SLOVENSKI STANDARD
# SIST EN 12543-2:2021

01-junij-2021

**Nadomešča:**
**SIST EN 12543-2:2009**

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**Neporušitvene preiskave - Značilnosti goriščne površine v industrijskih rentgenskih sistemih za neporušitveno preskušanje - 2. del: Metoda s kamero z luknjico**

Non-destructive testing - Characteristics of focal spots in industrial X-ray systems for use in non-destructive testing - Part 2: Pinhole camera radiographic method



Zerstörungsfreie Prüfung - Charakterisierung von Brennflecken in Industrie-Röntgenanlagen für die zerstörungsfreie Prüfung - Teil 2: Radiographisches Lochkamera-Verfahren



Essais non destructifs - Caractéristiques des foyers émissifs des tubes radiogènes industriels utilisés dans les essais non destructifs - Partie 2 : Méthode radiographique par sténopé

**Ta slovenski standard je istoveten z:** **EN 12543-2:2021**

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**ICS:**

19.100 Neporušitveno preskušanje Non-destructive testing

**SIST EN 12543-2:2021** **en,fr,de**

# EUROPEAN STANDARD

# NORME EUROPÉENNE

# EUROPÄISCHE NORM

**EN 12543-2**

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English Version

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Essais non destructifs - Caractéristiques des foyers émissifs des tubes radiogènes industriels utilisés dans les essais non destructifs - Partie 2 : Méthode radiographique par sténopé

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This European Standard was approved by CEN on 1 March 2021.

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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
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

**CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels**



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# European foreword

This document (EN 12543-2:2021) has been prepared 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 2021, and conflicting national standards shall be withdrawn at the latest by October 2021.

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 12543-2:2008.

The main changes compared to the previous edition are as follows:

— The document has been technically and editorially revised;

— The scope of application was extended up to 1000 kV for digital detectors;

— Table 1 has been extended to include pin holes of 10 micron diameter;

— In Annex A, Focal Spot Classes have been introduced for simple X-ray tube classification;



— Chapter 5 introduces a new measurement procedure “Integrated Line Profile”;

— Table A.1 and Table A2 provide a new classification and result of focal spot measurement.



According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

# Introduction

In order to cover the large range of effective focal spot sizes, different methods are described in EN 12543-1, EN 12543-2, EN 12543-3, EN 12543-4 and EN 12543-5.

The pinhole method (EN 12543-2) is intended for effective focal spot sizes above 0,1 mm and mainly used for sealed standard and mini focus tubes.

The edge method of EN 12543-4 is intended for field applications when the users have to observe the effective focal spot on a regular basis and the pinhole method is non-practical.

The edge measurement method of EN 12543-5 is intended for measurement of effective focal spot sizes between 5 µm and 300 µm and mainly for the use with µ-Focus tubes (up to 100 µm) and mini focus tubes with spot sizes of 100 µm to 300 µm.

In the overlapping ranges, the different standard parts provide comparable values within ± 20 % tolerance.

ASTM E1165 describes the same pinhole procedure.

# 1 Scope

This document specifies a method for the measurement of effective focal spot dimensions above 0,1 mm of X-ray systems up to and including 1000 kV tube voltage by means of the pinhole camera method with digital evaluation. The tube voltage applied for this measurement is restricted to 200 kV for visual film evaluation and may be selected higher than 200 kV if digital detectors are used.

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 method compared to the others in the EN 12543 series allows to obtain an image of the focal spot and to see the state of it (e.g. cratering of the anode).

This test method provides instructions for determining the effective size (dimensions) of standard (macro focal spots) and mini focal spots of industrial X-ray tubes. This determination is based on the measurement of an image of a focal spot that has been radiographically recorded with a “pinhole” technique and evaluated with a digital method.

For the characterization of commercial X-ray tube types (i.e. for advertising or trade) it is advised that the specific FS (Focal spot) values of Annex A are used.

# 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.



EN 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 19232-5)*



# 3 Terms and definitions

For the purposes of this document, the following terms and definitions 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 https://www.iso.org/obp

**3.1**
**actual focal spot**
X-ray emitting area of the anode as viewed from a position perpendicular to the anode surface

Note 1 to entry: The actual focal spot is also called thermal focal spot in other literature.

Note 2 to entry: See Figure 3, Key 7.

**3.2**
**effective focal spot**
X-rays emitting area of the anode as viewed from the image plane of the detector

Note 1 to entry: The effective focal spot is also called optical focal spot in other literature.

Note 2 to entry: See Figure 3, Key 4.

