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Del 2: Principer, utrustning och provstycken (ISO 15708-2:2017)

Non-destructive testing – Radiation methods for Computed tomography –
Part 2: Principles, equipment and samples (ISO 15708-2:2017)

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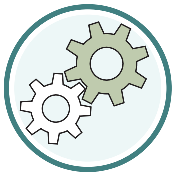

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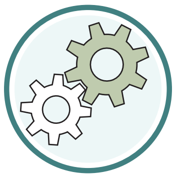

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Europastandarden EN ISO 15708-2:2019 gäller som svensk standard. Detta dokument innehåller den officiella engelska versionen av EN ISO 15708-2:2019.

Denna standard ersätter SS-EN 16016-2:2011, utgåva 1

The European Standard EN ISO 15708-2:2019 has the status of a Swedish Standard. This document contains the official version of EN ISO 15708-2:2019.

This standard supersedes the SS-EN 16016-2:2011, edition 1

Upplysningar om sakinnehållet i standarden lämnas av SIS, Swedish Standards Institute, telefon 08-555 520 00. Standarder kan beställas hos SIS som även lämnar allmänna upplysningar om svensk och utländsk standard.

Information about the content of the standard is available from the Swedish Standards Institute (SIS), telephone +46 8 555 520 00. Standards may be ordered from SIS, who can also provide general information about Swedish and foreign standards.

Denna standard är framtagen av kommittén för Oförstörande provning, SIS/TK 125.

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 15708-2

April 2019

ICS 19.100

Supersedes EN 16016-2:2011

English Version

Non-destructive testing - Radiation methods for Computed tomography - Part 2: Principles, equipment and samples (ISO 15708-2:2017)

Essais non destructifs - Méthodes par rayonnements pour la tomographie informatisée - Partie 2: Principes, équipements et échantillons (ISO 15708-2:2017)

Zerstörungsfreie Prüfung - Durchstrahlungsverfahren für Computertomografie - Teil 2: Grundlagen, Geräte und Proben (ISO 15708-2:2017)

This European Standard was approved by CEN on 11 February 2019.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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European foreword

The text of ISO 15708-2:2017 has been prepared by Technical Committee ISO/TC 135 "Non-destructive testing" of the International Organization for Standardization (ISO) and has been taken over as EN ISO 15708-2:2019 by Technical Committee CEN/TC 138 "Non-destructive testing" the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2019, and conflicting national standards shall be withdrawn at the latest by October 2019.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 16016-2:2011.

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Endorsement notice

The text of ISO 15708-2:2017 has been approved by CEN as EN ISO 15708-2:2019 without any modification.

Non-destructive testing — Radiation methods for computed tomography —

Part 2: Principles, equipment and samples

1 Scope

This document specifies the general principles of X-ray computed tomography (CT), the equipment used and basic considerations of sample, materials and geometry.

It is applicable to *industrial* imaging (i.e. non-medical applications) and gives a consistent set of CT performance parameter definitions, including how those performance parameters relate to CT system specifications.

This document deals with computed axial tomography and excludes other types of tomography such as translational tomography and tomosynthesis.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 15708-1:2017, *Non-destructive testing — Radiation methods for computed tomography — Part 1: Terminology*

ISO 15708-3:2017, *Non-destructive testing — Radiation methods for computed tomography — Part 3: Operation and interpretation*

ISO 15708-4:2017, *Non-destructive testing — Radiation methods for computed tomography — Part 4: Qualification*

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15708-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

4 General principles

4.1 Basic principles

Computed tomography (CT) is a radiographic inspection method which delivers three-dimensional information on an object from a number of radiographic projections either over cross-sectional planes (CT slices) or over the complete volume. Radiographic imaging is possible because different materials have different X-ray attenuation coefficients. In CT images, the X-ray linear attenuation coefficients are represented as different CT grey values (or in false colour). For conventional radiography the three-dimensional object is X-rayed from one direction and an X-ray projection is produced with the corresponding information aggregated over the ray path. In contrast, multiple X-ray-projections of an object are acquired at different projection angles during a CT scan. From these projection images the actual slices or volume are reconstructed. The fundamental advantage compared to radiography is the preservation of full volumetric information. The resulting CT image (2D-CT slice or 3D-CT volume), is a quantitative representation of the X-ray linear attenuation coefficient averaged over the finite volume of the corresponding volume element (voxel) at each position in the sample.

The linear attenuation coefficient characterizes the local instantaneous rate at which X-rays are attenuated as they propagate through the object during the scan. The attenuation of the X-rays as they interact with matter is the result of several different interaction mechanisms: Compton scattering and photoelectric absorption being the predominant ones for X-ray CT. The linear attenuation coefficient depends on the atomic numbers of the corresponding materials and is proportional to the material density. It also depends on the energy of the X-ray beam.

