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Non destructive testing - Radiation Methods - Computed Tomography - Part 4: Qualification

Zerstörungsfreie Prüfung - Durchstrahlungsverfahren - Teil 4: Qualifizierung

Essais non destructifs - Moyens utilisant les rayonnements - Tomographie informatisée - Partie 4: Qualification

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Foreword

This document (prEN 16016-4:2009) has been prepared by Technical Committee CEN/TC 138 “Non-destructive testing”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

This standard consists of the following parts, under the general title, *Radiation methods – Computed tomography* :

— Part 1 : Terminology ;

— Part 2 : Principle, equipment and samples

— Part 3 : Operation and interpretation

— Part 4 : Qualification.

Introduction

This document gives guidelines for the general principles of X-ray computed tomography (CT) applicable to industrial imaging (in the context of this standard, industrial means non-medical applications); it also gives a consistent set of CT performance parameter definitions, including how these 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.

1 Scope

This part describes guidelines for the qualification of the performance of a CT system with respect to various inspection tasks.

2 Normative references

The following referenced documents are indispensable for the application 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.

prEN 16016-1, *Non Destructive Testing – Radiation method – Computed tomography - Terminology.*

prEN 16016-3*, Non Destructive Testing – Radiation method – Computed tomography - Operation and Interpretation*.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in prEN 16016-1 apply.

4 Qualification of the inspection

4.1 General

CT is used in industry both for defect testing and dimensional testing and measurement. Because CT does not directly provide measurement of desired quantities like, for example, pore size or wall thickness, these quantities must be derived from the X-ray linear attenuation data represented by the CT grey values. The detectability of features and the degree of accuracy required depend on the inspection task, the specification of the available test equipment and the analysis and evaluation methods used. When determination of the such quantities is required, a special task-specific qualification test of the CT system is required. The qualification measures are described in 4.2 and 4.3. The qualification should be carried out by trained personnel.

4.2 Qualification of defect testing

Under test qualification, that the suitability of the proposed inspection technique for measuring a quantity to the required precision should be verified. The following steps described are typical of those for the successful verification of the suitability of CT for industrial applications.

4.2.1 Quality feature

Typical quantities to be measured are the sizes of pores, cavities, cracks, inclusions, contaminants as well as studies of the material distribution and the assembly and installation position of components. Because the test sample and the type, position and size of the features to be detected determine the properties of a CT system to be used, information such as the following should be known:

a) test object :

— dimensions ;

— weight ;

— materials ;

— path length to be X-rayed in the material.

b) test feature :

— type ;

— position ;

— size ;

— distribution, frequency.

c) feature detectability :

— limiting defect ;

— limiting feature.

Because the feature detectability strongly influences the specification and therefore the cost of a CT system, special attention must be taken when defining the sensitivity of the tests required. If, due to missing information, no limiting values for features are defined , it is recommended that you use the best possible sensitivity for the specific method and CT system and verify the attained feature detectability using, for example, destructive tests.

4.2.2 Feature detectability/test system/system parameterisation

The usability of the CT system and the selection of system parameters are determined by the requirements for feature detectability. Typical variables are :

a) spatial resolution :

— image scale ;

— detector spatial resolution ;

— focal spot size of radiation source.

b) contrast resolution :

— detector dynamics ;

— attenuation difference (defect size relative to the overall wall thickness) ;

— tube voltage ;

— tube current ;

— exposure time.

c) Reconstruction / visualisation :

— number of projections ;

— CT grey value dynamics of the reconstruction or visualisation ;

— CT image size in x, y and z .

CT system set-up and image quality parameters are described in 4.1 and 5.1 of prEN 16016-3.

4.2.3 Verification of suitability

A reliable statement on the defect detection sensitivity and the defect detectability of the CT system used in a test shall be made, if necessary, by stating the degree of accuracy of the test required (tolerance, degree of fluctuation). Several alternative procedures are described in the following.

4.2.3.1 Reference sample with a natural defect

If a reference sample with a known defect is available, inspection of this sample is carried out and the detectability is stated after the test has been done.

If a reference sample with unquantified defects is available, inspection of this part is carried out and the defect detectability is stated using a counter-check, using, for example, a destructive test after the CT scan has been done. Typical specifications are:

a) test parameters

— tube type ;

— detector type ;

— voxel size, spatial resolution ;

— contrast resolution ;

— filtering ;

— voltage ;

— current ;

— CT image size in x, y and z.

b) defect detectability

— tested area ;

— limiting defect size.

4.2.3.2 Reference sample with synthetic defect

If the test feature can be simulated using a synthetic defect, for example, a bored hole, the defect detectability verification can take place similar to the previous section.

4.2.3.3 Reference sample without specifications

If no specifications are available for the reference sample status and a counter-check is not possible, the test is carried out using the system sensitivity. Sample structures like, for example, wall thicknesses and external dimensional measurements can be used for estimating the defect detectability. Alternatively reference samples like, for example, wires or spheres of known dimensions can be used.

4.2.4 Consistency check

The CT test process requires several, in themselves very complex process steps, for which the error sources can not always be excluded. After the test has been carried out, the following parameters can be provided with possible errors stated:

— reconstruction: size, CT slice positions, possible artefacts ;

— image scale ;

— image unsharpness ;

— intensity jumps ;

— sinogram (CT grey value and curve progress) or CT projection sequence ;

— system status (error messages) ;

where test procedure errors are suspected, then where possible the error cause is to be eliminated and the test is to be repeated.

4.2.5 Documentation

In the qualification report, the relevant parameters and results of the qualification steps are to be described and presented. The CT images are to be archived for a period which is to be agreed with the end-user. The test parameters are to be archived so that an identical test procedure is possible in the case of recurrent test parts and features.

4.3 Qualification of dimensional testing

CT inspection provides information about the 3D structure of a sample from which surface and geometry data can be derived. Because these data are based on X-ray-physical absorption differences at the contour transitions, small differences in measured values may arise compared to classical tactile or optical measuring procedures. In the following sections, those CT scan parameters which influence the results will be described, together with those process steps which affect the accuracy of the results.

4.3.1 Test and measurement task

Dimensional measurement tasks include the measurement of single dimensions in the test object, wall thickness measurements, surface extraction, volume extraction or nominal-actual comparisons. The required measurement precision is to be defined for every task and if necessary for different parts of the sample.

4.3.2 Dimensional testing/test system/system parameterisation

The degree of accuracy attainable depends on the test object, the limitations of X-ray physics and the subsequent data handling. An initial estimation of the degree of accuracy of a CT-based dimensional measurement can take place with the following parameters:

a) spatial resolution in the test object :

— dimensions;

— geometric magnification, voxel size;

— detector resolution;

— focal spot.