**3.3**
**effective focal spot size**
focal spot size measured in accordance with this document

**3.4**
**nominal focal spot size**
**SS**
characteristic value for X-ray tubes having measured spot sizes within a defined range

Note 1 to entry: Annex A, Table A.1, defines the ranges of measured spot sizes in reference to the nominal value SS for characterization of X-ray tubes.

**3.5**
**Focal spot class**
**FS**
number used to classify X-ray tubes based on the nominal focal spot size

**3.6**
**basic spatial resolution of a detector**
$SR_b$**detector**
smallest degree of visible detail within a digital image, determined with the duplex wire image quality indicator (IQI) according to EN ISO 19232-5 located on the detector (magnification = 1), from the smallest number of the duplex wire pair with less than 20% modulation depth in a linearized profile and it corresponds to ½ of the detector unsharpness



# 4 Test equipment

## 4.1 Essential characteristics of the pinhole



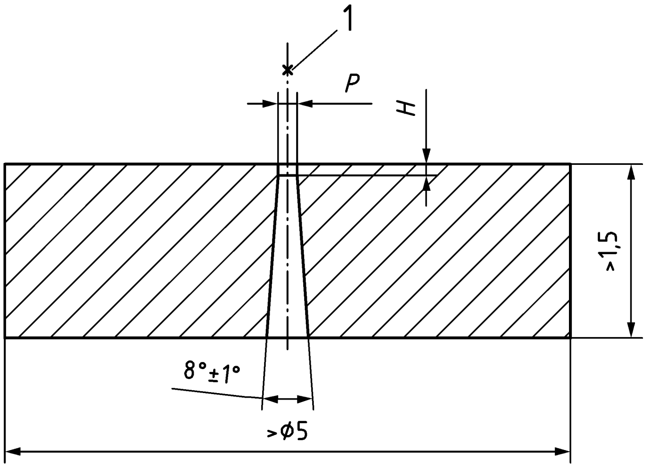
The pinhole camera shall consist of a diaphragm with a pinhole having following essential dimensions P and H according to Table 1 dependent from the effective focal spot size.

**Table 1 — Dimensions of the pinhole**

| Focal spot size<br>mm | Diameter *P*<br>µm | Height *H*<br>µm |
|---|---|---|
| 0,1 to 0,3 | 10 ± 5 | 20 ± 5 |
| > 0,3 to 1,0 | 30 ± 5 | 75 ± 10 |
| > 1,0 | 100 ± 5 | 500 ± 10 |

The essential dimensions *P* and *H* are shown in Figure 1.

Dimensions in millimetres




**Key**

1 focal spot

**Figure 1 — Essential dimensions of a pinhole diaphragm**

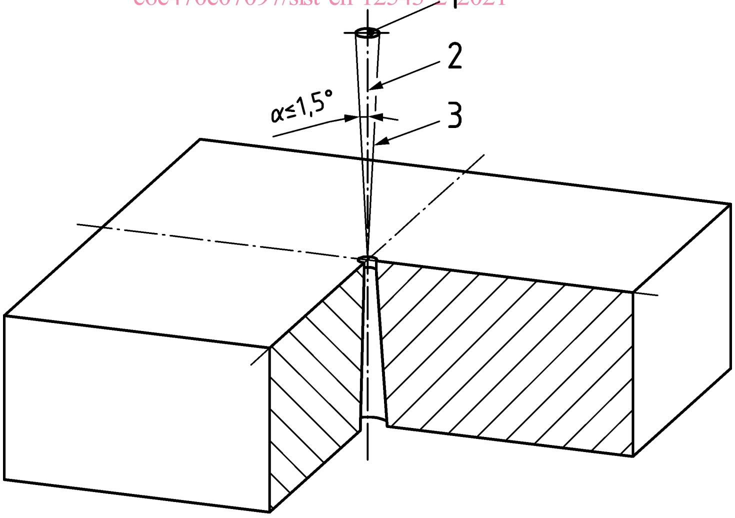
The pinhole diaphragm shall be made of tungsten or of a similar absorbent material (e.g. gold, platinum, tantalum or related alloys).



### 4.2 Alignment and position of the pinhole camera

The angle between the beam direction and the pinhole axis (see Figure 2) shall be smaller than ± 1,5 °. When deviating from Figure 2, the direction of the beam shall be indicated.






