



Designation: E1814 – 25

Standard Practice for Computed Tomographic (CT) Examination of Castings¹

This standard is issued under the fixed designation E1814; 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 a uniform procedure for the examination of castings by the computed tomography (CT) technique including both cone and fan beam. The requirements expressed in this practice are intended to control the quality of the nondestructive examination by CT and are not intended for controlling the acceptability or quality of the castings. This practice implicitly suggests the use of penetrating radiation, specifically X rays and gamma rays.

1.2 This practice provides a uniform procedure for a CT examination of castings for one or more of the following purposes:

1.2.1 Examining for discontinuities, such as porosity, inclusions, cracks, and shrink;

1.2.2 Performing measurements and determining conformance; and

1.2.3 Determining reverse engineering data, that is, creating computer-aided design (CAD) data files.

1.3 *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.*

1.4 *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

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.

E1316 Terminology for Nondestructive Examinations

E1441 Guide for Computed Tomography (CT)

E1570 Practice for Fan Beam Computed Tomographic (CT) Examination

E1672 Guide for Computed Tomography (CT) System Selection

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)

E1935 Test Method for Calibrating and Measuring CT Density

E2339 Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE)

E2767 Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE) for X-ray Computed Tomography (CT) Test Methods

E3375 Practice for Cone Beam Computed Tomographic (CT) Examination

3. Terminology

3.1 *Definitions*—Definitions of terms applicable to this practice may be found in Terminology E1316 and Guide E1441.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *fixturing, n*—the mounting hardware used to place the object in the CT system.

3.2.2 *scan plan, n*—documentation required for specifying scan location(s) such as system geometry, acquisition, and reconstruction parameters for a specific part examination.

4. Significance and Use

4.1 CT may be performed on an object when it is in the as-cast, intermediate, final machined condition, or as a flaw or failure detection tool. A CT examination can be used as a design tool to improve wax forms and moldings, establish process parameters, randomly check process control, perform final quality control (QC) examination for the acceptance or rejection of parts, and analyze failures and extend component lifetimes.

4.2 The most common applications of CT for castings are for the following: locating and characterizing discontinuities,

such as porosity, inclusions, cracks, and shrink; measuring as-cast part dimensions for comparison with design dimensions; wall thickness quantification; and extracting dimensional measurements for reverse engineering.

4.3 The quality to which a CT image reproduces an object or a feature within an object is dictated largely by the competing influences of the specific geometry, spatial resolution, contrast sensitivity, and material of the object itself, and artifacts of the imaging system. Operating parameters strike an overall balance between image quality, examination time, and cost.

4.4 Artifacts are often the limiting factor in CT image quality. (See Guide E1441 for an in-depth discussion of artifacts.) Artifacts are reproducible features in an image that are not related to actual features in the object. Artifacts can be considered correlated noise because they form repeatable fixed patterns under given conditions yet carry no object information. For castings, it is imperative to recognize what is and is not an artifact since an artifact can obscure or masquerade as a discontinuity or affect dimensional measurements.

4.5 When processing castings in accordance to this document, Practice E3375 may be used to help in the development of an approved process.

5. Basis of Application

5.1 The following items shall be agreed upon between the customer and supplier and specified in the contract or job order:

5.1.1 *Nondestructive Testing Agency Evaluation*—The use of a nondestructive testing (NDT) agency, as defined in Specification E543. If a systematic assessment of the capability of the agency is specified, a documented procedure, such as that described in Specification E543, should be used as the basis for evaluation.

5.1.2 *Personnel Qualifications*—Personnel utilizing Computed Tomography to this standard shall be qualified to perform interpretation in accordance with a nationally or internationally recognized NDT personnel qualification practice or standard and certified by the employer or certifying agency, as applicable or as defined by contractual agreement. The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties. If assistance is needed a certified Level III shall be available to assist with interpreting specifications and product requirements as applied.

5.1.3 *General Requirements*—General requirements shall be specified in accordance with Section 8: (1) written procedure, 8.1; and (2) CT system validation measurements, 8.2.

5.1.3.1 Specific requirements regarding the preparation and approval of the written procedures shall be agreed upon in advance by the customer and the supplier.

5.1.4 *Fixturing*—The object fixturing shall be determined by agreement between the customer and the supplier in accordance with 9.2 unless the fixture is considered uncontrolled.

5.1.5 *Image Processing*—Image processing routines used in analysis of the CT data shall be specified in accordance with

6.2: (1) dimensional measurements, 6.2.1; and (2) discontinuity characterization, 6.2.3.

5.1.6 *Discontinuity Types*—A listing of the expected kinds of discontinuities shall be provided or referenced, and the acceptance and rejection criteria shall be stipulated.

5.1.7 *Records*—Records requirements shall be specified in accordance with Section 10.

6. Apparatus

6.1 The overall system configuration and the selection of appropriate subsystem components are critical to the success of the CT application. Guidance on the selection of sub-system components and the overall system configuration is provided in Guide E1672. Guidance on the initial system performance evaluation for baseline and periodic system performance check of the CT system is provided in Test Method E1695. Guidance on calibrating and measuring CT density measurements is provided in Test Method E1935. The suitability of the CT system shall be demonstrated by attainment of the required image quality and compliance with all other requirements stipulated herein.

6.2 *Computer/Image Processing Software*—Image processing software may be used for image enhancement operations that will facilitate dimensional measurements and discontinuity detection or characterization.

6.2.1 Dimensional verification can be obtained from the CT image. There is a degree of blurring in the CT image that makes sharp boundaries indistinct. A common approach for on-screen dimensional measurements is to generate a density profile along a straight line between the points in the image representing the distance to be measured. The end points of the measurement are generally taken to be the density profile values located at the half maximum value point on each slope. This is called the full-width-at-half-maximum (FWHM) method. This method or various other techniques, that is, the area under the curve or determining contours for CAD output, can be generalized for wall thickness, hole diameter, and crack width measurements.

6.2.2 Some tools require the availability of an object that can be scanned and then dissected (destructive evaluation) for comparison with actual dimensional measurements. The CT system can be “spatially calibrated” (determine the voxel size for dimensional measurements) for a specific object from this comparison data.

6.2.3 Various types of density analysis tools may be needed for discontinuity characterization, such as tools for measuring low-density indications, missing mass, area, and shape.

6.3 Customers are cautioned to test thoroughly, or have prior experience with, the proposed image processing parameters before authorizing routine use. For example, some spatial filter functions produce directional results and may suppress desired image information. Other spatial filters can introduce artifacts into the image.

7. Safety

7.1 The CT procedures shall comply with applicable local, state, and federal safety regulations.