BS EN 60627:2015

BSI Standards Publication

Diagnostic X-ray imaging equipment — Characteristics of general purpose and mammographic anti-scatter grids

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National foreword

This British Standard is the UK implementation of EN 60627:2015. It is identical to IEC 60627:2013. It supersedes BS EN 60627:2001, which will be withdrawn on 14 April 2018.

The UK participation in its preparation was entrusted by Technical Committee CH/62, Electrical Equipment in Medical Practice, to Subcommittee CH/62/2, Diagnostic imaging equipment.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Diagnostic X-ray imaging equipment - Characteristics of general purpose and mammographic anti-scatter grids (IEC 60627:2013)

Équipements de diagnostic par imagerie à rayonnement X - Caractéristiques des grilles antidiffusantes d'usage général et de Mammographie (IEC 60627:2013)

Bildgebende Geräte für die Röntgendiagnostik - Kenngrößen von Streustrahlenrastern für die allgemeine Anwendung und für die Mammographie (IEC 60627:2013)

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 62B/914/FDIS, future edition 3 of IEC 60627, prepared by SC 62B "Diagnostic imaging equipment" of IEC/TC 62 "Electrical equipment in medical practice" was submitted to the IEC CENELEC parallel vote and approved by CENELEC as EN 60627:2015.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2016-01-14
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2018-04-14

This document supersedes EN 60627:2001.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For the relationship with EU Directive 93/42/EEC, see informative Annex ZZ, which is an integral part of this document.

Endorsement notice

The text of the International Standard IEC 60627:2013 was approved by CENELEC as a European Standard without any modification.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

Publication	Year	Title	EN/HD	Year
IEC 60601-1	2005	Medical electrical equipment - Part 1: General requirements for basic safety and essential performance	EN 60601-1 + corr. March	2006 2010
+A1	2012		+A1 +A1/AC	2013 2014
			+A12	2014
IEC 60601-1-3	2008	Medical electrical equipment - Part 1-3: General requirements for basic safety and essential performance - Collateral Standard: Radiation protection in diagnostic X-ray equipment	EN 60601-1-3 + corr. March	2008 2010
+A1	2013		+A1 +A1/AC	2013 2014
IEC/TR 60788	2004	Medical electrical equipment - Glossary of defined terms	-	-
IEC 61267	2005	Medical diagnostic X-ray equipment - Radiation conditions for use in the determination of characteristics	EN 61267	2006

Annex ZZ
(informative)

Coverage of Essential Requirements of EU Directives

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association, and within its scope the Standard covers all relevant essential requirements given in Annex I of EU Directive 93/42/EEC of 14 June 1993 concerning medical devices.

Compliance with this standard provides one means of conformity with the specified essential requirements of the Directive concerned.

WARNING: Other requirements and other EU Directives can be applied to the products falling within the scope of this standard.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

DIAGNOSTIC X-RAY IMAGING EQUIPMENT –

Characteristics of general purpose and mammographic anti-scatter grids

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60627 has been prepared by subcommittee 62B: Diagnostic imaging equipment, of IEC technical committee 62: Electrical equipment in medical practice.

This third edition cancels and replaces the second edition published in 2001, and constitutes a technical revision.

In this revision calcium tungstate phosphor FLUORESCENT SCREENS, which are no longer available, have been replaced by gadolinium oxysulphide (GOS) FLUORESCENT SCREENS. Further, a new quality parameter is introduced: the IMAGE IMPROVEMENT FACTOR or Q-factor, which better describes the properties of the ANTI-SCATTER GRID, especially for digital detector applications.

Further differences between this third edition and the previous second edition are:

– some definitions have been modified and others added to improve clarity, harmonization or generality;

– new instrumentation is prescribed for measurements of the TRANSMISSION OF PRIMARY RADIATION, the TRANSMISSION OF SCATTERED RADIATION and the TRANSMISSION OF TOTAL RADIATION, because FLUORESCENT SCREENS made of calcium tungstate phosphors are outdated and are no longer available;
– the definition of the PHANTOM used for measurements of the TRANSMISSION OF PRIMARY RADIATION, the TRANSMISSION OF SCATTERED RADIATION and the TRANSMISSION OF TOTAL RADIATION is modified and references to IEC 61267 are omitted;
– the RADIATION CONDITIONS used for the measurements have been adapted and are now the RQR and RQR-M conditions specified in IEC 61267:2005;
– tolerances are specified for the dimensions in the arrangements for the measurements of the TRANSMISSION OF PRIMARY RADIATION, the TRANSMISSION OF SCATTERED RADIATION and the TRANSMISSION OF TOTAL RADIATION.

The text of this standard is based on the following documents:

FDIS	Report on voting
62B/914/FDIS	62B/922/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

In this standard, the following print types are used:

– Requirements and definitions: roman type.
– *Test specifications: italic type.*
– Informative material appearing outside of tables, such as notes, examples and references: smaller type. Normative text of tables is also in a smaller type.
– TERMS DEFINED IN CLAUSE 3 OF THIS STANDARD OR IN OTHER IEC PUBLICATIONS REFERENCED IN THIS STANDARD: SMALL CAPITALS.

In referring to the structure of this standard, the term

– “clause” means one of the numbered divisions within the table of contents, inclusive of all subdivisions (e.g., Clause 5 includes subclauses 5.1, 5.2, etc.);
– “subclause” means a numbered subdivision of a clause (e.g., 5.1, 5.2 and 5.2.1 are all subclauses of Clause 5).

References to clauses within this standard are preceded by the term “Clause” followed by the clause number. References to subclauses within this particular standard are by number only.

In this standard, the conjunctive “or” is used as an “inclusive or”, so a statement is true if any combination of the conditions is true.

The verbal forms used in this standard conform to usage described in Annex H of the ISO/IEC Directives, Part 2. For the purposes of this standard, the auxiliary verb:

– “shall” means that compliance with a requirement or a test is mandatory for compliance with this standard;
– “should” means that compliance with a requirement or a test is recommended but is not mandatory for compliance with this standard;
– “may” is used to describe a permissible way to achieve compliance with a requirement or test.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

NOTE The attention of National Committees is drawn to the fact that equipment manufacturers and testing organizations may need a transitional period following publication of a new, amended or revised IEC publication in which to make products in accordance with the new requirements and to equip themselves for conducting new or revised tests.

