



Standard Test Method for Calibrating and Measuring CT Density¹

This standard is issued under the fixed designation E1935; 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 test method covers instruction for determining the density calibration of X- and γ -ray computed tomography (CT) systems and for using this information to measure material densities from CT images. The calibration is based on an examination of the CT image of a disk of material with embedded specimens of known composition and density. The measured mean CT values of the known standards are determined from an analysis of the image, and their linear attenuation coefficients are determined by multiplying their measured physical density by their published mass attenuation coefficient. The density calibration is performed by applying a linear regression to the data. Once calibrated, the linear attenuation coefficient of an unknown feature in an image can be measured from a determination of its mean CT value. Its density can then be extracted from a knowledge of its mass attenuation coefficient, or one representative of the feature.

1.2 CT provides an excellent method of nondestructively measuring density variations, which would be very difficult to quantify otherwise. Density is inherently a volumetric property of matter. As the measurement volume shrinks, local material inhomogeneities become more important; and measured values will begin to vary about the bulk density value of the material.

1.3 All values are stated in SI units.

1.4 *This standard does not purport to address the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*²

E1316 Terminology for Nondestructive Examinations

¹ This test method 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.

E1441 Guide for Computed Tomography (CT) Imaging
E1570 Practice for Computed Tomographic (CT) Examination

3. Terminology

3.1 *Definitions:*

3.1.1 The definitions of terms relating to CT, that appear in Terminology E1316 and Guide E1441, shall apply to the terms used in this test method.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *density calibration*—calibration of a CT system for accurate representation of material densities in examination objects.

3.2.2 *effective energy*—the equivalent monoenergetic energy for a polyenergetic CT system. Thus, the actual, polyenergetic CT system yields the same measured attenuation coefficient for an examination object as a theoretical, monoenergetic CT system at the effective energy.

3.2.3 *phantom*—a part or item being used to calibrate CT density.

3.2.4 *examination object*—a part or specimen being subjected to CT examination.

4. Basis of Application

4.1 The procedure is generic and requires mutual agreement between purchaser and supplier on many points.

5. Significance and Use

5.1 This test method allows specification of the density calibration procedures to be used to calibrate and perform material density measurements using CT image data. Such measurements can be used to evaluate parts, characterize a particular system, or compare different systems, provided that observed variations are dominated by true changes in object density rather than by image artifacts. The specified procedure may also be used to determine the effective X-ray energy of a CT system.

5.2 The recommended test method is more accurate and less susceptible to errors than alternative CT-based approaches, because it takes into account the effective energy of the CT system and the energy-dependent effects of the X-ray attenuation process.