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GB/T 41123.3-2021

Non-destructive testing - Radiation methods for industrial computed tomography - Part 3: Qualification

Issued on: December 31, 2021 **Implemented on: July 1, 2022**

Issued by: SAMR; SAC

Preview: page 1 of 5 shown, full document available. Complete English PDF, instant download:
https://chinastandards.org/standards/gb-t-41123-3-2021

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Table of Contents

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1 Scope

This Document specifies the basic requirements for performance verification of radiation methods for industrial computed tomography (CT) system when performing different testing tasks.

This Document is applicable to radiation methods for industrial computed tomography (non-medical applications); and gives a unified set of CT performance parameter definitions, and the relationship between these performance parameters and CT system technical specifications.

This Document is applicable to computed axial tomography and inapplicable to other types of tomography such as translational scan tomography and tomosynthesis, etc.

2 Normative References

The provisions in following documents become the essential provisions of this Document through reference in this Document. For the dated documents, only the versions with the dates indicated are applicable to this Document; for the undated documents, only the latest version (including all the amendments) is applicable to this Document.

GB/T 41123.2-2021 Non-Destructive Testing - Radiation Methods for Industrial Computed Tomography - Part 2: Operation and Interpretation (ISO 15708-3:2017, IDT)

ISO 15708-1 Non-Destructive Testing - Radiation Methods for Computed Tomography - Part 1: Terminology

NOTE: GB/T 12604.12-2021 Non-Destructive Testing - Terminology - Part 12: Radiation Methods for Industrial Computed Tomography (ISO 15708-1:2017, MOD)

Preview: page 2 of 5 shown, full document available. Complete English PDF, instant download:
https://chinastandards.org/standards/gb-t-41123-3-2021

3 Terms and Definitions

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

The terminology databases maintained by ISO and IEC for standardization are located at the following addresses:

4.1 Overview

Industrial CT is used for defect detection and size measurement. The size measurement value (such as aperture or wall thickness) cannot be directly given by CT scanning, which shall be calculated according to the X-ray attenuation data characterized by CT gray value. Feature detectability and detection accuracy depend on the detection task, detection equipment, and the employed analysis and evaluation methods. When the detection task, detection equipment and the employed analysis and evaluation methods are determined, the CT system shall be verified accordingly. See 4.2 and 4.3 for the verification methods. Validation should be performed by trained personnel. Trainees shall demonstrate that they are trained and qualified in digital radiography or computed radiography.

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4.2.1 Overview

In the detection verification, it should confirm whether the CT detection technology meets the detection accuracy requirements. The following verification is a typical process for determining applicability for industrial CT.

4.2.2 Quality characteristics

Typical detected features include the sizes of pores, holes, cracks, inclusions, contamination, as well as material distribution and assembly and mounting locations of components. Since the detection performance of a CT system depends on the type, location, and size of the test sample and features to be detected, the following information should be known.

a) Detected object:

1) Size;

2) Weight;

3) Material;

4) The thickness of X-ray transillumination in the material.

b) Detected characteristics:

1) Type;

2) Location;

Preview: page 3 of 5 shown, full document available. Complete English PDF, instant download:
https://chinastandards.org/standards/gb-t-41123-3-2021

Determine the CT system settings and image quality parameters as described in 4.2 and 5.1 of

GB/T 41123.2-2021.

4.2.4.1 Overview

A reasonable description of the defect detection sensitivity and defect detectability of the CT system shall be reflected in the detection accuracy (tolerance, fluctuation degree) required by the test. Below are a few options.

4.2.4.2 Reference samples for natural defects

If there are reference samples with known defects, verify the defect detectability by testing the samples.

If the reference sample has unquantified defects, test the sample first, and then re-verify the defect detectability, for instance, using a destructive test for verification.

4.2.4.3 Reference samples for artificial defects

If the detected feature can be simulated by artificial defects (such as holes), the defect detectability shall be verified by the method of 4.2.4.2.

4.2.4.4 Reference samples with unknown parameters

If the reference sample status is unknown and revalidation is impossible, use the system sensitivity for detection. Defect detectability can be estimated by sample structure (e.g., wall thickness, external dimensions, etc.). Other wire and spherical reference samples of known size can also be used.

4.2.5 Consistency checking

CT scanning steps are complex, so it cannot be guaranteed that errors shall be completely eliminated during the scanning process. After the CT scan is complete, possible sources of error can be traced through the following points:

--- Reconstruction: size, CT slice position, possible artifacts;

--- CT image scale;

--- Sinogram (CT gray value and curve changes) or CT projection sequence (comparison between projections, such as projected image quality, intensity changes);

--- System status (error message).

If there is an error, the error shall be corrected or the source of the error shall be eliminated, then re-tested.

Preview: page 4 of 5 shown, full document available. Complete English PDF, instant download:
https://chinastandards.org/standards/gb-t-41123-3-2021

4.2.6 Documentation

All parameter settings and verification results in the verification steps are described and presented in the verification report. The CT image archive period is determined according to the end user requirements. Save test parameters for repeated testing of parts and features using the same test flow.

4.3.1 Overview

CT detection provides the three-dimensional structural information of the sample; and the external contour and geometric structure data of the sample can be obtained through the three-dimensional structural information. Since these data are based on differences in the physical absorption of X-rays at contour transitions, small differences in measured values can occur compared to conventional contact methods or optical measurement processes. The following Clauses describe CT scan parameters that affect the results and process steps that affect the accuracy of the results.

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4.3.2 Detection and measurement tasks

Dimensional measurement tasks include single dimension measurement, wall thickness measurement, surface extraction, volume extraction or nominal-actual comparison. The measurement accuracy is specified for each task and, if necessary, separately specified for different parts of the sample.

4.3.3 Dimensional measurement/detection system/system parameter setting

The achievable measurement accuracy depends on the object to be measured, the limitations of the physical principle of X-ray measurement, and the data processing method. The following parameters are used to preliminarily estimate the CT dimensional measurement accuracy.

a) Spatial resolution of the measured object:

1) Image size;

2) Geometric magnification, voxel size;

3) detector resolution;

4) Focus size.

b) X-ray transmission characteristics of the measured object:

1) Materials;

2) Maximum penetration thickness of X-ray;

accuracy. Using spherical and dumbbell-shaped reference test pieces is also a method of

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