It is the recommendation of the committee that the content of this publication be adopted for implementation nationally not earlier than 36 months from the date of publication.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The first edition of IEC 60627 was intended for ANTI-SCATTER GRIDS used in general radiography and is not appropriate for ANTI-SCATTER GRIDS used in mammography. As a consequence, a complementary standard IEC 61953 was published. Later, it was decided to revise and merge together the two standards covering ANTI-SCATTER GRIDS. Wherever possible, a harmonized approach has been used. This constituted the second edition of IEC 60627 published in 2001.

This third edition is a revision of the second edition. This revision was initiated by the fact that calcium tungstate phosphors have become obsolete, and are no longer available. Instrumentation with FLUORESCENT SCREENS made of gadolinium oxysulphide (GOS) is the present state of the art.

Further, a new quality parameter is introduced: the IMAGE IMPROVEMENT FACTOR Q. This factor better describes the properties of ANTI-SCATTER GRIDS than the GRID EXPOSURE FACTOR B and the CONTRAST IMPROVEMENT FACTOR K, especially for digital detector applications. Namely, the signal-to-noise ratio (SNR) for digital X-ray detectors is increased proportionally with the square root of the factor Q when an ANTI-SCATTER GRID is applied. This effect is due to the efficient reduction of SCATTERED RADIATION and overcompensates the loss of PRIMARY RADIATION when using an ANTI-SCATTER GRID in situations where a considerable amount of SCATTERED RADIATION is present. The name IMAGE IMPROVEMENT FACTOR is chosen to reflect the improved image quality (characterized by SNR and other parameters) under equal RADIATION dose conditions.

Special laboratory provisions and carefully controlled test conditions are needed for the measurements described here.

DIAGNOSTIC X-RAY IMAGING EQUIPMENT –

Characteristics of general purpose and mammographic anti-scatter grids

1 Scope

This International Standard is applicable to ANTI-SCATTER GRIDS used in medical diagnostic X-ray imaging equipment. ANTI-SCATTER GRIDS are used to reduce the incidence of SCATTERED RADIATION, produced particularly in the body of the PATIENT, upon the IMAGE RECEPTION AREA and thus to improve the contrast of the X-RAY PATTERN. This International Standard specifies the definitions, determination and indication of characteristics of ANTI-SCATTER GRIDS.

In this standard only LINEAR GRIDS are considered.

Since at present only FOCUSED GRIDS are used in mammography, this standard is restricted to FOCUSED GRIDS where MAMMOGRAPHIC ANTI-SCATTER GRIDS are concerned.

This standard is not intended to be applied for ACCEPTANCE TESTS.

This standard does not cover the homogeneity of performance over the area of a grid.

This standard is intended to be applied for the determination of the characteristics of ANTI-SCATTER GRIDS under test conditions. These conditions are not usually available at the site of the RESPONSIBLE ORGANIZATION.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60601-1:2005, *Medical electrical equipment – Part 1: General requirements for basic safety and essential performance*
Amendment 1:2012

IEC 60601-1-3:2008, *Medical electrical equipment – Part 1-3: General requirements for basic safety and essential performance – Collateral standard: Radiation protection in diagnostic X-ray equipment*
Amendment 1:2013

IEC/TR 60788:2004, *Medical electrical equipment – Glossary of defined terms*

IEC 61267:2005, *Medical diagnostic X-ray equipment – Radiation conditions for use in the determination of characteristics*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60601-1:2005+A1:2012, IEC 60601-1-3:2008+A1:2013, IEC/TR 60788:2004 and the following apply.

3.1 Grid definitions

3.1.1
ANTI-SCATTER GRID
device to be placed before the IMAGE RECEPTION AREA in order to reduce the incidence of SCATTERED RADIATION upon that area and thus increase the contrast in the X-RAY PATTERN

3.1.2
LINEAR GRID
ANTI-SCATTER GRID composed of highly absorbing strips and highly transmitting interspaces which are parallel in their longitudinal direction

3.1.3
PARALLEL GRID
LINEAR GRID in which the planes of the absorbing strips are parallel to each other and perpendicular to the incident face

3.1.4
FOCUSED GRID
LINEAR GRID in which the planes of the absorbing strips converge to a straight line at the FOCUSING DISTANCE

3.1.5
TAPERED GRID
LINEAR GRID in which the height of the absorbing strips decreases as the distance between the absorbing strips and the TRUE CENTRAL LINE increases. This decrease is symmetrical about the TRUE CENTRAL LINE

3.1.6
CROSS-GRID
ANTI-SCATTER GRID composed of two LINEAR GRIDS built together in such a way that the directions of their absorbing strips form an angle

3.1.7
ORTHOGONAL CROSS-GRID
CROSS-GRID in which the directions of the absorbing strips form an angle of 90°

3.1.8
OBLIQUE CROSS-GRID
CROSS-GRID in which the directions of the absorbing strips form an angle other than 90°

3.1.9
STATIONARY GRID
ANTI-SCATTER GRID used in such a way that it does not move in relation to the RADIATION BEAM

3.1.10
MOVING GRID
ANTI-SCATTER GRID used in an ACCESSORY that enables the ANTI-SCATTER GRID to be moved, when irradiated by a RADIATION BEAM, in order to avoid the imaging of the absorbing strips and the consequent loss of information

3.1.11
MAMMOGRAPHIC ANTI-SCATTER GRID
FOCUSED GRID specially designed for mammography

Note 1 to entry: In this standard the term "general purpose ANTI-SCATTER GRID" is used to describe any ANTI-SCATTER GRID not specially designed for mammography.

3.2 Geometric characteristics

3.2.1
STRIP FREQUENCY
N
number of absorbing strips per unit length of a LINEAR GRID (unit: cm^{-1})

3.2.2
GRID RATIO
r
ratio between the height of the absorbing strips and the distance between the absorbing strips in the centre of a LINEAR GRID

3.2.3
FOCUSING DISTANCE
f_0
distance between the incident face of a FOCUSED GRID and the line into which the planes of the absorbing strips of the grid converge (unit: cm)

Note 1 to entry: Attention is drawn to the differences between "FOCUSING DISTANCE", "FOCAL SPOT to grid distance" and "FOCAL SPOT to film distance".

3.2.4
APPLICATION LIMITS
f_1, f_2
lower, f_1, and upper, f_2, limits of the distance from the FOCAL SPOT to the incident face of a FOCUSED GRID or a PARALLEL GRID between which the obtained radiological information can be considered acceptable for many purposes (unit: cm)

Note 1 to entry: See Annex A for details on the calculation of the APPLICATION LIMITS.

