



BS 6530 : 1984
IEC 336 : 1982

UDC 616-073.754.7 : 621.386.2.08

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British Standard Methods for
**Determining the characteristics of focal spots in
diagnostic X-ray tube assemblies for medical use**



(Implementation of CENELEC HD 509 S1)

Méthodes de détermination des caractéristiques des foyers des gaines équipées pour diagnostic médical

Verfahren zur Bestimmung der Kenndaten von Brennflecken von Diagnostikröntgengeräten
für medizinische Zwecke

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National foreword

This British Standard has been prepared under the direction of the Light Electrical Engineering Standards Committee and revises BS 5269 : Part 1 : 1975 which is withdrawn. It is identical with IEC Publication 336 'Characteristics of focal spots in diagnostic X-ray tube assemblies for medical use' published in 1982 by the International Electrotechnical Commission (IEC).

This British Standard describes methods for determination of focal spot characteristics and should not be used or quoted as a specification. Reference to the standard should indicate that the methods used are in accordance with BS 6530.

This British Standard is also in agreement with Harmonization Document HD 509 S1, published by the European Committee for Electrotechnical Standardization (CENELEC).

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

Where the page numbers are quoted, they are IEC page numbers.

Cross-references

International standards	Corresponding British Standards
IEC 613 : 1978	BS 6058 : 1981 Method of specifying and verifying the characteristics of rotating anode X-ray tubes and X-ray tube assemblies used in medical diagnosis (Identical)
IEC 637 : 1979	BS 6059 : 1981 Specification for essential data to be supplied with X-ray tubes and X-ray tube assemblies for medical use (Identical)

There is no British Standard equivalent to the N.B.S. Handbooks 78 and 89 referred to in the introduction. The Handbooks are obtainable from the National Bureau of Standards, Washington D.C., U.S.A.

Compliance with a British Standard does not of itself confer immunity from legal obligations.



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British Standard Methods for

Determining the characteristics of focal spots in diagnostic X-ray tube assemblies for medical use

SECTION ONE — GENERAL

1. Scope

This standard deals with methods of determining characteristics of FOCAL SPOTS of diagnostic X-RAY TUBE ASSEMBLIES for medical use, operating at X-RAY TUBE POTENTIAL DIFFERENCES up to and including 200 kV.

It is not intended that this standard be applied for the determination of the characteristics of FOCAL SPOTS of X-RAY TUBE ASSEMBLIES particularly designed for use in equipment for RECONSTRUCTIVE TOMOGRAPHY.

Measuring methods and requirements for test arrangements to be applied for evaluating compliance with this standard are described together with the means of indicating compliance both of the specified characteristics of FOCAL SPOTS and the radiograms prepared in checking these characteristics.

2. Introduction

IEC Publication 336 (First edition, 1970): Measurement of the Dimensions of Focal Spots of Diagnostic X-ray Tubes using a Pinhole Camera, was based upon an earlier I.C.R.U. recommendation and upon national standards and has become well established as a valuable means of determining the dimensions of FOCAL SPOTS.

Since publication of the first edition of this standard, X-ray tube technology as well as the systematic investigation of imaging procedures has developed significantly. The method for the determination of the dimensions of a FOCAL SPOT based upon a FOCAL SPOT PINHOLE RADIOGRAM becomes very difficult for NOMINAL FOCAL SPOT VALUES smaller than 0.3 because the results are affected by factors, such as transmission through the shielding of the DIAPHRAGM and the need for repeated IRRADIATIONS of the RADIOGRAPHIC FILM due to tube loading considerations. Therefore, a new method, using a pair of FOCAL SPOT SLIT RADIOGRAMS, has been developed which will be applied over the entire range of usual NOMINAL FOCAL SPOT VALUES. It avoids former uncertainties in determining the dimensions of FOCAL SPOTS and gives valuable results even in cases of distorted FOCAL SPOTS. Furthermore, it provides basic data in the form of a pair of FOCAL SPOT SLIT RADIOGRAMS allowing determination of the imaging properties of the FOCAL SPOTS in the form of a pair of one-dimensional MODULATION TRANSFER FUNCTIONS.

