Designation: E2597/E2597M – 22

Standard Practice for Manufacturing Characterization of Digital Detector Arrays[1]

This standard is issued under the fixed designation E2597/E2597M; 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 describes the evaluation of Digital Detector Arrays (DDAs), and assures that one common standard exists for quantitative comparison of DDAs so that an appropriate DDA is selected to meet NDT requirements.

1.2 This practice is intended for use by manufacturers or integrators of DDAs to provide quantitative results of DDA characteristics for NDT user or purchaser consumption. Some of these tests require specialized test phantoms to assure consistency among results among suppliers or manufacturers. These tests are not intended for users to complete, nor are they intended for long term stability tracking and lifetime measurements. However, they may be used for this purpose, if so desired.

NOTE 1—Further information on application of DDAs is contained in Guide E2736 and Practices E2698 and E2737.

1.3 The results reported based on this practice should be based on a group of at least three individual detectors for a particular model number.

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 are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.5 *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.*

1.6 *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]

E1316 Terminology for Nondestructive Examinations

E1815 Test Method for Classification of Film Systems for Industrial Radiography

E2002 Practice for Determining Total Image Unsharpness and Basic Spatial Resolution in Radiography and Radioscopy

E2445 Practice for Performance Evaluation and Long-Term Stability of Computed Radiography Systems

E2446 Practice for Manufacturing Characterization of Computed Radiography Systems

E2698 Practice for Radiographic Examination Using Digital Detector Arrays

E2736 Guide for Digital Detector Array Radiography

E2737 Practice for Digital Detector Array Performance Evaluation and Long-Term Stability

2.2 *ISO Standards:*[3]

ISO 7004 Photography—Industrial Radiographic Films—Determination of ISO Speed, ISO Average Gradient and ISO Gradients G2 and G4 When Exposed to X- and Gamma-Radiation

ISO 17636-2 Non-destructive Testing of Welds — Radiographic Testing — Part 2: X- and Gamma-ray Techniques With Digital detectors

ISO 10893-7 Non-destructive Testing of Steel Tubes — Part 7: Digital Radiographic Testing of the Weld Seam of Welded Steel Tubes for the Detection of Imperfections

2.3 *Other Standards:*

EN 12681-2 Founding — Radiographic Testing — Part 2: Techniques With Digital Detectors[4]

IEC 62220-1 Medical Electrical Equipment Characteristics of Digital X-ray Imaging Devices Part 1: Determination of

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

Current edition approved Jan. 1, 2022. Published February 2022. Originally approved in 2007. Last previous edition approved in 2014 as E2597/E2597M – 14. DOI: 10.1520/E2597_E2597M-22.

[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.

[3] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

[4] Available from https://www.en-standard.eu/.

the Detective Quantum Efficiency[5]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *achievable contrast sensitivity (CSa), n*—optimum contrast sensitivity (see Terminology E1316 for a definition of contrast sensitivity) obtainable using a standard phantom with an X-ray technique that has little contribution from scatter.

3.1.2 *active DDA area, n*—the size and location of the DDA, which is recommended by the manufacturer as usable.

3.1.3 *bad pixel, n*—a DDA pixel that does not conform to a specified performance as defined in 6.2.

3.1.4 *burn-in, n*—change in gain of the scintillator that persists well beyond the exposure.

3.1.5 *DDA correction, n*—the process of subtracting the response of each pixel in absence of ionizing radiation (DDA offset image) and normalization of the gain of each pixel in the presence of ionizing radiation and the absence of a specimen (DDA gain image) and finally the replacement of the bad pixels by corrected values (bad pixel correction). The result is a corrected digital radiograph.

3.1.6 *DDA gain image, n*—image obtained with no structured object in the X-ray beam to correct the pixel response in a DDA.

3.1.7 *DDA offset image, n*—image of the DDA in the absence of X-rays providing the background signal of all pixels.