3.2.5
TRUE CENTRAL LINE
– for a PARALLEL GRID: line on the incident face in the direction of the absorbing strips and passing through the centre of the grid area
– for a FOCUSED GRID: perpendicular projection onto the incident face of the grid, of the line into which the planes of the absorbing strips converge
– for a TAPERED GRID: line on the incident face in the direction of the absorbing strips and lying within a symmetry plane of the grid structure

Note 1 to entry: A CROSS-GRID has two TRUE CENTRAL LINES.

3.2.6
CENTRAL-LINE INDICATION
marking on the incident face of a LINEAR GRID, which is intended to indicate the position and direction of the TRUE CENTRAL LINE

Note 1 to entry: In most cases, this marking coincides with the geometric centre line of the grid's incident face.

3.3 Physical characteristics

3.3.1
TRANSMISSION OF PRIMARY RADIATION
T_p
characteristic of an object, evaluated as the ratio of the MEASURED VALUE of the quantity or rate of PRIMARY RADIATION with the object placed in a RADIATION BEAM to that with the object removed from the beam, under specific measuring conditions

3.3.2
TRANSMISSION OF SCATTERED RADIATION
T_s
characteristic of an object, evaluated as the ratio of the MEASURED VALUE of the quantity or rate of SCATTERED RADIATION with the object placed in a RADIATION BEAM to that with the object removed from the beam, under specific measuring conditions

3.3.3
TRANSMISSION OF TOTAL RADIATION
T_t
characteristic of an object, evaluated as the ratio of the MEASURED VALUE of the quantity or rate of total RADIATION with the object placed in a RADIATION BEAM to that with the object removed from the beam, under specific measuring conditions

3.3.4
GRID SELECTIVITY
Σ
characteristic of an ANTI-SCATTER GRID, evaluated as the ratio of the TRANSMISSION OF PRIMARY RADIATION to the TRANSMISSION OF SCATTERED RADIATION

3.3.5
CONTRAST IMPROVEMENT RATIO
K
characteristic of an ANTI-SCATTER GRID, evaluated as the ratio of the TRANSMISSION OF PRIMARY RADIATION to the TRANSMISSION OF TOTAL RADIATION

3.3.6
GRID EXPOSURE FACTOR
B
characteristic of an ANTI-SCATTER GRID, evaluated as the reciprocal value of the TRANSMISSION OF TOTAL RADIATION

3.3.7
IMAGE IMPROVEMENT FACTOR
Q
characteristic of an ANTI-SCATTER GRID, evaluated as the ratio of the square of the TRANSMISSION OF PRIMARY RADIATION to the TRANSMISSION OF TOTAL RADIATION

3.4 Other terms

3.4.1
DECENTRING
distance between the TRUE CENTRAL LINE of a FOCUSED GRID and the perpendicular projection of the FOCAL SPOT of an X-RAY TUBE onto the incident face of the grid

3.4.2
DEFOCUSING
difference between the distance from the FOCAL SPOT of an X-RAY TUBE to the incident face of a FOCUSED GRID and the FOCUSING DISTANCE of that grid

Note 1 to entry: See Clause A.1 for an explanation of DECENTRING and DEFOCUSING.

3.4.3
SERIAL NUMBER
number and/or other designation to identify an individual unit of a certain model of equipment or ACCESSORY

4 Structure of ANTI-SCATTER GRIDS

ANTI-SCATTER GRIDS usually consist of strips of highly absorbent material, of thickness *d* and height *h*, arranged at regular intervals *D* from each other; see Figure 1.

The height *h* of the strips is either constant over the area of the ANTI-SCATTER GRID or decreases in TAPERED GRIDS from the highest strip – with height h_0 – towards two edges.

NOTE *D* and *d* are measured at the incident face of the grid.

The interspaces between the strips are usually filled with highly transmitting material. The ANTI-SCATTER GRID may have a frame and covers to protect against mechanical damage and to ensure the rigidity of the grid.

The STRIP FREQUENCY shall be determined according to the formula

$$N = \frac{1}{(d + D)}$$

The GRID RATIO shall be determined according to one of the following formulae

– for a PARALLEL GRID and for a FOCUSED GRID:

$$r = \frac{h}{D}$$

– for a TAPERED GRID:

$$r_0 = \frac{h_0}{D_0}$$

– for a CROSS-GRID:

$$r_1 = \frac{h_1}{D_1}$$

$$r_2 = \frac{h_2}{D_2}$$

Letter symbols without index designate general properties of a LINEAR GRID. The index "0" designates quantities at the TRUE CENTRAL LINE. Indices "1" or "2" designate quantities for the LINEAR GRIDS forming a CROSS-GRID.

5 Measurement and determination of physical characteristics

5.1 Method and arrangement for measurement

5.1.1 Determination of physical characteristics

For the purpose of this standard, the values of the TRANSMISSION OF PRIMARY RADIATION, the TRANSMISSION OF SCATTERED RADIATION and the TRANSMISSION OF TOTAL RADIATION shall be determined as the ratio of the two MEASURED VALUES obtained with the instrumentation described in 5.1.2 and the PHANTOM described in 5.1.3, in the arrangements described in 5.1.4, and with the RADIATION CONDITIONS described in 5.1.5.

5.1.2 Instrumentation

5.1.2.1 General

A RADIATION DETECTOR shall be used which incorporates a FLUORESCENT SCREEN and a photo-detector; see Figure 2. The FLUORESCENT SCREEN shall be made from a terbium-activated gadolinium oxysulphide (GOS, Gd_2O_2S:Tb) scintillator, preferably without dye.

The area density of the scintillator shall be

a) for general purpose ANTI-SCATTER GRIDS $75\ mg \cdot cm^{-2} \pm 10\ mg \cdot cm^{-2}$;

b) for MAMMOGRAPHIC ANTI-SCATTER GRIDS $30\ mg \cdot cm^{-2} \pm 3\ mg \cdot cm^{-2}$.

NOTE The previously specified scintillator material, calcium tungstate, is no longer commercially available. Current state-of-the-art is GOS, which is non-toxic and non-hygroscopic as opposed to thallium-doped cesium iodide (CsI:Tl). Experimental results show equivalent outcome for calcium tungstate and GOS scintillators.

The diameter of the measuring field shall be 6,0 mm ± 0,5 mm.

The luminance produced at the FLUORESCENT SCREEN shall be measured with the photo-detector, which shall be sensitive in the energy range of the light photons produced.