Thus, not only the method for the determination of the dimensions of FOCAL SPOTS but also that for the determination of the MODULATION TRANSFER FUNCTION will be based exclusively upon the use of the pair of FOCAL SPOT SLIT RADIOGRAMS for all NOMINAL FOCAL SPOT VALUES.

In addition, further standard methods are described for establishing focal spot characteristics. These are in common use and will continue to have their place for use by manufacturers (FOCAL SPOT PINHOLE RADIOGRAMS) and in the field (FOCAL SPOT STAR RADIOGRAMS).

In its report in 1958, (see N.B.S. Handbook 78), the I.C.R.U. had recommended applying to the measured length of line focal spots a multiplier of 0.7. This correction was confirmed by I.C.R.U. in 1963 (see N.B.S. Handbook 89).

The same factor was incorporated into IEC Publication 336 (1970) and after very careful consideration, has been retained in this standard, see Table VI. In this way discrepancies between NOMINAL FOCAL SPOT VALUES according to the present standard and the dimensions of FOCAL SPOTS, so well established through the application of the first edition of IEC Publication 336, are avoided.

Maintaining the multiplier 0.7 for NOMINAL FOCAL SPOT VALUES of 0.3 and greater is justifiable due to the fact that these FOCAL SPOTS are almost exclusively designed for very high loads which cause the distribution in radiant intensity over the length to exhibit a pronounced peak with relatively shallow shoulders. This results in larger linear dimensions for the length of the FOCAL SPOT compared to width even though the MODULATION TRANSFER FUNCTIONS for both width and length may be approximately equal.

FOCAL SPOTS in the range below 0.3 are normally designed for magnification techniques with a more rectangular distribution of the radiant intensity over both width and length. Here the MODULATION TRANSFER FUNCTIONS are comparatively equal so indicating the same dimensions for width and length. Additionally, in the absence of earlier standards there is no sound reason to perpetuate the factor of 0.7 for the new range.

The production of FOCAL SPOT STAR RADIOGRAMS has been standardized because of their usefulness in making a simple assessment of the imaging properties of a system under field conditions by establishing the STAR PATTERN RESOLUTION LIMIT under those conditions (assuming the FOCAL SPOT has such a characteristic).

Within the scope of this standard it is not intended to recommend or require that a statement of these characteristics should be part of the specification of an X-RAY TUBE ASSEMBLY. The information to be given with an X-RAY TUBE ASSEMBLY is the subject of IEC Publication 637. This requires the NOMINAL FOCAL SPOT VALUE and the one-dimensional MODULATION TRANSFER FUNCTION to be given in the ACCOMPANYING DOCUMENTS (see Table I).

TABLE I
Methods for evaluation of specific aspects characterizing the FOCAL SPOT

Information obtained:				
by means of a	accord- ing to Section	about	accord- ing to Section	used for evaluating compliance with IEC Publication 637 of the:
Pair of FOCAL SPOT SLIT RADIOGRAMS*	Two	Dimensions	Five	Specified NOMINAL FOCAL SPOT VALUE
		Imaging properties	Six	Specified pair of one-dimensional MODULATION TRANSFER FUNCTIONS
FOCAL SPOT PINHOLE RADIOGRAM	Three	Orientation		
		Radiant intensity distribution		
		Symmetry		
FOCAL SPOT STAR RADIOGRAM**	Four	STAR PATTERN RESOLUTION LIMIT	Seven	
		BLOOMING VALUE	Eight	
		Modification of focal spot properties over the life time		

* A method for the determination of the r.m.s. value of the line spread function as a further characteristic of the FOCAL SPOT is under consideration.

The r.m.s. value could give valuable information as a single value about the properties of the FOCAL SPOT with respect to the total imaging process of a system.

** The distribution of radiant intensity over a FOCAL SPOT does not always provide a point where the MODULATION TRANSFER FUNCTION will reach the spatial frequency axis. In this case the method by means of a FOCAL SPOT STAR RADIOGRAM is not applicable.

3. Terminology

3.1 Degree of requirements

In this standard the auxiliary verb:

- "shall" implies that compliance with a requirement is mandatory for compliance with the standard;
- "should" implies that compliance with a requirement is strongly recommended but is not mandatory for compliance with the standard;
- "may" implies that compliance with a requirement is permitted to be accomplished in a particular manner, for compliance with the standard.

