Designation: E2737 – 23

Standard Practice for Digital Detector Array Performance Evaluation and Long-Term Stability[1]

This standard is issued under the fixed designation E2737; 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 covers the baseline and periodic performance evaluation of Digital Detector Array (DDA) systems used for industrial radiography. It is intended to ensure that the evaluation of image quality, as far as this is influenced by the DDA system, meets the needs of users, and their customers, and enables process control to monitor long-term stability of the DDA system.

1.2 This practice specifies the fundamental parameters of DDA systems to be measured to determine baseline performance, and to track the long-term stability of the DDA system.

1.3 The DDA system tests specified in this practice shall be completed upon acceptance of the system from the manufacturer to baseline the performance of the DDA. Periodic performance testing shall then be used to monitor long-term stability of the system in order to identify when an action needs to be taken due to system degradation beyond a certain defined level.

1.4 Two types of phantoms, the duplex plate and the five-groove wedge, are used for testing as specified herein. The use of these two types of phantoms is not intended to exclude the use of other phantom configurations. In the event the tests or phantoms specified herein are not sufficient or appropriate, the user, in coordination with the cognizant engineering organization (CEO) may develop additional or modified tests, test objects, phantoms, or image quality indicators to evaluate the DDA system performance. Acceptance levels for these ALTERNATE test methods shall be determined by agreement between the user and CEO.

1.5 The user of this practice shall consider that higher energies than 450 keV may require different test methods or modifications to the test methods described here. This practice is not intended for usage with isotopes.

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]

E543 Specification for Agencies Performing Nondestructive Testing
E1025 Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiography
E1165 Test Method for Measurement of Focal Spots of Industrial X-Ray Tubes by Pinhole Imaging
E1316 Terminology for Nondestructive Examinations
E1742/E1742M Practice for Radiographic Examination
E2002 Practice for Determining Image Unsharpness and Basic Spatial Resolution in Radiography and Radioscopy
E2446 Practice for Manufacturing Characterization of Computed Radiography Systems
E2597/E2597M Practice for Manufacturing Characterization of Digital Detector Arrays
E2698 Practice for Radiographic Examination Using Digital Detector Arrays
E2736 Guide for Digital Detector Array Radiography

[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.

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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.

E2903 Test Method for Measurement of the Effective Focal Spot Size of Mini and Micro Focus X-ray Tubes

2.2 *Industry Standards:*

ANSI/ASNT CP-189 Standard for Qualification & Certification of Nondestructive Testing Personnel[3]

EN 4179 Qualification & Approval of Personnel for Non-Destructive Testing[4]

ISO 9712 Non-Destructive Testing - Qualification & Certification of NDT Personnel[5]

NAS 410 National Aerospace Standard: Certification & Qualification of Nondestructive Test Personnel[6]

SNT-TC-1A Personnel Qualification & Certification in Nondestructive Testing[7]

3. Terminology

3.1 *Definitions*—The definition of terms relating to gamma and X-radiology, which appear in Terminology E1316, Practice E2002, Practice E2597/E2597M, Practice E2698, and Guide E2736, shall apply to the terms used in this practice.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *active DDA area*—the active pixelized region of the DDA, which is recommended by the manufacturer as usable.

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

3.2.3 *duplex plate phantom Type 1*—a phantom manufactured from a single material type and having two thickness made up of either two overlapping plates or a single plate machined to provide two thicknesses with the two thicknesses typically aligning on 3 edges (Fig. 1).

3.2.3.1 *Discussion*—Duplex plate phantom Type 1 was first mentioned in E2737 – 10.

3.2.4 *duplex plate phantom Type 2*—a phantom manufactured from a single material type and having two thickness made up of either two overlapping plates or a single plate machined to provide two thicknesses (Fig. 2).

3.2.5 *five-groove wedge*—a continuous wedge with five long grooves on one side.

3.2.6 *frame rate*—number of frames acquired per second.

3.2.7 *lag*—residual signal in the DDA that occurs shortly after detector read-out and erasure.

3.2.8 *manufacturer*—DDA system manufacturer, supplier for the user of the DDA system.

3.2.9 *material thickness range (MTR)*—the material thickness range within a single DDA image, whereby a minimum specific image quality is achieved throughout the entire thickness range.

3.2.10 *phantom*—a part or item being used to quantify DDA characterization metrics.

3.2.11 *saturation pixel value*—the maximum possible usable pixel value of the DDA after offset correction.

NOTE 1—Saturation may occur because of a saturation of the pixel itself, the amplifier, or digitizer, where the DDA encounters saturation pixel values as a function of increasing exposure levels.

3.2.12 *user*—the user and operating organization of the DDA system.

3.3 *Definitions: Abbreviations Specific to This Standard*:

3.3.1 D_{hole}—diameter of the IQI hole (in pixels).

3.3.2 *CNC*—Computer Numerical Control.

3.3.3 *GSL*—Groove Sensitivity Level – The smallest long groove which is visible in the image at the first single dot marking.

3.3.4 *MT*—the penetrated material thickness in the ROI under consideration.

3.3.5 MT_{step}—material thickness of the plate(s) under the IQI.

3.3.6 MT_{IQI}—thickness of hole-type IQI.

3.3.7 MT_{total}—total material thickness of plate and hole-type IQI ($=MT_{step} + MT_{IQI}$).

3.3.8 PV_{median}*[hole]*—median pixel value of ROI within the IQI hole.

3.3.9 PV_{mean}—mean pixel value, for example, of a ROI.

3.3.10 PV_{mean}*[beside squares]*—mean pixel value measured inside the area between two boxes.

3.3.11 PV_{thick}—mean pixel value of the ROI on the thick area of the five-groove wedge.

3.3.12 PV_{thin}—mean pixel value at the thinnest area of the five-groove wedge.

3.3.13 PV_{mean}*(Offset)*—mean pixel value of the approximately central 90 % of the area in the offset image.

3.3.14 *Sigma[beside squares]*—standard deviation of the pixel values in the area between two boxes.

4. Significance and Use

4.1 This practice is intended to be used by the DDA user to measure and record the baseline performance of an acquired DDA in order to monitor its performance throughout its service as an imaging system. This practice is not intended to be used as an "acceptance test" of a DDA.

4.2 This practice defines the tests to be performed and their required intervals. Also defined are the methods of tabulating results that DDA users will complete following initial baselining of the DDA system. These tests will also be performed periodically at the stated required intervals to evaluate the DDA system to determine if the system remains within acceptable operational limits as established in this practice and defined between the user and CEO.

4.3 There are several factors that affect the quality of a DDA image including the basic spatial resolution, geometric unsharpness, scatter, signal to noise ratio, contrast sensitivity, contrast/noise ratio, image lag, and for some types of DDAs,

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

[4] Available from British Standards Institution (BSI), 389 Chiswick High Rd., London W4 4AL, U.K., http://www.bsigroup.com.

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

[6] Available from Aerospace Industries Association (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209, http://www.aia-aerospace.org.

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