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Standard Guide for the Qualification and Control of the Assisted Defect Recognition of Digital Radiographic Test Data[1]

This standard is issued under the fixed designation E3327/E3327M; 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 Assisted defect recognition (AssistDR) describes a class of computer algorithms that assist a human operator in making a determination about nondestructive test data. This guide uses the term AssistDR to describe those computer assisted evaluation algorithms and associated software. For the purposes of this guide, the usage of the words "defect," "evaluate," "evaluation," etc., in no way implies that the algorithms are dispositioning or otherwise making an unaided final disposition. Depending on the application, AssistDR computer algorithms detect and optionally classify indications of defects, flaws, discontinuities, or other anomalous signals in the acquired images. Software that does make an unaided final disposition is classified as automated defect recognition (AutoDR). While the concepts discussed in this guide are pertinent to AutoDR applications, additional validation tests or controls may be necessary when implementing AutoDR.

1.2 This guide establishes the minimum considerations for the radiographical examination of components using AssistDR for non-film radiographic test data. Most of the examples and discussion in this guide are built around two-dimensional test data for simplicity. The principles can be applied to three (volumetric computed tomography, for example) or higher dimensional test data.

1.3 The methods and practices described in this guide are intended for the application of AssistDR where image analysis will aid a human operator in the detection and evaluation of indications. The degree to which AssistDR is integrated into the testing and evaluation process will help the user determine the appropriate levels of process qualification and control required. This guide is not intended for applications wishing to employ AutoDR in which there is no human review of the results.

1.4 This guide applies to radiographic examination using an X-ray source. Some of the concepts presented may be appropriate for other nondestructive test methods when approved by the AssistDR system purchaser.

1.5 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each AssistDR system may not be exact equivalents; therefore, each AssistDR system should be used independently of the other.

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]

E1316 Terminology for Nondestructive Examinations
E1441 Guide for Computed Tomography (CT)
E1695 Test Method for Measurement of Computed Tomography (CT) System Performance
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/E2445M Practice for Performance Evaluation and Long-Term Stability of Computed Radiography Systems
E2586 Practice for Calculating and Using Basic Statistics
E2597/E2597M Practice for Manufacturing Characterization of Digital Detector Arrays

[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.

E2698 Practice for Radiographic Examination Using Digital Detector Arrays
E2862 Practice for Probability of Detection Analysis for Hit/Miss Data
E2737 Practice for Digital Detector Array Performance Evaluation and Long-Term Stability
E3023 Practice for Probability of Detection Analysis for $\hat{a}$ Versus a Data
E3169 Guide for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE)

2.2 *ISO Standards:*[3]
ISO 9000 Family Quality Management

2.3 *Other Documents:*
NEMA PS3 / ISO 12052Digital Imaging and Communications in Medicine (DICOM) Standard, National Electrical Manufacturers Association, Rosslyn, VA, USA (available free at http://www.dicomstandard.org/)
MIL-HDBK-1823A Nondestructive Evaluation System Reliability Assessment[4]

3. Terminology

3.1 See Terminology E1316 as well as the ASTM CT, CR, and DDA standards listed in Section 2 for a complete set of standard non-film radiographic test method definitions.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *assisted defect recognition (AssistDR), n*—the software or computer algorithms, typically involving image segmentation, feature identification, classification, and measurement, that aid operators in detecting and optionally the evaluation of indications in digital nondestructive testing data. Also referred to as software assisted evaluation, computer assisted evaluation, computer assisted detection, semi-automated defect recognition, supervised automated defect recognition, or computer aided detection.

3.2.2 *automated defect recognition (AutoDR), n*—the software or computer algorithms, typically involving image segmentation, feature identification, classification, and measurement, that classify the part being tested as acceptable or rejectable without the involvement of an operator.

3.2.3 *confidence interval, n*—a range of values such that there is a specified probability that the value of an unknown constant parameter of interest is contained in the range.

3.2.4 *confidence level, n*—the probability that a specified range of values covers an unknown constant parameter of interest.

3.2.5 *data curation, v*—the organization and integration of data collected from various sources, involving annotation, publication, and presentation of the data such that the value of the data is maintained over time, and the data remains available for reuse and preservation.

3.2.6 *failure mode and effects analysis (FMEA), n*—the systematic process of reviewing as many components and subsystems as possible to identify potential risks in a system and their root causes and impact.

3.2.7 *false negative (FN), n*—an examination result that reports that no indication is present when there is an indication in the ground truth, that is, a missed identification of an indication that should have been detected, sometimes called a "miss."

3.2.8 *false positive (FP), n*—an examination result that reports that an indication is present when there is no corresponding indication in the ground truth, that is, identification of an indication that should not have been identified, sometimes called a "false call."

3.2.9 *false positive rate (FPR), n*—number of false positive examination results divided by the total opportunities.

3.2.10 *ground truth, n*—list of indications and associated metadata present in the test data as determined by the process expert.

3.2.11 *negative, n*—an examination result that does not report the presence of an indication.

3.2.12 *negative predictive value (NPV), n*—the probability that a negative is a true negative.

3.2.13 *opportunity, n*—a single occurrence of the unit of measure for the examination, for example, a part, an image, or a pixel.

3.2.14 *positive, n*—an examination result that reports the presence of an indication.

3.2.15 *positive predictive value (PPV), n*—the probability that a positive is a true positive.

3.2.16 *probability of detection (POD), n*—a method to quantitatively assess the performance of a test method described in Practice E2862, Practice E3023, and MIL-HDBK-1823A.

3.2.17 *process expert, n*—the individual or group of individuals responsible for establishing ground truth for the data used in the examination, for example, subject matter experts, AssistDR system experts, certified Level 3s, statisticians, etc.

3.2.18 *receiver operator characteristic curve (ROC), n*—a graphical plot that illustrates the diagnostic ability of a binary classifier system as its discrimination threshold is varied. The ROC curve is created by plotting the true positive rate (TPR) against the false positive rate (FPR) at various threshold settings.

3.2.19 *sensitivity, n*—measure of the portion of true positives that are correctly identified in an examination. Sensitivity is synonymous with true positive rate (TPR).

3.2.20 *specificity, n*—measure of the portion of true negatives which are correctly identified in an examination. Specificity is synonymous with true negative rate (TNR).

3.2.21 *total indications, n*—the number of indications present in the ground truth.

3.2.22 *total opportunities, n*—the number of possibilities for indications to be identified in the ground truth.

[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 http://everyspec.com/MIL-HDBK/MIL-HDBK-1800-1999/MIL-HDBK-1823A_33187/.