SLOVENSKI STANDARD
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Neporušitveno preiskave - Značilnosti goriščne površine v industrijskih rentgenskih sistemih za neporušitveno preskušanje - 2. del: Metoda z robom z merilniki tipa luknje (ISO/DIS 32543-2:2024)

Non-destructive testing - Characteristics of focal spots in industrial X-ray systems - Part 2: Edge method with hole type gauges (ISO/DIS 32543-2:2024)

Zerstörungsfreie Prüfung - Charakterisierung von Brennflecken in Industrie-Röntgenanlagen - Teil 2: Radiographisches Lochkamera Verfahren (ISO/DIS 32543-2:2024)

Essais non destructifs - Caractéristiques des foyers émissifs des tubes radiogènes industriels - Partie 2: Méthode par effet de bord avec jauges de type à trous (ISO/DIS 32543-2:2024)

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DRAFT International Standard

ISO/DIS 32543-2

Non-destructive testing — Characteristics of focal spots in industrial X-ray systems —

Part 2: Edge method with hole type gauges

Essais non destructifs — Caractéristiques des foyers émissifs des tubes radiogènes industriels —

Partie 2: Méthode radiographique par sténopé

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Introduction

To cover the large range of effective focal spot sizes, four different methods are described in EN 12543 series.

In this document, the edge method is intended as user method for measurement of effective focal spot sizes of nano, micro, mini and macro (standard) focus tubes. The edge method uses hole type gauges and is intended for field and lab applications when the users need to observe the effective focal spot on a regular basis and other methods are non-practical.

EN ISO 32543-1, the pin hole method, permits the measurement of spot shape and sizes ≥ 100 µm and EN ISO 32543-3 covers the range of spot sizes for micro focus tubes from 5 µm to 300 µm.

Two further methods are in preparation as future part in ISO 32543 series, concerning:

— the line pair gauges for measuring the effective focal spot size of micro- and nanofocus X-ray tubes with focal spot sizes of 0,2 µm to 100 µm. This method is intended for the use by manufacturers and users and a measuring range between 0,2 µm to 100 µm;

— the reconstruction of the spot shape from hole gauge measurements. The results are equivalent to the pin hole method down to 0,2 µm, if no phase contrast is observed.

In the overlapping ranges the different methods give similar values based on the edge response measurement, which allow using the dedicated method also in a limited way outside the above specified ranges.

Non-destructive testing — Characteristics of focal spots in industrial X-ray systems —

Part 2: Edge method with hole type gauges

1 Scope

This document specifies a method for the measurement of effective focal spot dimensions above 0,2 µm of X-ray systems by means of the edge method applied to digital images taken from hole type or disk type gauges if no phase contrast is observed. The imaging quality and the resolution of X-ray images depend highly on the characteristics of the effective focal spot, in particular the size and the two-dimensional intensity distribution as seen from the detector plane.

This document provides instructions for determining the effective size (dimensions) of standard, mini and micro focal spots of industrial X-ray tubes for users in applications where the pin hole method of ISO 32543-1 is not practicable. This determination is based on the measurement of a profile of an image of a hole or disk type gauge.

The method as described in this document can be used for long term monitoring of focal spot sizes without a pin hole camera.

The accuracy of this method is lower than the one of ISO 32543-1, ISO/DIS 32543-3 and the future standards in preparation, for measurements of the effective focal spot size, using ASTM hole plate IQIs (as described in ASTM E 1025, E 1742), due to its manufacturer tolerance of ±10 % of the hole diameter. It can be used by manufacturers if special hole gauges, manufactured with lower tolerance, as described in 5.2.1 are applied (see Figure 1).

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 12181 (all parts), *Geometrical product specifications (GPS) — Roundness*

ISO 16371-1, *Non-destructive testing — Industrial computed radiography with storage phosphor imaging plates — Part 1: Classification of systems*

ISO 19232-5, *Non-destructive testing — Image quality of radiographs — Part 5: Determination of the image unsharpness and basic spatial resolution value using duplex wire-type image quality indicators*

ISO 32543-1, *Non-destructive testing — Characteristics of focal spots in industrial X-ray systems — Part 1: Pinhole camera radiographic method*

ISO/DIS 32543-3, *Non-destructive testing - Characteristics of focal spots in industrial X-ray systems for use in non-destructive testing - Part 3: Measurement of the effective focal spot size of mini and micro focus X-ray tubes*

ASTM E 2903, *Standard Test Method for Measurement of the Effective Focal Spot Size of Mini and Micro Focus X-ray Tubes*

ASTM E 1165, *Standard Test Method for Measurement of Focal Spots of Industrial X-Ray Tubes by Pinhole Imaging*

ASTM E 2002, *Standard Practice for Determining Total Image Unsharpness and Basic Spatial Resolution in Radiography and Radioscopy*

ASTM E 1742, *Standard Practice for Radiographic Examination*

ASTM E 1025, *Standard Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) used for Radiology*

ASTM E 1000, *Standard Guide for Radioscopy*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1
Thermal focal spot
X-ray producing area of the target as viewed from a position perpendicular to the target surface

Note 1 to entry: Also named as actual focal spot in ASTM E 1165.

3.2
Effective focal spot
X-ray producing area of the target as viewed by a detection device from the defined image plane

Note 1 to entry: Also named optical focal spot in other publications.

