



Designation: E3505 – 25

Standard Practice for Direct Determination of Computed Tomography (CT) Detail Detection Sensitivity and Calculation of Numerical Detection Limit¹

This standard is issued under the fixed designation E3505; 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 provides instructions for determining the detail detection sensitivity (DDS) and its numerical limit (DDS_{Limit}) in slices of X-ray computed tomography (CT) volumes.

1.1.1 This practice defines image quality indicators (IQI) in the form of flat right circular cylinders (disk IQI) featuring a pattern of round or square holes of known dimension to determine the DDS.

1.1.2 This practice describes a procedure to measure the DDS with the defined disk IQI.

1.1.3 This practice describes a procedure to measure CDF, MTF, and CDD according to Test Method E1695 and Guide E1441 from the disk IQI and the estimation of the numerical limit of DDS, DDS_{Limit} .

1.2 This practice does not intend to predict the detectability of specific object features or discontinuities in a specific application. Representative quality indicators (RQIs, Practice E1817), standard practices, and studies for probability of detection (Practices E2862 and E3023) should be considered for qualifying individual applications (see Guide E3327 and Practice E3375).

1.3 This practice describes the overall CT detail detection sensitivity (DDS) in an idealized object. Performance tests of system components such as X-ray tubes, gamma sources, and detectors are covered by separate documents (see Guide E1000, Test Method E1165, Practice E2597, Practice E2737, Test Method E2903) and should be considered for further system analysis.

1.4 This practice does not exclude other hole arrangements approved by the CEO. In such cases, the below analysis and interpretation might not be applicable, and the analysis should be described in a specific document approved by the CEO.

1.5 The values stated in SI units are to be regarded as the standard. Inch-pound units are provided for information only.

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

- E1000 Guide for Radioscopy
- 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
- E1255 Practice for Radioscopy
- E1316 Terminology for Nondestructive Examinations
- E1441 Guide for Computed Tomography (CT)
- E1695 Test Method for Measurement of Computed Tomography (CT) System Performance
- E1817 Practice for Controlling Quality of Radiological Examination by Using Representative Quality Indicators (RQIs)
- E2597 Practice for Manufacturing Characterization of Digital Detector Arrays
- E2737 Practice for Digital Detector Array Performance Evaluation and Long-Term Stability
- E2862 Practice for Probability of Detection Analysis for Hit/Miss Data

¹ This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.01 on Radiography (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 www.astm.org/contact. 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
- E3023 Practice for Probability of Detection Analysis for $\hat{a}$ Versus a Data
- E3327 Guide for the Qualification and Control of the Assisted Defect Recognition of Digital Radiographic Test Data
- E3375 Practice for Cone Beam Computed Tomographic (CT) Examination
- 2.2 ISO Standards:³
- ISO 286-1:2010 Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes
- ISO 9712 Non-destructive testing—Qualification and certification of NDT personnel
- ISO 15708-2:2025 Non-destructive testing—Radiation methods for computed tomography – Part 2: Principles, equipment and samples

3. Terminology

3.1 Definitions:

3.1.1 The definitions of terms relating to gamma- and X-radiography, which appear in Terminology E1316 and Guide E1441, shall apply to the terms used in this practice.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *CT settings*, n —set of all system adjustments and X-ray parameters including prefiltering that are used to perform a CT examination of an object, as well as the reconstruction algorithm and its parameter settings.

3.2.2 *CT slice*, n —in cone beam CT, one voxel layer of the reconstructed volume; in fan beam CT, one reconstructed tomographic slice.

3.2.3 DDS_{Limit} n —numerical limit of DDS corresponding to 100 % CDD value.

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>.

3.2.4 *detail detection sensitivity (DDS)*, n —size of the smallest hole that can be perceived by a human observer in a CT slice of a disk IQI.

3.2.5 *examination object*, n —a part or specimen being subjected to CT examination.

3.3 Abbreviations:

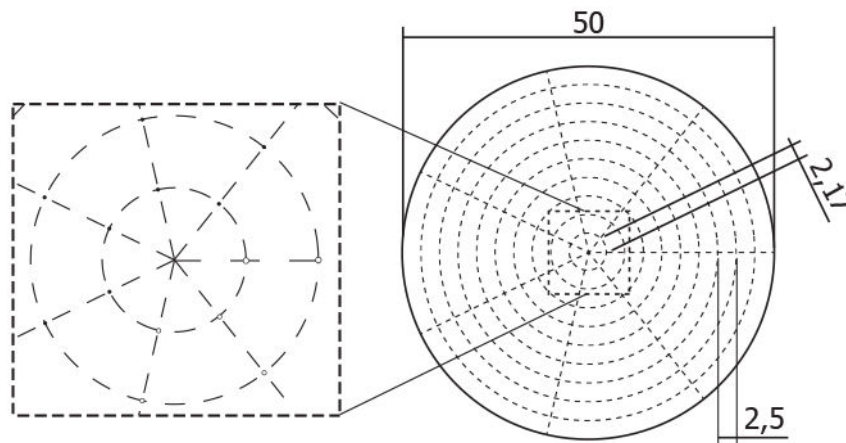
- 3.3.1 *AssistDR*—assisted defect recognition E3327
- 3.3.2 *AutoDR*—automated defect recognition E3327
- 3.3.3 *CDD*—contrast detail diagram E1441
- 3.3.4 *CDF*—contrast discrimination function E1695
- 3.3.5 *CEO*—cognizant engineering organization; the company, government agency or other authority responsible for the design, or end use, of the material or component for which nondestructive examination is required. E1316 Section A
- 3.3.6 *ERF*—edge response function E1695
- 3.3.7 *LSF*—line spread function E1695
- 3.3.8 *MTF*—modulation transfer function E1695

4. Summary of Practice

4.1 This practice defines disk IQIs which are flat cylinders with a defined sequence of holes of defined sizes.

4.2 The disk IQI is scanned at the CT settings used in the related examination. The disk IQI is placed in the middle of the field of view, horizontally aligned to the central line of the X-ray detector. A CT slice containing the defined holes is visually examined to find the size of the smallest visible holes. This size quoted with length units (hole size) is the DDS.

4.3 From a CT slice without holes of the disk IQI, or a CT slice from a hole-free disk of same size and material covering the disk IQI (see Fig. 2), the MTF, CDF, and CDD shall be determined according to Test Method E1695 and Guide E1441. From the 100 % CDD value, the numerical limit for the DDS, DDS_{Limit} , shall be determined. It is the hole size at which the CDD reaches 100 %.



NOTE 1—See Table 1a, Table 1b, and Table 1c. The minimum five holes (here nine) of same diameter shall be equidistantly arranged between center and edge. To keep the distance requirement between the holes, the two largest inner holes may be left out.

FIG. 1 a Disk IQI Design Requirements for an Example of a 50 mm Disk, 7 Spokes of Star Type