Note. - These definitions are under consideration.

3.2 Definitions

Terms in this standard printed in small-capitals are used as defined in Appendix C. They will form part of a terminology standard on medical radiology (under consideration).

4. Other IEC standards

Within this standard reference is made to the following IEC standards:

	Clause or sub-clause
IEC Publication 613: Electrical Thermal and Loading Characteristics of Rotating Anode X-ray Tubes for Medical Diagnosis.	8.2.1
IEC Publication 637: Marking of and Accompanying Documents for X-ray Tubes and X-ray Tube Assemblies for Medical Use.	2 and Table I 26.2 26.3 33.2

SECTION TWO — FOCAL SPOT SLIT RADIOGRAMS

5. Scope

This section deals with the production of FOCAL SPOT SLIT RADIOGRAMS to be used for the determination of focal spot dimensions according to Section Five and the determination of the MODULATION TRANSFER FUNCTION according to Section Six.

A method of indicating compliance with this standard of a pair of FOCAL SPOT SLIT RADIOGRAMS is included.

6. Test equipment

6.1 SLIT CAMERA

FOCAL SPOT SLIT RADIOGRAMS shall be obtained by means of a SLIT CAMERA containing a slit diaphragm of the dimensions given in Figure 1.

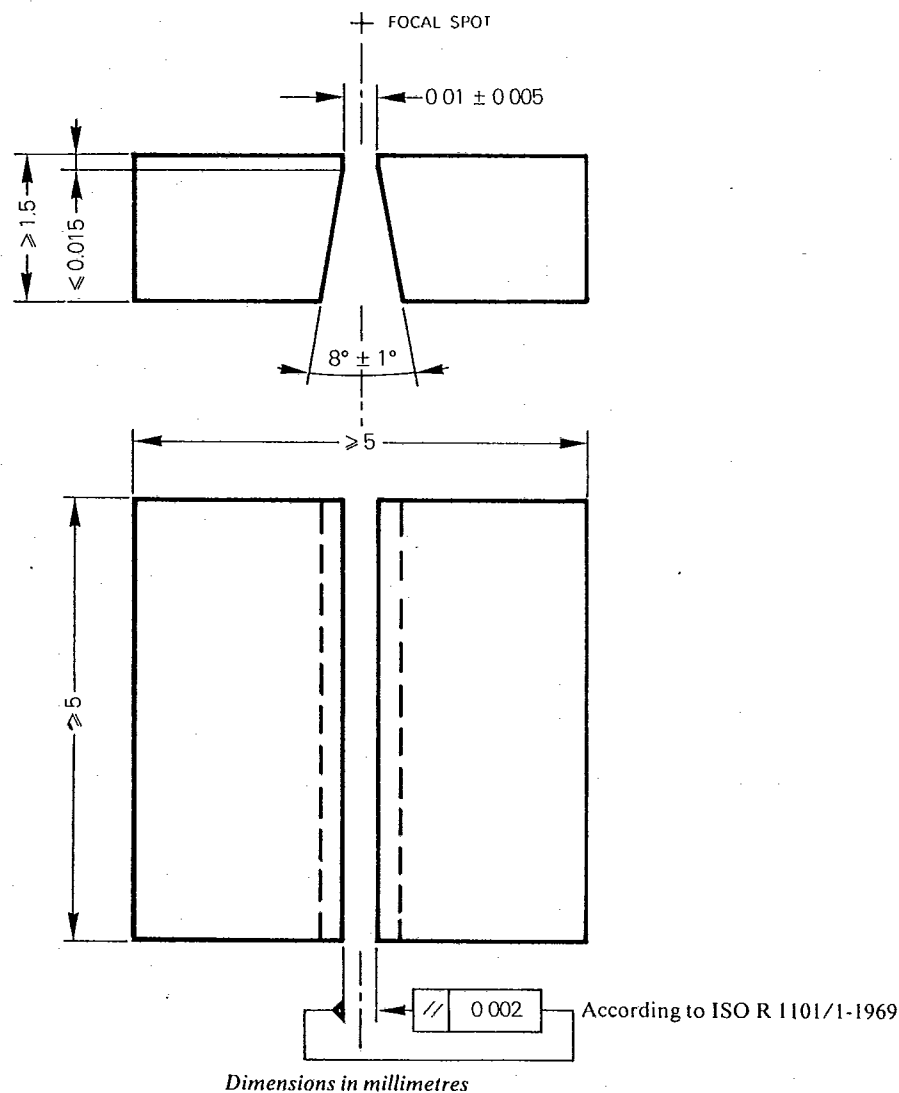


FIG. 1. — Essential dimensions of the slit diaphragm.

