

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

Part 1: Scanning method

The European Standard EN 12543-1:1999 has the status of a
British Standard

ICS 19.100

National foreword

This British Standard is the English language version of EN 12543-1:1999.

The UK participation in its preparation was entrusted to Technical Committee WEE/46, Non-destructive testing, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 11 and a back cover.

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English version

Non-destructive testing — Characteristics of focal spots in industrial X-ray systems for use in non-destructive testing — Part 1: Scanning method

Essais non destructifs - Caractéristiques des foyers émissifs des tubes radiogènes utilisés dans les essais non destructifs - Partie 1: Méthode par balayage

Zerstörungsfreie Prüfung - Charakterisierung von Brennflecken in Industrie-Röntgenanlagen für die zerstörungsfreie Prüfung - Teil 1: Scan-Verfahren

This European Standard was approved by CEN on 16 August 1999.

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Foreword

This European Standard 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of an identical text or by endorsement, at the latest by March 2000, and conflicting national standards shall be withdrawn at the latest by March 2000.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

In the framework of its scope, Technical Committee CEN/TC 138 entrusted CEN/TC 138/WG 1 "Ionizing Radiation" with preparing the following standard:

EN 12543-1, *Non-destructive testing - Characteristics of focal spots in industrial X-ray systems for use in non-destructive testing - Part 1: Scanning method.*

EN 12543-1 is a part of series of European Standards with the same number; the other parts are the following:

EN 12543-2, *Non-destructive testing - Characteristics of focal spots in industrial X-ray systems for use in non-destructive testing - Part 2: Pinhole camera radiographic method.*

EN 12543-3, *Non-destructive testing - Characteristics of focal spots in industrial X-ray systems for use in non-destructive testing - Part 3: Slit camera radiographic method.*

EN 12543-4, *Non-destructive testing - Characteristics of focal spots in industrial X-ray systems for use in non-destructive testing - Part 4: Edge method.*

EN 12543-5, *Non-destructive testing - Characteristics of focal spots in industrial X-ray systems for use in non-destructive testing - Part 5: Measurement of the effective focal spot size of mini and micro-focus X-ray tubes.*

Introduction

In order to cover the different requirements for focal spot size measurement, five different methods are described in EN 12543-1 to EN 12543-5.

The scanning method (EN 12543-1) is dedicated to those applications where quantitative values for the intensity distribution and spot size are needed, i. e. calibration and image processing purposes.

The radiographic methods (EN 12543-2 and EN 12543-3) describe the traditional techniques and are dedicated for certification purposes and for field applications up to 200 kV.

Where no pinhole or slit cameras are available in the field, the edge method (EN 12543-4) may be applied. It represents a very simple method for field application.

In order to cover also the micro focus systems, a specific method is presented in EN 12543-5.

1 Scope

This European Standard specifies the measurement of focal spot dimensions of industrial X-ray systems up to and including 500 kV tube voltage. It describes a method of direct mechanical scanning of focal spots above 0,1 mm with a highly collimated receiver.

The image quality and the resolution of X-ray images depend highly on the characteristics of the focal spot, in particular the size and the two-dimensional intensity distribution.

For the characterization of commercial X-ray tube types (i.e. for advertising or trade) the specific maximum values given in annex A should be preferred.

2 Terms and definitions

For the purposes of this standard, the following definition applies:

Focal spot: the X-ray emitting area on the anode of the X-ray tube as seen from the measuring device.

3 Test method

3.1 Principle and equipment

This clause deals with the production of focal spot scans to be used for the determination of the focal spot intensity distribution and dimensions. The coarsely precollimated central beam of the X-ray tube is measured by a scintillation counter through a double slit collimator. The collimator forms a hole with the dimensions $h \times h$. The width h depends on the spot size d and shall be selected corresponding to table 1:

Table – 1 Collimator hole dimension h in relation to the focal spot size d

d mm	h
0,1 to 0,2	$\leq 10 \mu\text{m}$
0,2 to 0,3	$\leq 15 \mu\text{m}$
0,3 to 1,0	$\leq 20 \mu\text{m}$
$> 1,0$	$\leq 0,025 \times d$

The precollimator, double slit collimator and radiation detector shall be mounted as one unit on a x-y scanning table. The output signal of the detector shall be registered by a data acquisition facility (figures 1, 2). The data acquisition shall be well synchronized with the x-y scanning table. The data acquisition is done in the way that at certain step widths a line scan is registered (figure 3). The step width depends on the required resolution, but it shall not exceed 0,1 mm.

The precollimator shall be made of lead containing a hole of approximately 5 mm diameter. The thickness depends

on the maximum X-ray voltage. It shall correspond to a hundredth value layer at least.

The measuring collimator is made of two perpendicular slits, see figure 4. Each slit is formed by two metal blocks with the thickness L facing each other and kept at a distance h by spacers at the edges. The thickness L shall be

$$L > 20 \times (a/d) \times h \quad (1)$$

where a is the distance between the focal spot and the collimator surface (source side) and d is the focal spot size to be measured. The minimum thickness L of the collimators shall be defined such that the measured signal intensity through the hole shall be at least 100 times larger than the background noise due to the penetration of the collimator material. The roughness R_a of the slit surfaces shall be better than $2 \mu\text{m}$, and the flatness and the parallelism better than $h/5$. The material of the metal blocks shall be tungsten or another similar absorbant material.