3.3
Effective size of focal spot
s
focal spot size measured in accordance with this document ($s = s_{ERF50}$)

3.4
Roundness
RON_t
value of the largest positive local roundness deviation added to the absolute value of the largest negative local roundness deviation from a reference circle according to ISO 12181 series.

3.5
Effective size of focal spot measured from an ERV_{50}
s_{ERV50}
focal spot size derived from measured edge response function at edge response value 50 % (ERV_{50}) (see 7.2) as applied in ASTM E 2903 and ASTM E 1165, Annex A, according to Formula (7).

Note 1 to entry: ASTM E 1165, Annex A uses an extension value of 1,4 instead of 1,47 as used in the standard practice of ASTM E1165 before Annex A.

3.6
Nominal focal spot size
SS
Value determined from Table A.1 based on the measured focal spot $s = s_{ERV50}$

3.7
Focal spot size class
FS
Classification value for X-ray tubes, which have a focal spot size in the defied range as defined ANNEX A, Table A.1

3.8
Edge response function
ERF
Function determined by measuring the spatial distribution of the X-ray image of a sharp edge of a dense material

3.9
Edge response value
ERV
value of the spatial distances, measured at 16 % and 84 % of the profile intensity of an ERF and extended to 0 % and 100 % in the profile line by a factor of 1,47 (=100/(84-16)).

Note 1 to entry: The concept was published by Klasens[1] and is used also in ASTM E 1000 for measurement of the unsharpness in radioscopic images.

Note 2 to entry: The value ERV corresponds to the spot size, s, as measured with the method of ISO 32543-1 or ASTM E 1165 (without Annex)

3.10
Edge response value 50
ERV_{50}
value of the spatial distances, measured 2 times at 50 % and 84 % of the profile intensity of an ERF and extended to 0 % and 100 % in the profile line by a factor of 1,47.

Note 1 to entry: The value ERV_{50} corresponds to the spot size, s, as measured with the method of ISO/DIS 32543-3 or ASTM E 2903 and is used instead of ERV if an edge transmission of gauges needs to be considered.

3.11
Signal to noise ratio
SNR
ratio of mean grey value to the standard deviation of the grey values (noise) measured in a region of interest

Note 1 to entry: grey values are numeric values of pixels, which are directly proportional to the detector exposure dose and having a value of zero, if the detector was not exposed

3.12
Contrast-to-noise ratio
CNR
ratio of the difference of the mean signal levels between two image areas to the averaged standard deviation of the signal levels

3.13
Pixel coverage of a focal spot
N
number of pixels in an image by which it is blurred by the focal spot size in x- or y-direction (e.g. width or length).

Note 1 to entry: N corresponds to the number of pixels across the spot edge profile.

3.14
basic spatial resolution value of a digital detector
$SR_b^{detector}$
half of the measured detector unsharpness in a digital image, which corresponds to the effective pixel size and indicates the smallest geometrical detail which can be resolved with a digital detector at magnification equal to one

Note 1 to entry: For this measurement, the duplex wire IQI is placed directly on the digital detector array (3.3) or imaging plate.

Note 2 to entry: The measurement of unsharpness is described in ISO 19232-5. See also ASTM E1000 and ASTM E2736.

[SOURCE: ISO 17636-2:2022(en), definition 3.8]

3.15
Interpolated basic spatial resolution value of a digital detector
$iSR_b^{detector}$
smallest geometrical detail, which can be resolved in a digital image at magnification equal to one and corresponds to half of the measured interpolated detector unsharpness, in a digital image and is determined from a profile function in a digital image by interpolation from a linearized profile function and obtained by interpolation to 20 % modulation depth from neighbour element modulations.

Note 1 to entry: The measurement of interpolated unsharpness is described in ISO 19232-5 and ASTM E 2002. See also ASTM E1000 and ASTM E2736.

3.16
Anticipated focal spot size
afs
size of a focal spot as provided by a manufacturer, a specification or obtained by an older measurement

4 Principle and detectors

4.1 Principle

The method is based on indirect measurement of the focal spot size calculated from the geometric unsharpness of the radiographs of hole or disk gauges. For this purpose, hole or disk gauges with sharp edges are imaged either on an imaging plate (IP) by computed radiography (CR), or by means of a digital detector array (DDA) using a suitable geometric magnification (see below for magnification requirements). The edge unsharpness of the hole or disk structures is evaluated.

The hole method of ASTM E 1165, Annex A, will be adapted for this document for spot sizes ≥ 0,1 mm. Other gauges are required to cover the range of spot sizes < 0,1 mm.

4.2 Detectors

4.2.1 General

The shape of focal spots is important for manufacturers and evaluation of possible changes in the X-ray tube with operating time.

4.2.2 Imaging plates for computed radiography

The following equipment is required for the measurement, if using computed radiography (CR):

— a test object as described below;

— a computed radiography system, consisting of imaging plates and a scanner, configured such that the pixel size is appropriate for the measurement (clause 5). The image shall be of a sufficient size to image magnified test objects and the region around the test object to obtain a profile as shown in Figure 5b).

The computed radiography system shall meet the requirements of ISO16371-1 Class IP I, IP II or IP Special and imaging plates shall be packed in low absorbing cassettes using no metal screens.

4.2.3 Digital Detector Arrays (DDA)

The following equipment is required for the measurement, if using digital detector array devices:

— test object as described in clause 5;

— DDA, configured such that the pixel size is appropriate for the measurement (clause 5). The image shall be of sufficient size to image the magnified test object and a region around test object to obtain a profile as shown in Figure 5b);