**Key**

1 focal spot

2 beam direction

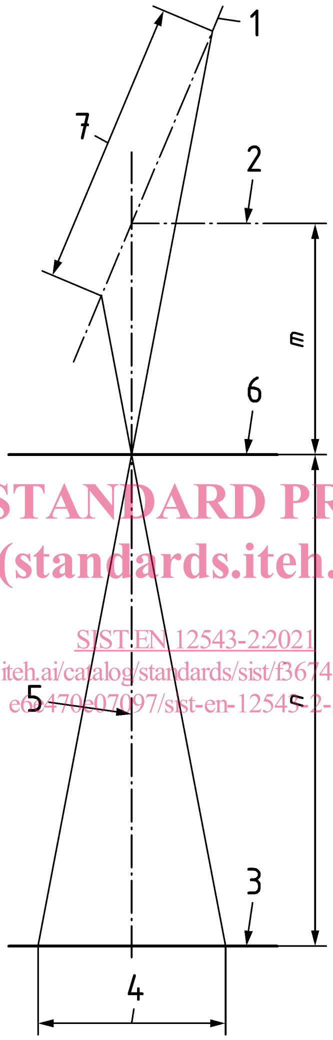
3 maximum deviation of the axis of the pinhole

**Figure 2 — Alignment of the pinhole camera**

The incident face of the pinhole diaphragm shall be placed at a distance m from the focal spot so that the variation of the magnification over the extension of the actual focal spot does not exceed ± 5 % in the beam direction. In no case shall this distance be less than 100 mm.

### 4.3 Position of the radiographic image detector

The radiographic image detector [film, imaging plate (CR) or digital detector array (DDA)] shall be placed normal to the beam direction at a distance *n* from the incident face of the pinhole diaphragm determined from the applicable magnification according to Figure 3 and Table 2.






**Key**

1 plane of anode
2 reference plane
3 radiographic image detector
4 magnified length of the effective focal spot
5 beam direction
6 incident face of the diaphragm
7 physical length of the actual focal spot
*n* distance from pin hole to detector
*m* distance from focal spot centre to pin hole

**Figure 3 — Beam direction dimensions and planes**

**Table 2 — Magnification for focal spot pinhole images**

| Anticipated Focal Spot Size *d*<br><br>mm | Minimum Magnification *n/m* | Distance between Focal Spot and Pinhole *m*<br><br>m [a] | Distance between Pinhole and Detector *n*<br><br>m [a] |
|---|---|---|---|
| 0,1 to 1,0 | 5: 1 | 0,10 | 0,50 |
| 1,0 to 2,0 | 3: 1 | 0,25 | 0,75 |
| > 2,0 | 1: 1 | 0,5 | 0,5 |

[a] When using a technique that entails the use of enlargement factors and a 1 m focal spot to detector distance (FDD = *m*+*n*) is not possible (see 5.1), the distance between the focal spot and the pinhole (*m*) shall be adjusted to suit the actual focal spot to detector distance (FDD) used (for example, if a 600 mm FDD is used, *m* shall be 100 mm for 5:1 enlargement, 150 mm for 3:1 enlargement, 300 mm for 1:1 enlargement, and the like).

## 4.4 Requirements on the radiographic image detector

Digital radiographic image detectors can be used instead of film, provided sensitivity, dynamic range and detector unsharpness allow capturing of the full spatial size of the focal spot image without detector saturation. The maximum allowed basic spatial resolution ($SR_b^{\text{detector}}$) of the digital detector is determined from the pinhole diameter $P$ and magnification $n/m$. It is calculated according to Formula (1).



$$SR_b^{detector} = \frac{P}{2} \cdot \left(1 + \frac{n}{m}\right) \quad (1)$$

The basic spatial resolution of the digital detector ($SR_b^{\text{detector}}$) shall be determined with the duplex wire IQI according to EN ISO 19232-5. For correct quantitative measurements the minimum projected length and width of the focal spot image should be covered always by at least the pixel number which is equivalent to 20 x $SR_b^{\text{detector}}$. The signal-to-noise ratio of the focal spot image (ratio of the maximum intensity value inside the focal spot and the standard deviation of the background signal outside) should be at least 70. The maximum intensity inside the focal spot should be above 30 %, but lower than 90 % of the maximum linear detector output value. The grey value resolution of the detector shall be at least 12 bit.

Imaging plate systems (Computed Radiography, CR) or digital detector arrays (e.g. based on CCD-, amorphous-Si- or CMOS-detectors coupled to an X-ray fluorescence screen, or direct converting detectors) may be used as digital image detectors. The pixel values (grey values) shall be linear to the dose.

If radiographic film is used as image detector, it should meet the requirements of the film system class C 4 or better according to EN ISO 11699-1 and shall be used without screens. The film shall be exposed to a maximum optical density between 1,5 and 2,5. The film shall be digitized with a maximum pixel size of 50 µm or a smaller size, which shall fulfil the requirements of the above described $SR_b^{\text{detector}}$ condition and be evaluated according to 5.3.

If the user has no digital equipment, the film may be evaluated visually; the procedure is described in 5.4. The visual evaluation of film radiographs will be less accurate than the evaluation of digital images with the profile function as described in 5.3.