The ADDITIONAL FILTRATION between the supporting plane of the ANTI-SCATTER GRID and the active layer of the FLUORESCENT SCREEN shall be not more than

a) for general purpose ANTI-SCATTER GRIDS 0,5 mm Al;

b) for MAMMOGRAPHIC ANTI-SCATTER GRIDS 0,1 mm Al

for the RADIATION CONDITION applied.

The dark current and the direct IRRADIATION of the photo-detector shall not significantly affect the result of the measurements.

The response of the photo-detector shall be linearly proportional to the RADIATION intensity.

5.1.2.2 Test for dark current and direct IRRADIATION

Use the following test PROCEDURE *to check the effects of the dark current and the direct* IRRADIATION *of the photo-detector:*

a) *use an arrangement as described in 5.2.3, except that the* ANTI-SCATTER GRID *is removed, and apply a* RADIATION CONDITION *as specified in 5.1.5;*

b) *measure the detector signal at the maximum* X-RAY TUBE CURRENT *used for the grid measurements with the photo-detector shielded by X-ray transparent material against the visible light excited in the* FLUORESCENT SCREEN *and with the photo-detector unshielded;*

c) *measure the detector signal without* IRRADIATION *(this is the dark-current value of the* RADIATION DETECTOR*);*

d) *calculate the ratio of the* MEASURED VALUES *for the shielded and unshielded measurements after subtraction of the dark-current value;*

e) *this ratio shall not exceed 0,002.*

5.1.2.3 Test for linearity

Use the following test PROCEDURE *to check the linearity of the photo-detector:*

a) *use an arrangement as described in 5.2.3, except that the* ANTI-SCATTER GRID *is removed, and apply a* RADIATION CONDITION *as specified in 5.1.5;*

b) *measure the detector signal at the maximum* X-RAY TUBE CURRENT *used for the grid measurements, at one half of that current, and without* IRRADIATION*, while using the same* X-RAY TUBE VOLTAGE *for these three measurements;*

c) *the* MEASURED VALUE *at one half of the maximum* X-RAY TUBE CURRENT *shall be within ± 5 % of the average of the other two* MEASURED VALUES*.*

5.1.3 Phantoms

a) For general purpose ANTI-SCATTER GRIDS, the PHANTOM used for the determination of TRANSMISSION OF PRIMARY RADIATION and for the determination of TRANSMISSION OF SCATTERED RADIATION shall be a water-filled container. The container shall have

- sides of outside dimensions of 300 mm ± 1 mm and height of 200 mm ± 1 mm;
- top and bottom surfaces and side walls made of polymethyl-methacrylate (PMMA), each having 10 mm ± 2 mm thickness; and
- the interior filled with water.

When used under NARROW-BEAM CONDITIONS, the above PHANTOM may be replaced by a PHANTOM identical except for reduced outside dimensions. This equivalence should be checked.

Alternatively to the above PHANTOM, a PHANTOM made up of water-equivalent solid material having the same overall dimensions as the container, may be used. This equivalence should be checked.

b) b) For MAMMOGRAPHIC ANTI-SCATTER GRIDS, the PHANTOM used for the determination of TRANSMISSION OF PRIMARY RADIATION and for the determination of TRANSMISSION OF SCATTERED RADIATION shall be a PMMA block of square cross-section with sides of 150 mm ± 1 mm and a thickness of 50 mm ± 1 mm.

5.1.4 Arrangements

a) For general purpose ANTI-SCATTER GRIDS, the arrangements for the measurements shall be according to the arrangements shown in Figure 3 (PHANTOM in the upper position, NARROW-BEAM CONDITION) and Figure 4 (PHANTOM in the lower position, BROAD BEAM CONDITION).

The positions of the FOCAL SPOT, general purpose ANTI-SCATTER GRID and measuring field are the same for both configurations. All distances in the figures are given with a tolerance of maximum ± 10 mm, unless specified otherwise.

The distance from the FOCAL SPOT to the supporting plane of the general purpose ANTI-SCATTER GRID shall be 100 cm (1 000 mm), even if the FOCUSING DISTANCE of the FOCUSED GRID under consideration is not 100 cm. For the geometry described, the results of the measurements are insensitive to the FOCUSING DISTANCE f_0.

The general purpose ANTI-SCATTER GRID shall be so fixed that the central line as defined by the CENTRAL-LINE INDICATION is above the centre of the measuring field. The supporting plane of the grid shall be perpendicular within ± 0,2° to the plane containing the FOCAL SPOT and the central line as defined by the CENTRAL-LINE INDICATION. The distance between the supporting plane of the grid and the output plane of the FLUORESCENT SCREEN of the RADIATION DETECTOR shall be 20 mm.

The DIAPHRAGMS shown in Figures 3 and 4 and the PRIMARY RADIATION blocker shown in Figure 4 shall be made of lead of a thickness of 5 mm ± 1 mm. The upper DIAPHRAGM shall be positioned at a distance between 150 mm and 300 mm from the FOCAL SPOT. The lower DIAPHRAGM shall be positioned at a distance of 220 mm from the supporting plane of the grid. For the measurements in NARROW-BEAM CONDITION (see Figure 3), the PHANTOM shall be positioned with its top surface against the upper DIAPHRAGM with an extra DIAPHRAGM positioned against its bottom surface. For the measurements in BROAD BEAM CONDITION (see Figure 4), the PHANTOM shall be positioned with its top surface against the lower DIAPHRAGM so that its bottom surface is at a distance of 20 mm from the supporting plane of the grid.

b) For MAMMOGRAPHIC ANTI-SCATTER GRIDS, the arrangements for the measurements shall be according to the arrangements shown in Figure 5 (PHANTOM in the upper position, NARROW-BEAM CONDITION) and Figure 6 (PHANTOM in the lower position, BROAD BEAM CONDITION).

The positions of the FOCAL SPOT, MAMMOGRAPHIC ANTI-SCATTER GRID and measuring field are the same for both configurations. They are described in terms of the arrangements with the PHANTOM in the lower position (see Figure 6). All distances in the figures are given with a tolerance of maximum ± 5 mm, unless specified otherwise.

The distance from the FOCAL SPOT to the supporting plane of the MAMMOGRAPHIC ANTI-SCATTER GRID shall be 60 cm (600 mm), even if the FOCUSING DISTANCE of the grid under consideration is not 60 cm. For the geometry described, the results of the measurements are insensitive to the FOCUSING DISTANCE f_0.