The slit diaphragm shall be made from:

- tungsten,
- tantalum,
- alloy of gold and 10% platinum,
- alloy of tungsten and 10% rhenium, or
- alloy of platinum and 10% iridium.

6.2 RADIOGRAPHIC FILM

FOCAL SPOT SLIT RADIOGRAPHS shall be made on a fine grain RADIOGRAPHIC FILM for use without INTENSIFYING SCREENS, for example dental RADIOGRAPHIC FILM.

7. Test arrangement

7.1 Alignment of the SLIT CAMERA

The REFERENCE AXIS shall pass through the centre of the incident face of the slit diaphragm and shall form an angle with the axis of symmetry of the slit diaphragm smaller than or equal to 10^{-3} radian (see Figure 2 and Appendix B).

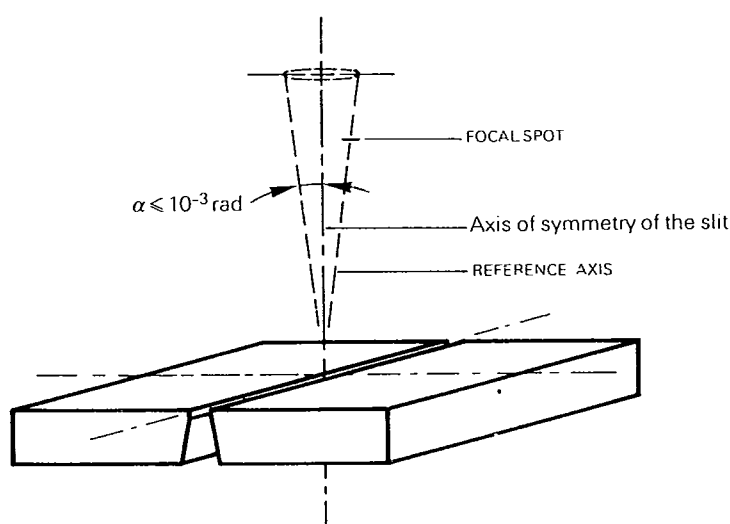


FIG. 2. — Alignment of the SLIT CAMERA.

7.2 Position of the SLIT CAMERA

The incident face of the slit diaphragm shall be placed at a distance from the FOCAL SPOT so that the variation of the magnification over the extension of the ACTUAL FOCAL SPOT does not exceed $\pm 5\%$ in the REFERENCE DIRECTION, (see Figure 3, page 19) according to the following formulae:

$$\frac{n}{m} = E \quad \frac{n}{m+k} \geq 0.95 E \quad \frac{n}{m-p} \leq 1.05 E$$

where:

E is the magnification,

k the distance from the REFERENCE PLANE to the edge of the ACTUAL FOCAL SPOT distal from the diaphragm,

p the distance from the REFERENCE PLANE to the edge of the ACTUAL FOCAL SPOT near to the diaphragm.

In no case shall this distance be less than 100 mm.