4.2 Advantages of CT

This radiographic method can be an excellent examination technique whenever the primary goal is to locate and quantify volumetric details in three dimensions. In addition, since the method is X-ray based it can be used on metallic and non-metallic samples, solid and fibrous materials and smooth and irregularly surfaced objects.

In contrast to conventional radiography, where the internal features of a sample are projected onto a single image plane and thus are superposed on each other, in CT images the individual features of the sample appear separate from each other, preserving the full spatial information.

With proper calibration, dimensional inspections and material density determinations can also be made.

Complete three-dimensional representations of examined objects can be obtained either by reconstructing and assembling successive CT slices (2D-CT) or by direct 3D CT image (3D-CT) reconstruction. Computed tomography is thus valuable in the industrial application areas of non-destructive testing, 2D and 3D metrology and reverse engineering.

CT has several advantages over conventional metrology methods:

— acquisition without contact;

— access to internal and external dimensional information;

— a direct input to 3D modelling especially of internal structures.

In some cases, dual energy (DE) CT acquisitions can help to obtain information on the material density and the average atomic number of certain materials. In the case of known materials the additional information can be traded for improved discrimination or improved characterization.

4.3 Limitations of CT

CT is an indirect test procedure and measurements (e.g. of the size of material faults; of wall thicknesses must be compared with another absolute measurement procedure, see ISO 15708-3). Another potential drawback of CT imaging is the possible occurrence of artefacts (see 4.5) in the data. Artefacts limit the ability to quantitatively extract information from an image. Therefore, as with any examination technique, the user must be able to recognize and discount common artefacts subjectively.

Like any imaging system, a CT system can never reproduce an exact image of the scanned object. The accuracy of the CT image is dictated largely by the competing influences of the imaging system, namely spatial resolution, statistical noise and artefacts. Each of these aspects is discussed briefly in 4.4.1. A more complete description will be found in ISO 15708-3.

CT grey values cannot be used to identify unknown materials unambiguously unless a priori information is available, since a given experimental value measured at a given position may correspond to a broad range of materials.

Another important consideration is to have sufficient X-ray transmission through the sample at all projection angles (see 8.2) without saturating any part of the detector.

4.4 Main CT process steps

4.4.1 Acquisition

During a CT scan, multiple projections are taken in a systematic way: the images are acquired from a number of different viewing angles. Feature recognition depends, among other factors, on the number of angles from which the individual projections are taken. The CT image quality can be improved if the number of projections of a scan is increased.

As all image capture systems contain inherent artefacts, CT scans usually begin with the capture of offset and gain reference images to allow flat field correction; using black (X-rays off) and white (X-rays on with the sample out of the field of view) images to correct for detector anomalies. The capture of reference images for distortion correction (pin cushion distortion in the case of camera-based detector systems with optical distortion), and centre of rotation correction can also take place at this stage. Each subsequent captured image for the CT data set has these corrections applied to it. Some systems can be configured to either the X-ray settings or enhance the image to ensure that the background intensity level of the captured images remains constant throughout the duration of the CT scan.

The quality of a CT image depends on a number of system-level performance factors, with one of the most important being spatial resolution.

Spatial resolution is generally quantified in terms of the smallest separation at which two features can be distinguished as separate entities. The limits of spatial resolution are determined by the design and construction of the system and by the resolution of and number of CT projections. The resolution of the CT projection is limited by the maximum magnification that can be used while still imaging all parts of the sample at all rotation angles.

It is important to notice that the smallest feature that can be detected in a CT image is not the same as the smallest that can be resolved spatially. A feature considerably smaller than a single voxel can affect the voxel to which it corresponds to such an extent that it appears with a visible contrast so that it can be easily detected with respect to adjacent voxels. This phenomenon is due to the “partial-volume effect”.

Although region-of-interest CT (local tomography) can improve spatial resolution in specified regions of larger objects, it introduces artefacts (due to incomplete data) which can sometimes be reduced with special processing.

Radiographic imaging as used for CT examination is always affected by noise. In radiography this noise arises from two sources: (1) intrinsic variation corresponding to photon statistics related to the emission and detection of photons and (2) variations specific to instruments and processing used. Noise in CT projections is often amplified by the reconstruction algorithm. In the CT images statistical noise appears as a random variation superimposed on the CT grey value of each voxel and limits density resolution.

Although statistical noise is unavoidable, the signal-to-noise ratio can be improved by increasing the number of projections and/or time of exposure for each of them, the intensity of the X-ray source or the voxel size. However, some of these measures will decrease spatial resolution. This trade-off between spatial resolution and statistical noise is inherent in computed tomography.

4.4.2 Reconstruction

A CT scan initially produces a number of projections of an object. The subsequent reconstruction of the CT image from these individual projections is the main step in computed tomography, which distinguishes this examination technique from other radiographic methods.