For the measurement with the MAMMOGRAPHIC ANTI-SCATTER GRID in place and the PHANTOM in the lower position (see Figure 6), the FOCAL SPOT, the centre of the bottom surface of the PHANTOM, and the centre of the measuring field shall be co-linear. The normal from the FOCAL SPOT to the bottom surface of the PHANTOM shall bisect one of the side faces of the PHANTOM.

The incident face of the MAMMOGRAPHIC ANTI-SCATTER GRID shall be parallel to the bottom surface of the PHANTOM. The central line of the grid as defined by the CENTRAL-LINE INDICATION shall be parallel to a side of the PHANTOM. The chest-wall side of the grid, if applicable, shall be oriented to, and aligned with, that side of the PHANTOM which is bisected by the normal from the FOCAL SPOT to the bottom surface of the PHANTOM.

The MAMMOGRAPHIC ANTI-SCATTER GRID shall be so aligned that the normal from the FOCAL SPOT to the bottom surface of the PHANTOM intersects the incident face of the grid at the central line as defined by the CENTRAL-LINE INDICATION. The supporting plane of the grid shall be perpendicular within ± 0,2° to the plane containing the FOCAL SPOT and the central line as defined by the CENTRAL-LINE INDICATION. The distance between the supporting plane of the grid and the output plane of the FLUORESCENT SCREEN of the RADIATION DETECTOR shall be 10 mm.

The measurement configuration described above may need to be modified for either or both of the following special situations:

– the grid is smaller than the PHANTOM:

  the grid shall then be positioned so that the FOCAL SPOT, the centre of the grid and the centre of the measuring field are co-linear;

– the grid lines run parallel to the chest-wall side:

  the grid shall then be tilted to compensate for DECENTRING, which shall be achieved by raising or lowering the side of the grid distant from the CENTRAL-LINE INDICATION, such that the absorbing strips above the measuring field are directed towards the FOCAL SPOT and the TRANSMISSION OF PRIMARY RADIATION is maximized.

NOTE In practice, a tilting angle of approximately 7° is sufficient.

The DIAPHRAGMS shown in Figures 5 and 6 and the PRIMARY RADIATION blocker shown in Figure 6 shall be made of lead of a thickness between 1 mm and 2 mm. The upper DIAPHRAGM shall be positioned at a distance of 200 mm or less from the FOCAL SPOT. The lower DIAPHRAGM shall be positioned at a distance of 60 mm from the supporting plane of the MAMMOGRAPHIC ANTI-SCATTER GRID. For the measurements in BROAD BEAM CONDITION (see Figure 6), the PHANTOM shall be positioned with its top surface against the lower DIAPHRAGM so that its bottom surface is at a distance of 10 mm from the supporting plane of the grid.

The arrangement for the measurements in NARROW-BEAM CONDITION (see Figure 5) shall be the same as described above, except that the PHANTOM is positioned with its top surface against the upper DIAPHRAGM, close to the X-RAY TUBE with the RADIATION BEAM passing the PHANTOM near its centre, and with an extra DIAPHRAGM positioned against the bottom surface of the PHANTOM.

5.1.5 Radiation conditions

a) For general-purpose ANTI-SCATTER GRIDS, the measurements shall be performed with RADIATION CONDITION RQR 6, as defined in IEC 61267:2005, applied in NARROW-BEAM or BROAD BEAM CONDITIONS as specified in 5.1.4 a).

   Where a general-purpose ANTI-SCATTER GRID is specified for low-energy use, additional measurements may be performed with RADIATION CONDITION RQR 4.

   Where a general-purpose ANTI-SCATTER GRID is specified for high-energy use, additional measurements may be performed with RADIATION CONDITION RQR 9.

b) For MAMMOGRAPHIC ANTI-SCATTER GRIDS, the measurements shall be performed with RADIATION CONDITION RQR-M 2, as defined in IEC 61267:2005, applied in NARROW-BEAM or BROAD BEAM CONDITIONS as specified in 5.1.4 b).

An X-RAY TUBE producing little EXTRA-FOCAL RADIATION should be selected.

NOTE The use of an X-RAY TUBE with a large amount of EXTRA-FOCAL RADIATION can slightly increase the value of the TRANSMISSION OF SCATTERED RADIATION.

5.1.6 Constancy of source

The LOADING FACTORS of the X-RAY TUBE shall be so controlled that the effect of energy fluence rate variations on the accuracy of each individual measurement is less than ± 0,5 %.

5.2 Physical characteristics

5.2.1 Measurements for the TRANSMISSION OF PRIMARY RADIATION (T_p)

The two measurements required for the determination of the TRANSMISSION OF PRIMARY RADIATION shall be performed under NARROW-BEAM CONDITIONS:

– with the PHANTOM and the ANTI-SCATTER GRID arranged as described in 5.1.4 and shown in Figure 3 or Figure 5 as appropriate;

– without the ANTI-SCATTER GRID but otherwise under the same conditions.

The diameter of the beam of PRIMARY RADIATION shall be between 8 mm and 10 mm in the supporting plane of the ANTI-SCATTER GRID.

The TRANSMISSION OF PRIMARY RADIATION T_p shall be calculated as the ratio of the MEASURED VALUES recorded with and without the ANTI-SCATTER GRID.

5.2.2 Measurements for the TRANSMISSION OF SCATTERED RADIATION (T_s)

The two measurements required for the determination of the TRANSMISSION OF SCATTERED RADIATION shall be performed under BROAD BEAM CONDITIONS:

– with the PHANTOM and the ANTI-SCATTER GRID arranged as described in 5.1.4 and shown in Figure 4 or Figure 6 as appropriate;

– without the ANTI-SCATTER GRID but otherwise under the same conditions.

The size of the RADIATION BEAM shall be adjusted to

a) for general-purpose ANTI-SCATTER GRIDS 300 mm × 300 mm;

b) for MAMMOGRAPHIC ANTI-SCATTER GRIDS 150 mm × 150 mm

in the plane of the exit surface of the PHANTOM, even if the grid is smaller.

The PRIMARY RADIATION shall be stopped by a PRIMARY RADIATION blocker as described in 5.1.4, which is placed on the incident face of the PHANTOM in order to stop all PRIMARY RADIATION in the direction of the measuring field. The diameter of this PRIMARY RADIATION blocker shall be

a) for general-purpose ANTI-SCATTER GRIDS 6,0 mm ± 0,2 mm;

b) for MAMMOGRAPHIC ANTI-SCATTER GRIDS 6,5 mm ± 0,1 mm.