3.1.8 *efficiency, n—SNR_N* (see 3.1.16) divided by the square root of the dose (in mGy), this is used to measure the response of the detector at different beam energies and qualities.

3.1.9 *frame rate, n*—number of frames acquired per second.

3.1.10 *GlobalLag1f (global lag 1st frame), n*—the ratio of mean signal value of the first frame of the DDA where the X-rays are completely off to the mean signal value of an image where the X-rays are fully on. This parameter is specifically for the integration time used during data acquisition.

3.1.11 *GlobalLag1s (global lag 1 s), n*—the projected value of GlobalLag1f for an integration time of 1 s.

3.1.12 *GlobalLag60s (global lag 60 s), n*—the ratio between mean pixel value of an image acquired with the DDA after 60 s where the X-rays are completely off, to same of an image where the X-rays are fully on.

3.1.13 *internal scatter ratio (ISR), n*—ratio of external primary radiation to scattered radiation within the detector.

3.1.14 *ISO material thickness limit (ISO-MTL), n*—limit determined similar to SMTR, but using as thicker wall thickness limit the value where the normalized SNR (SNR_N) is above 70 (basic technique) or 100 (enhanced technique).

3.1.15 *lag, n*—residual signal in the DDA that occurs shortly after the exposure is completed.

3.1.16 *normalized signal-to-noise ratio of the detector–(SNR_N), n*—the SNR is normalized by the interpolated basic spatial resolution $iSR_b^{detector}$ as measured directly on the detector without any object other than beam filters in the beam path.

3.1.17 *pixel value, n*—the numeric value of a pixel in the DDA image; this is typically interchangeable with the terms *gray value*, *detector response*, *Analog-to-Digital Unit*, or *detector signal*.

3.1.18 *phantom, n*—a part or item being used to quantify DDA characterization metrics.

3.1.19 *saturation pixel value, n*—the maximum possible pixel value of the DDA after offset correction.

3.1.20 *specific material thickness range (SMTR), n*—the penetrated material thickness range within a given minimum SNR in the image is achieved. The wall thickness range of a DDA is limited for the thinner wall thickness by 80 % of the saturation pixel value at this thickness and the thicker wall thickness by a SNR of 130 (basic contrast sensitivity) or 250 for (enhanced contrast sensitivity).

NOTE 2—This is not related to the image quality requirement of 1-2T or 2-2T, because the spatial resolution is not considered.

3.1.21 *total image acquisition time, n*—complete acquisition time of a DDA image, consisting of the effective exposure time of the integrated frames and the image transfer time between detector and computer including the detector read-out time, that is, from start of the exposure until storage of the final image on the computer.

4. Significance and Use

4.1 This practice provides a means to compare DDAs on a common set of technical measurements, realizing that in practice, adjustments can be made to achieve similar results even with disparate DDAs, given geometric magnification, or other industrial radiologic settings that may compensate for one shortcoming of a device.

4.2 A user should understand the definitions and corresponding performance parameters used in this practice in order to make an informed decision on how a given DDA can be used in the target application.

4.3 The parameters that will be evaluated for each DDA are: interpolated basic spatial resolution ($iSR_b^{detector}$), efficiency (normalized Detector *SNR* (SNR_N) at 1 mGy, for different energies and beam qualities), achievable contrast sensitivity (*CSa*), specific material thickness range (*SMTR*) and ISO-MTL , image lag, burn-in, bad pixels distribution and statistics and internal scatter ratio (*ISR*).

4.4 Given that each of these parameters are discussed together in many of the following sections, the following list will be helpful in selecting the key sections for a given test as follows. It should be noted that other sections of the document are needed to establish the appropriate technique for the parameter under test. Note that for each parameter (test), the first section listed is typically an apparatus or gauge (if required), the second section listed are the standardized measurements, and the third section listed involves the analysis or computations:

[5] Available from International Electrotechnical Commission (IEC), 3, rue de Varembé, 1st floor, P.O. Box 131, CH-1211, Geneva 20, Switzerland, https://www.iec.ch.