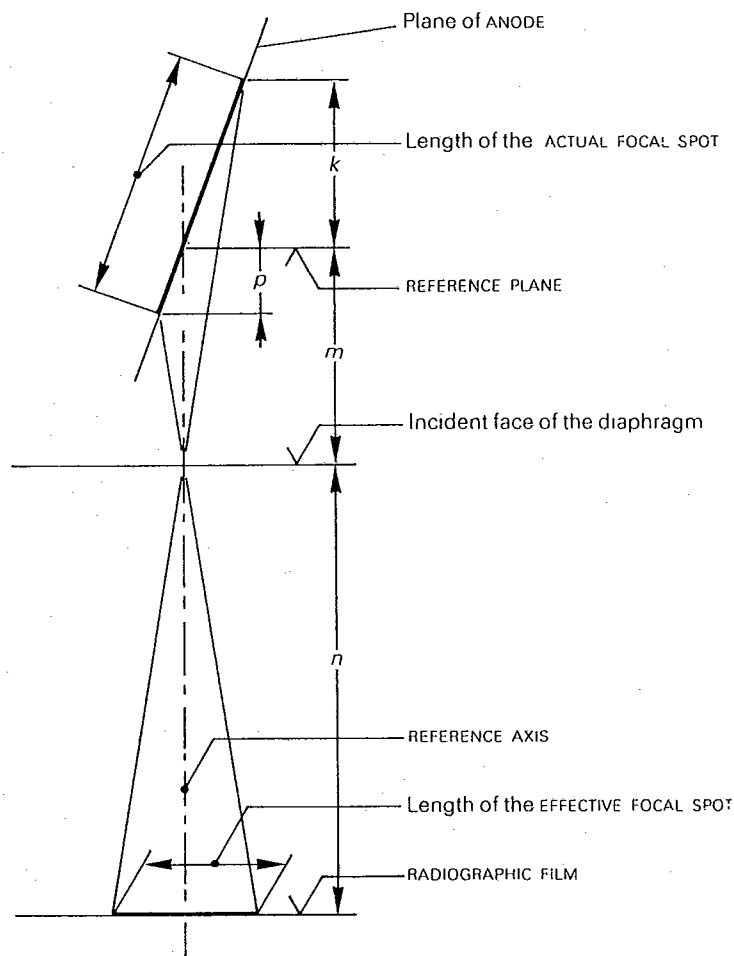


FIG. 3. — Reference dimensions and planes.

7.3 Orientation of the slit diaphragm

7.3.1 For the production of a pair of FOCAL SPOT SLIT RADIOGRAMS the slit diaphragm shall be orientated so that the length of the slit is normal within ± 0.09 rad ($\pm 5^\circ$) to each of two directions of evaluation.

7.3.2 For measurements over the length of the FOCAL SPOT, the direction of evaluation shall be parallel to the longitudinal axis of the X-RAY TUBE ASSEMBLY or to a specified longitudinal axis (see Sub-clause 7.3.4).

7.3.3 For measurements over the width of the FOCAL SPOT, the direction of evaluation shall be, in general, normal to the direction of evaluation according to Sub-clause 7.3.2.

If the projection of the EFFECTIVE FOCAL SPOT in the REFERENCE DIRECTION is distorted, the direction of evaluation over the width may be chosen normal to the pronounced orientation of the regions of highest radiant intensity, usually the direction over the FOCAL SPOT showing the smallest width, (see Figure 4, page 21).

For the visualization of the orientation and the distribution of radiant intensity, see Section Three, FOCAL SPOT PINHOLE RADIOGRAMS.

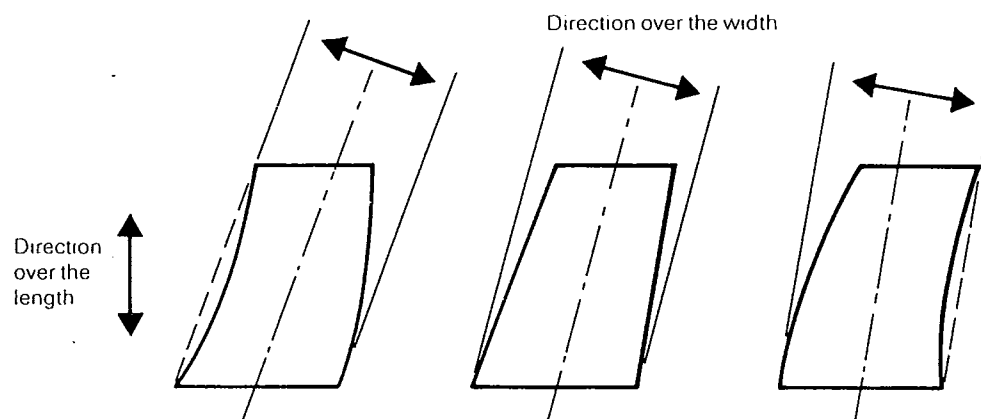


FIG. 4. — Directions of evaluation over distorted FOCAL SPOTS.