The PRIMARY RADIATION blocker shall be aligned laterally by minimizing the detector signal.

The TRANSMISSION OF SCATTERED RADIATION T_s shall be calculated as the ratio of the MEASURED VALUES recorded with and without the ANTI-SCATTER GRID.

5.2.3 Measurements for the TRANSMISSION OF TOTAL RADIATION (T_t)

The two measurements required for the determination of the TRANSMISSION OF TOTAL RADIATION shall be performed with the same arrangement as described in 5.2.2, but without the PRIMARY RADIATION blocker mentioned therein.

The TRANSMISSION OF TOTAL RADIATION T_t shall be calculated as the ratio of the MEASURED VALUES recorded with and without the ANTI-SCATTER GRID.

5.2.4 Calculation of the GRID SELECTIVITY (Σ)

The GRID SELECTIVITY shall be determined according to the following formula:

$$\Sigma = \frac{T_p}{T_s}$$

5.2.5 Calculation of the CONTRAST IMPROVEMENT RATIO (K)

The CONTRAST IMPROVEMENT RATIO shall be determined according to the following formula:

$$K = \frac{T_p}{T_t}$$

5.2.6 Calculation of the GRID EXPOSURE FACTOR (B)

The GRID EXPOSURE FACTOR shall be determined according to the following formula:

$$B = \frac{1}{T_t}$$

5.2.7 Calculation of the IMAGE IMPROVEMENT FACTOR (Q)

The IMAGE IMPROVEMENT FACTOR shall be determined according to the following formula:

$$Q = \frac{T_p^{\,2}}{T_t}$$

5.2.8 Accuracy of measurements

a) For general-purpose ANTI-SCATTER GRIDS, the overall uncertainties in the determination of TRANSMISSION OF PRIMARY RADIATION, TRANSMISSION OF SCATTERED RADIATION and TRANSMISSION OF TOTAL RADIATION shall not exceed 2,0% (95 % confidence limits).

When these requirements are fulfilled, the GRID SELECTIVITY of a general-purpose ANTI-SCATTER GRID will be known within ± 3,0 %, the CONTRAST IMPROVEMENT RATIO within ± 3,0 %, the GRID EXPOSURE FACTOR within ± 2,0 % and the IMAGE IMPROVEMENT FACTOR within ± 4,5 %.

b) For MAMMOGRAPHIC ANTI-SCATTER GRIDS the overall uncertainties in the determination of TRANSMISSION OF PRIMARY RADIATION, TRANSMISSION OF SCATTERED RADIATION and TRANSMISSION OF TOTAL RADIATION shall not exceed 1,0 % (95 % confidence limits).

When these requirements are fulfilled, the GRID SELECTIVITY of a MAMMOGRAPHIC ANTI-SCATTER GRID will be known within ± 1,5 %, the CONTRAST IMPROVEMENT RATIO within ± 1,5 %, the GRID EXPOSURE FACTOR within ±1,0 % and the IMAGE IMPROVEMENT FACTOR within ± 2,5 %.

6 Requirements for ANTI-SCATTER GRIDS

6.1 Manufacturing tolerances

The STRIP FREQUENCY shall be within ± 10 % of the value given according to 6.4.2 c).

The GRID RATIO shall be within ± 10 % of the value given according to 6.4.2 d).

6.2 Determination of the APPLICATION LIMITS

The APPLICATION LIMITS for PARALLEL GRIDS and FOCUSED GRIDS shall be determined as the FOCAL SPOT to grid distances at which the value of TRANSMISSION OF PRIMARY RADIATION at that border of the effective area of the grid which is most distant from the TRUE CENTRAL LINE is

a) for general-purpose ANTI-SCATTER GRIDS 60 %;

b) for MAMMOGRAPHIC ANTI-SCATTER GRIDS 80 %

of the value at the FOCUSING DISTANCE.

The values shall be calculated on the assumption of an ideal grid, that is, an ANTI-SCATTER GRID of exact geometrical form.

NOTE The calculation methods for STATIONARY GRIDS and for MOVING GRIDS, taking into account the magnitude of the grid movement, are described in Annex A.

6.3 Accuracy of characteristics

6.3.1 GRID SELECTIVITY

The value of the GRID SELECTIVITY given as required in 6.4.4 d) shall be

a) for general-purpose ANTI-SCATTER GRIDS within ± 10 %;

b) for MAMMOGRAPHIC ANTI-SCATTER GRIDS within ± 5 %

of the value determined according to 5.2.4.

6.3.2 CONTRAST IMPROVEMENT RATIO

The value of the CONTRAST IMPROVEMENT RATIO given as required in 6.4.4 e) shall be

a) for general-purpose ANTI-SCATTER GRIDS within ± 10 %;

b) for MAMMOGRAPHIC ANTI-SCATTER GRIDS within ± 5 %

of the value determined according to 5.2.5.

6.3.3 GRID EXPOSURE FACTOR

The value of the GRID EXPOSURE FACTOR given as required in 6.4.4 f) shall be

a) for general-purpose ANTI-SCATTER GRIDS within ± 10 %;

b) for MAMMOGRAPHIC ANTI-SCATTER GRIDS within ± 5 %

of the value determined according to 5.2.6.

6.3.4 IMAGE IMPROVEMENT FACTOR

The value of the IMAGE IMPROVEMENT FACTOR given as required in 6.4.4 g) shall be

a) for general-purpose ANTI-SCATTER GRIDS within ± 10 %;

b) for MAMMOGRAPHIC ANTI-SCATTER GRIDS within ± 5 %

of the value determined according to 5.2.7.

6.4 Markings and ACCOMPANYING DOCUMENTS

6.4.1 Data in ACCOMPANYING DOCUMENTS

The ACCOMPANYING DOCUMENTS related to the grid or to the equipment holding the grid shall provide data about the individual ANTI-SCATTER GRID, or the grid series or the grid type to which it belongs. The ACCOMPANYING DOCUMENTS shall be marked so that the identification of the individual ANTI-SCATTER GRID, or the grid series or the grid type to which it belongs, is ensured.

