INTERNATIONAL

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Standard Guide for Non-computed X-Ray Compton Scatter Tomography[1]

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1. Scope

1.1 *Purpose*—This guide covers a tutorial introduction to familiarize the reader with the operational capabilities and limitations inherent in a single non-computed X-ray Compton Scatter Tomography (CST). Also included is a brief description of the physics and typical hardware configuration for CST. This single technique is still used for a small number of inspections. This is not meant as comprehensive guide covering the variety of Compton scattering techniques that are now used for non-destructive testing and security screen screening.

1.2 *Advantages*—X-ray Compton Scatter Tomography (CST) is a radiologic nondestructive examination method with several advantages that include:

1.2.1 The ability to perform X-ray examination without access to the opposite side of the examination object;

1.2.2 The X-ray beam need not completely penetrate the examination object allowing thick objects to be partially examined. Thick examination objects become part of the radiation shielding thereby reducing the radiation hazard;

1.2.3 The ability to examine and image object subsurface features with minimal influence from surface features;

1.2.4 The ability to obtain high-contrast images from low subject contrast materials that normally produce low-contrast images when using traditional transmitted beam X-ray imaging methods; and

1.2.5 The ability to obtain depth information of object features thereby providing a three-dimensional examination. The ability to obtain depth information presupposes the use of a highly collimated detector system having a narrow angle of acceptance.

1.3 *Applications*—This guide does not specify which examination objects are suitable, or unsuitable, for CST. As with most nondestructive examination techniques, CST is highly application specific thereby requiring the suitability of the method to be first demonstrated in the application laboratory. This guide does not provide guidance in the standardized practice or application of CST techniques. No guidance is provided concerning the acceptance or rejection of examination objects examined with CST.

1.4 *Limitations*—As with all nondestructive examination methods, CST has limitations and is complementary to other NDE methods. Chief among the limitations is the difficulty in performing CST on thick sections of high-*Z* materials. CST is best applied to thinner sections of lower *Z* materials. The following provides a general idea of the range of CST applicability when using a 160 keV constant potential X-ray source:

Material	Practical Thickness Range
Steel	Up to about 3 mm (⅛ in.)
Aluminum	Up to about 25 mm (1 in.)
Aerospace composites	Up to about 50 mm (2 in.)
Polyurethane Foam	Up to about 300 mm (12 in.)

The limitations of the technique must also consider the required *X*, *Y*, and *Z* axis resolutions, the speed of image formation, image quality and the difference in the X-ray scattering characteristics of the parent material and the internal features that are to be imaged.

1.5 The values stated in both inch-pound and SI units are to be regarded separately as the standard. The values given in parentheses are 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]

[1] This guide is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of 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.

E747 Practice for Design, Manufacture and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology
E1025 Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiography
E1255 Practice for Radioscopy
E1316 Terminology for Nondestructive Examinations
E1441 Guide for Computed Tomography (CT)
E1453 Guide for Storage of Magnetic Tape Media that Contains Analog or Digital Radioscopic Data
E1475 Guide for Data Fields for Computerized Transfer of Digital Radiological Examination Data
E1647 Practice for Determining Contrast Sensitivity in Radiology

2.2 *ANSI/ASNT Standards:*[3]
SNT-TC-1A ASNT Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing
ANSI/ASNT CP-189 Standard for Qualification and Certification in Nondestructive Testing Personnel

2.3 *Military Standard:*[4]
MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification

2.4 *Aerospace Standard:*[5]
AIA-NAS-410 Aerospace Industries Association, National Aerospace Standard-4105 Certification and Qualification of Nondestructive Test Personnel[6]

2.5 *ISO Standard:*[7]
ISO 9712 Nondestructive Testing—Qualification and Certification of NDT Personnel

3. Terminology

3.1 *Definitions:*

3.1.1 CST, being a radiologic examination method, uses much the same vocabulary as other X-ray examination methods. A number of terms used in this standard are defined in Terminology E1316. It may also be helpful to read Guide E1441.

4. Summary of Guide

4.1 *Description*—Compton Scatter Tomography is a uniquely different nondestructive test method utilizing penetrating X-ray or gamma-ray radiation. Unlike computed tomography (CT), CST produces radioscopic images which are not computed images. Multiple slice images can be simultaneously produced so that the time per slice image is in the range of a few seconds. CST can produce images that are thin with respect to the examination object thickness (slice images) and which are at right angles to the X-ray beam. Each two-dimensional slice image (*X*–*Y* axes) is produced at an incremental distance along and orthogonal to the X-ray beam (*Z*–axis). A stack of CST images therefore represents a solid volume within the examination object. Each slice image contains examination object information which lies predominantly within the desired slice. To make an analogy as to how CST works, consider a book. The examination object may be larger or smaller (in length, width and depth) then the analogous book. The CST slice images are the pages in the book. Paging through the slice images provides information about examination object features lying at different depths within the examination object.

4.2 *Image Formation*—CST produces one or more digital slice plane images per scan. Multiple slice images can be produced in times ranging from a few seconds to a few minutes depending upon the examined area, desired spatial resolution and signal-to-noise ratio. The image is digital and is typically assembled by computer. CST images are free from reconstruction artifacts as the CST image is produced directly and is not a calculated image. Because CST images are digital, they may be enhanced, analyzed, archived and in general handled as any other digital information.

4.3 *Calibration Standards*—As with all nondestructive examinations, known standards are required for the calibration and performance monitoring of the CST method. Practice E1255 calibration block standards that are representative of the actual examination object are the best means for CST performance monitoring. Conventional radiologic performance measuring devices, such as Test Method E747 and Practice E1025 image quality indicators or Practice E1647 contrast sensitivity gages are designed for transmitted X-ray beam imaging and are of little use for CST. With appropriate calibration, CST can be utilized to make three-dimensional measurements of internal examination object features.

5. Significance and Use

5.1 *Principal Advantage of Compton Scatter Tomography*—The principal advantage of CST is the ability to perform three-dimensional X-ray examination without the requirement for access to the back side of the examination object. CST offers the possibility to perform X-ray examination that is not possible by any other method. The CST sub-surface slice image is minimally affected by examination object features outside the plane of examination. The result is a radioscopic image that contains information primarily from the slice plane. Scattered radiation limits image quality in normal radiographic and radioscopic imaging. Scatter radiation does not have the same detrimental effect upon CST because scatter radiation is used to form the image. In fact, the more radiation the examination object scatters, the better the CST result. Low subject contrast materials that cannot be imaged well by conventional radiographic and radioscopic means are often excellent candidates for CST. Very high contrast sensitivities and excellent spatial resolution are possible with CST tomography.

[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 Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

[5] Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, http://www.faa.gov.

[6] This document has superseded MIL-STD-410; however, MIL-STD-410 is still acceptable to the FAA

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