7.3.4 If the X-RAY TUBE ASSEMBLY does not have an identifiable longitudinal axis, a longitudinal axis shall be specified together with the focal spot characteristics (see Clauses 10, 16 and Sub-clauses 26.2, 33.2).

7.4 Position of the RADIOGRAPHIC FILM

The RADIOGRAPHIC FILM shall be placed normal to the REFERENCE DIRECTION at a distance from the incident face of the slit diaphragm determined from the appropriate magnification according to Table II.

TABLE II

Magnification for FOCAL SPOT SLIT RADIOGRAMS

NOMINAL FOCAL SPOT VALUE (see Clause 24) f	Magnification (see Figure 3, page 19) $E = \frac{n}{m}$
$f \leq 0.4$	$E \geq 3$
$0.5 \leq f \leq 1.0$	$E \geq 2$
$1.1 \leq f$	$E \geq 1$

8. Operating conditions

8.1 X-RAY TUBE ASSEMBLY

The X-RAY TUBE shall be installed in an X-RAY TUBE HOUSING of the type for which it is specified for NORMAL USE or it shall be placed under equivalent mounting and operating conditions as far as these can influence the results of the test.

8.2 LOADING FACTORS

8.2.1 Focal spot radiogram(s) shall be obtained with constant LOADING FACTORS according to Table III:

TABLE III
LOADING FACTORS

NOMINAL X-RAY TUBE VOLTAGE U (kV)	LOADING FACTOR	
	Required X-RAY TUBE VOLTAGE	Required X-RAY TUBE CURRENT
$U \leq 75$	NOMINAL X-RAY TUBE VOLTAGE	50% of the X-RAY TUBE CURRENT which corresponds to the NOMINAL ANODE INPUT POWER specified for the FOCAL SPOT
$75 < U \leq 150$	75 kV	
$150 < U \leq 200$	50% of the NOMINAL X-RAY TUBE VOLTAGE	

Note — The X-RAY TUBE CURRENT determining the NOMINAL ANODE INPUT POWER according to IEC Publication 613 may be applicable for LOADING TIMES up to 0.1 s. The value of 50 % is applicable for LOADING TIMES according to the RADIOGRAPHIC RATINGS for longer LOADING TIMES necessary for the required blackening of the RADIOGRAPHIC FILM.

For ROTATING ANODE X-RAY TUBES the ANODE shall be rotated at the highest ANODE SPEED specified in the applicable RADIOGRAPHIC RATINGS.

8.2.2 Special LOADING FACTORS

If the LOADING FACTORS according to Table III do not fall within the RADIOGRAPHIC RATINGS for the X-RAY TUBE concerned or if they otherwise do not cover the typical special applications of specified NORMAL USE of the X-RAY TUBE, appropriate LOADING FACTORS shall be chosen. In this case, the LOADING FACTORS under which the focal spot radiogram(s) were obtained, shall be stated together with the characteristic(s) (see Clauses 10, 16, and Sub-clauses 26.2, 33.2).

Note — The LOADING FACTORS according to Table III are reasonable for the usual diagnostic X-RAY TUBES with application over a wide range in X-RAY TUBE VOLTAGES and X-RAY TUBE LOAD. For X-RAY TUBES specified for special applications which are applied over small ranges of X-RAY TUBE VOLTAGES and X-RAY TUBE LOADS, the LOADING FACTORS for the test should correspond to those specific applications.

In particular cases, it will be appropriate, as information to the user, to give the characteristics of a FOCAL SPOT for several conditions of LOADING.

8.2.3 Special arrangements

If, for the purpose of producing suitable focal spot radiograms, special arrangements were made for adjustment and alignment of SLIT CAMERA and X-RAY TUBE ASSEMBLY or if special electrical or loading conditions prevailed, details shall be stated together with the characteristic(s) in the statement of compliance (see Clauses 10, 16, and Sub-clauses 26.2, 33.2).

9. Production of the FOCAL SPOT SLIT RADIOGRAMS

The direction of evaluation over the width of the FOCAL SPOT according to Sub-clause 7.3.3 shall be determined.

A pair of FOCAL SPOT SLIT RADIOGRAMS shall be produced according to Clauses 6 to 8.