6.4.2 Mandatory markings and indications for LINEAR GRIDS

A LINEAR GRID shall carry the following markings and indications:

a) the name or trademark of the MANUFACTURER or supplier;

b) the MODEL OR TYPE REFERENCE or the SERIAL NUMBER allowing the identification according to 6.4.1;

c) the STRIP FREQUENCY (unit: cm^{-1}) *N* 40

d) the GRID RATIO (where both GRID RATIOS shall be given for CROSS-GRIDS) *r* 12

NOTE Numerical values are given as examples.

e) the CENTRAL-LINE INDICATION (where both CENTRAL-LINE INDICATIONS shall be given for CROSS-GRIDS);

f) for general-purpose ANTI-SCATTER GRIDS, a marking which indicates the centre of the effective area of the grid if this does not coincide with the mechanical centre of the grid;

g) for MAMMOGRAPHIC ANTI-SCATTER GRIDS, an indication which ensures that the chest-wall side of the grid can be identified, where appropriate.

6.4.3 Mandatory markings and indications for FOCUSED GRIDS

A FOCUSED GRID shall carry the following markings and indications in addition to those required in 6.4.2:

a) the FOCUSING DISTANCE (unit: cm) f_o 90

b) an indication to ensure that the incident face of the ANTI-SCATTER GRID can be identified.

EXAMPLE Graphical symbol IEC 60417-5337 (2002-10) for X-RAY TUBE or IEC 60417-5338 (2002-10) for X-ray source assembly [1][1].

6.4.4 Additional mandatory markings and indications

The following markings and indications shall be given on the ANTI-SCATTER GRID or in the ACCOMPANYING DOCUMENTS related to the grid or to the equipment holding the grid

a) the APPLICATION LIMITS (unit: cm) f_1 76
f_2 110

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1 Figures in square brackets refer to the bibliography.

b) the chemical symbol of the material of the absorbing strips Pb

c) the TRANSMISSION OF PRIMARY RADIATION T_p 0,75

d) the GRID SELECTIVITY Σ 7,1

e) the CONTRAST IMPROVEMENT RATIO K 3,1

f) the GRID EXPOSURE FACTOR B 4,1

g) the IMAGE IMPROVEMENT FACTOR Q 2,3

h) the maximum deviation between the CENTRAL-LINE INDICATION and the TRUE CENTRAL LINE (unit: mm) Δ 2

NOTE Numerical values and chemical symbol are given as examples.

i) an indication of the nature of the interspace material between the absorbing strips

j) an indication of the nature of the protective covers.

The indications under i) and j) may be limited to a general indication of the organic material or metal.

For general-purpose ANTI-SCATTER GRIDS, the values of T_p, Σ, K, B and Q shall be indicated by

- adding "U 60" for RADIATION CONDITION RQR 4,
- adding "U 80" for RADIATION CONDITION RQR 6, and
- adding "U 120" for RADIATION CONDITION RQR 9.

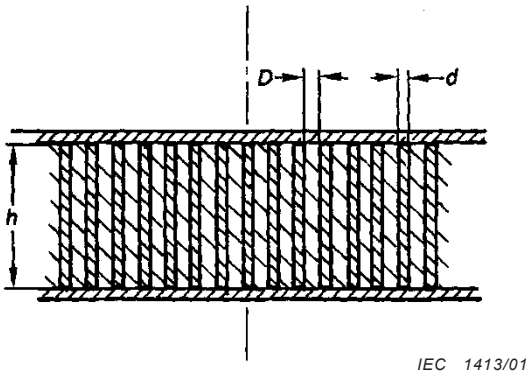
If the values are only given for RQR 6, the indication "U 80" may be omitted.

6.4.5 Further requirements

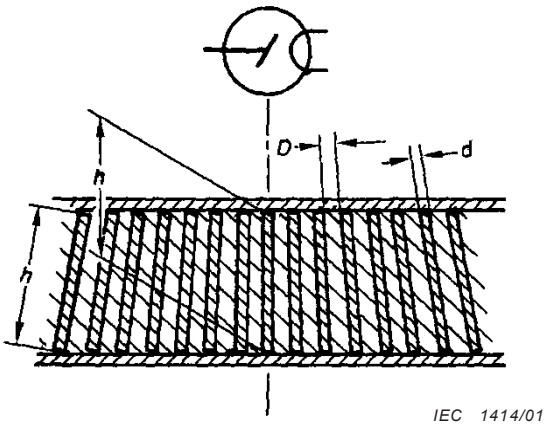
Where any of the markings required in 6.4.2 and 6.4.3 is incorporated in a recognizable and understandable form in the MODEL OR TYPE REFERENCE or in the SERIAL NUMBER, it is not necessary for that marking to be repeated on the ANTI-SCATTER GRID. However, it shall be given in the ACCOMPANYING DOCUMENTS related to the grid or to the equipment holding the grid.

None of the markings on the ANTI-SCATTER GRID shall interfere with the radiographic image under normal use.

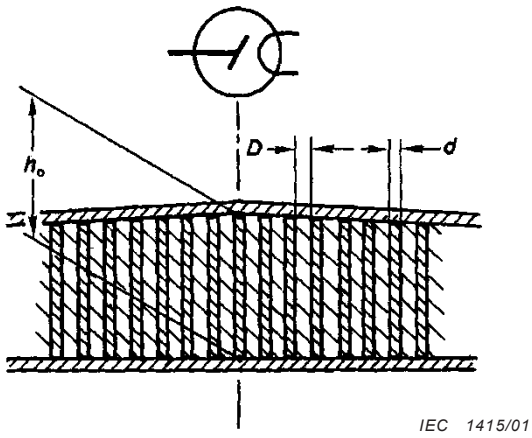
If any of the tolerances achieved are narrower than the tolerances required in this standard, the tolerances achieved should be stated in the ACCOMPANYING DOCUMENTS related to the grid or to the equipment holding the grid.