The radiation detector shall work in the X-ray voltage range between 10 kV and the nominal voltage of the tube to be measured. At the brightest parts of the intensity distribution of the spot the output signal shall have a signal-to-noise ratio of at least 40 dB, and the output signal shall follow the radiation intensity linearly. Data acquisition and data processing shall be stable to at least $\pm 1 \%$ over the measuring time. The x-y scanning table shall be capable of resolving and reproducing at least $h/2$.

3.2 Alignments

One of the axes of the x-y scanning table shall be to $\pm 3^\circ$ parallel to the axis of the tube assembly. The x-y scanning table plane shall be to $\pm 3^\circ$ perpendicular to the main beam of the tube assembly. The distance between the focal spot and the collimators shall be as small as practicable. When deviating from figure 1 the direction of the main beam shall be indicated.

NOTE If the tube axis is not defined, then the direction of the electron trajectory is used instead.

3.3 Graphic software

The graphic software shall offer the possibility of an isodose contour plot (figure 6). Plots according to figures 3 and 5 can give additional information about the radiation intensity distribution, which may be useful for computer tomography and image processing.

4 Measurement and determination of the focal spot size

4.1 Measurement

The dimensions of the focal spot shall be determined from the isodose contour plot (see figure 6) at 10 % of the maximum intensity.

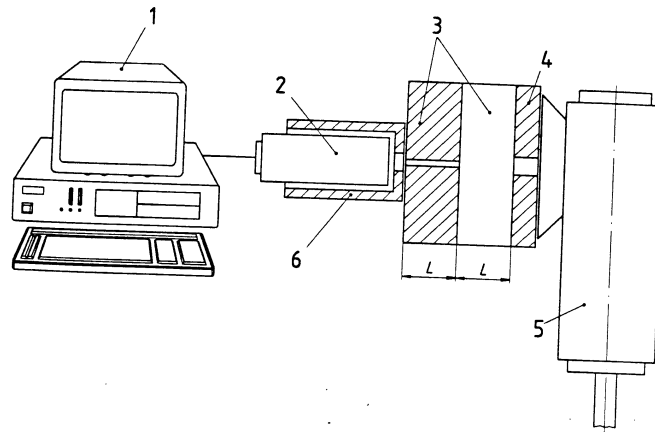
4.2 Determination of the focal spot size

Each focal spot size is described by its size l (length) in the direction of the tube axis and its size w (width) across the X-ray tube.

The operating parameters of the X-ray tube shall be recorded.

The larger of these sizes (l or w) shall be used as the "focal spot size d ".

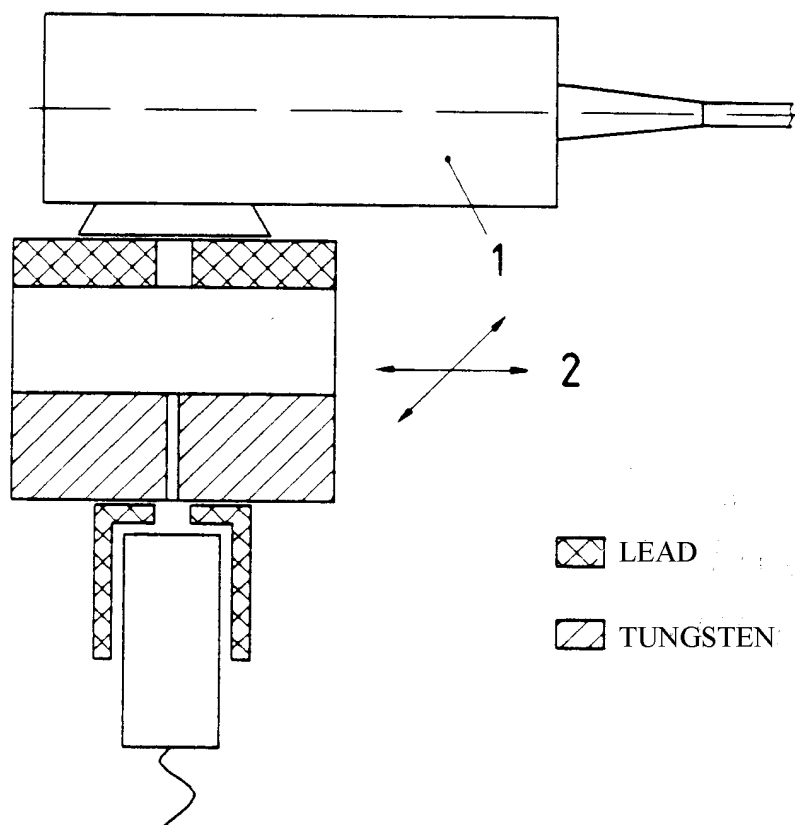
A specification of the focal spot size d on the X-ray tube shall refer to this standard.



