree of radiation attenuation by the object or feature being examined and/or insufficient radiation quanta absorbed within the detector IP.

³ Available from Society of Motion Picture and Television Engineers (SMPTE), 3 Barker Ave, 5th Floor, White Plains, NY 10601.