Key

- 1 personal computer and data acquisition unit
- 2 scintillation counter
- 3 double slit collimator ($h \times h \times 2L$)
- 4 precollimator
- 5 X-ray tube
- 6 scattered radiation protection

Figure 1 – Measuring facility for radiometric determination of the focal spot size (scheme)



Key

- 1 X-ray tube
- 2 scan directions

Figure 2 – Measuring facility for radiometric determination of the focal spot size (example)

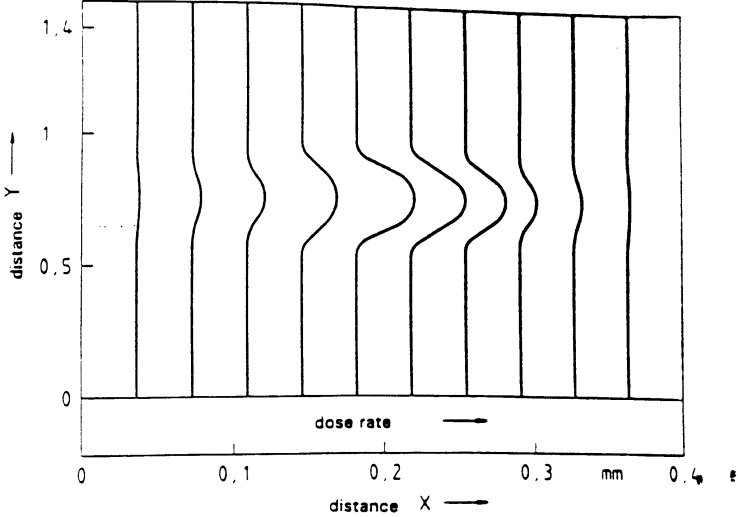
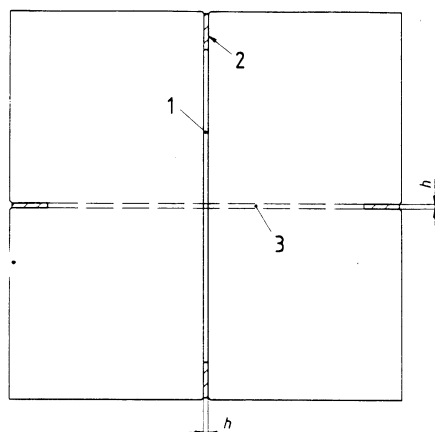


Figure 3 – Line scans of a focal spot



Key

- 1 slit
- 2 foil (steel)
- 3 hidden slit

Figure 4 – Double slit collimator (from above)

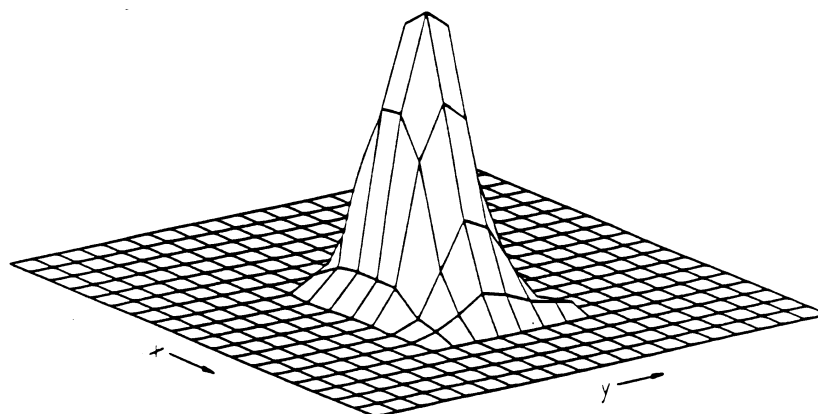


Figure 5 – Graphical interpretation of the intensity distribution of focal spot scans

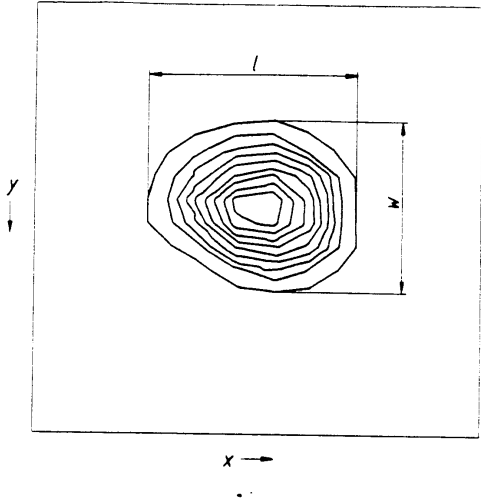


Figure 6 – Isodose contour plot

Annex A
(informative)

Preferred values of d for the characterization of X-ray tubes

Table A.1 – Preferred values of d in millimetres

0,1;	0,15;	0,2;	0,3;	0,4;	0,5;
0,6;	0,8;	1,0;	1,4;	1,8;	2,2;
2,6;	3,0;	3,5;	4,0;	4,5;	5,0;
5,5;	6,0;	7,0;	8,0;	9,0;	10,0;

Additionally to d , the dimensions of l and w can be indicated in the same steps.

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