PARALLEL GRID

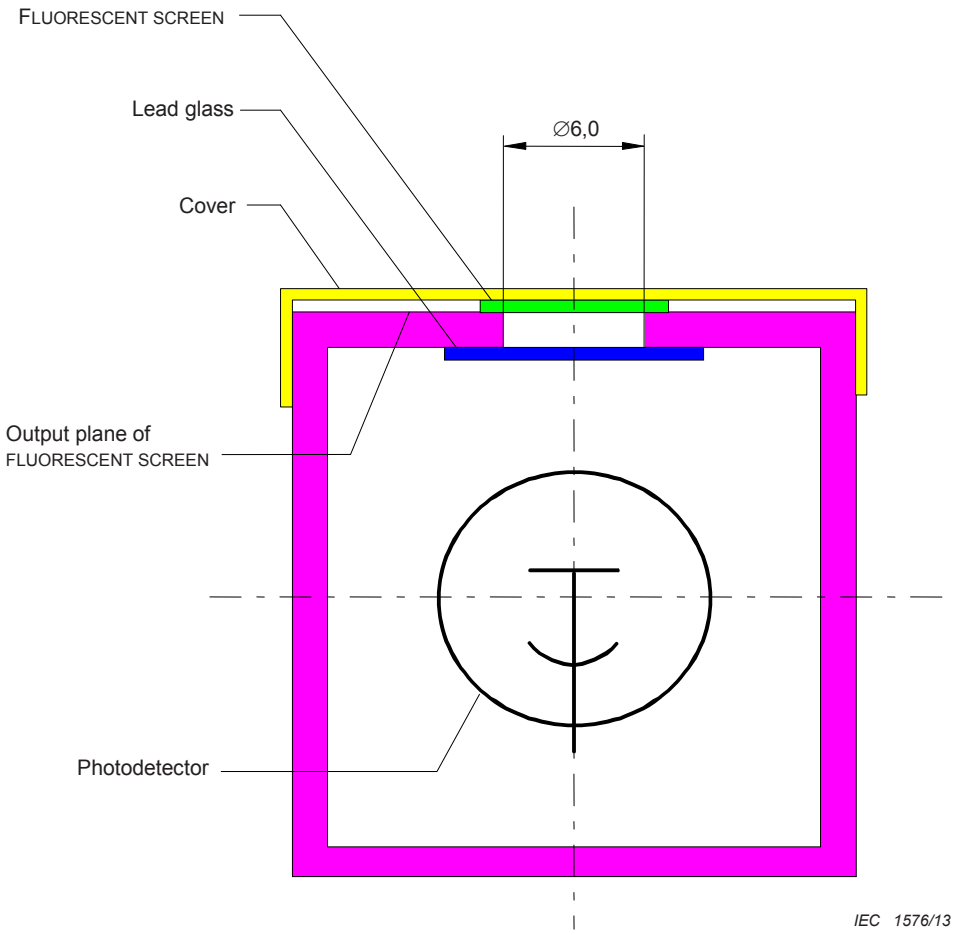


FOCUSED GRID



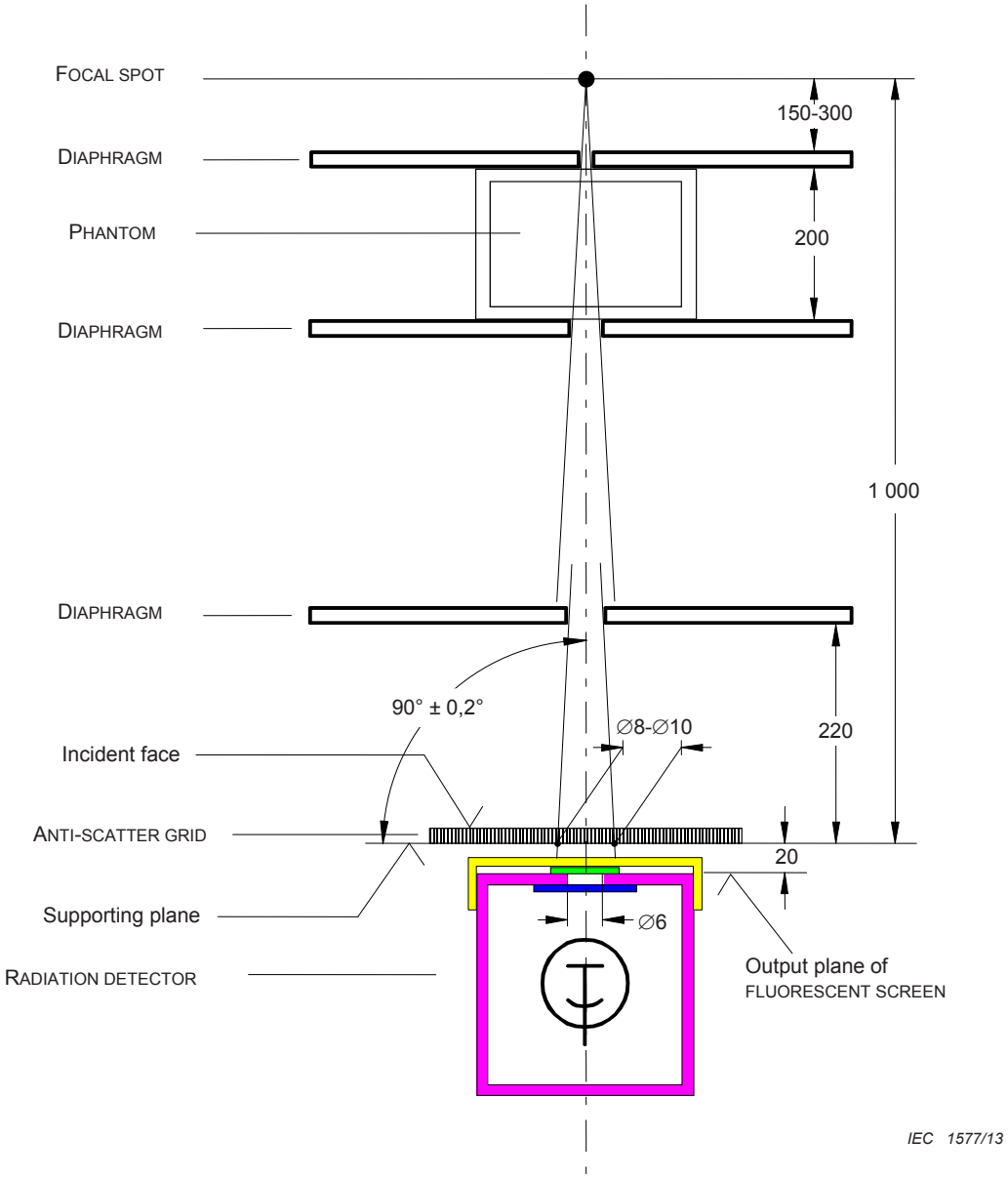
TAPERED GRID

Figure 1 – Structure of ANTI-SCATTER GRIDS



Dimensions in millimetres

Figure 2 – RADIATION DETECTOR



Dimensions in millimetres

Figure 3 – Measurement arrangement for general purpose ANTI-SCATTER GRIDS with NARROW-BEAM CONDITION (determination of the TRANSMISSION OF PRIMARY RADIATION)

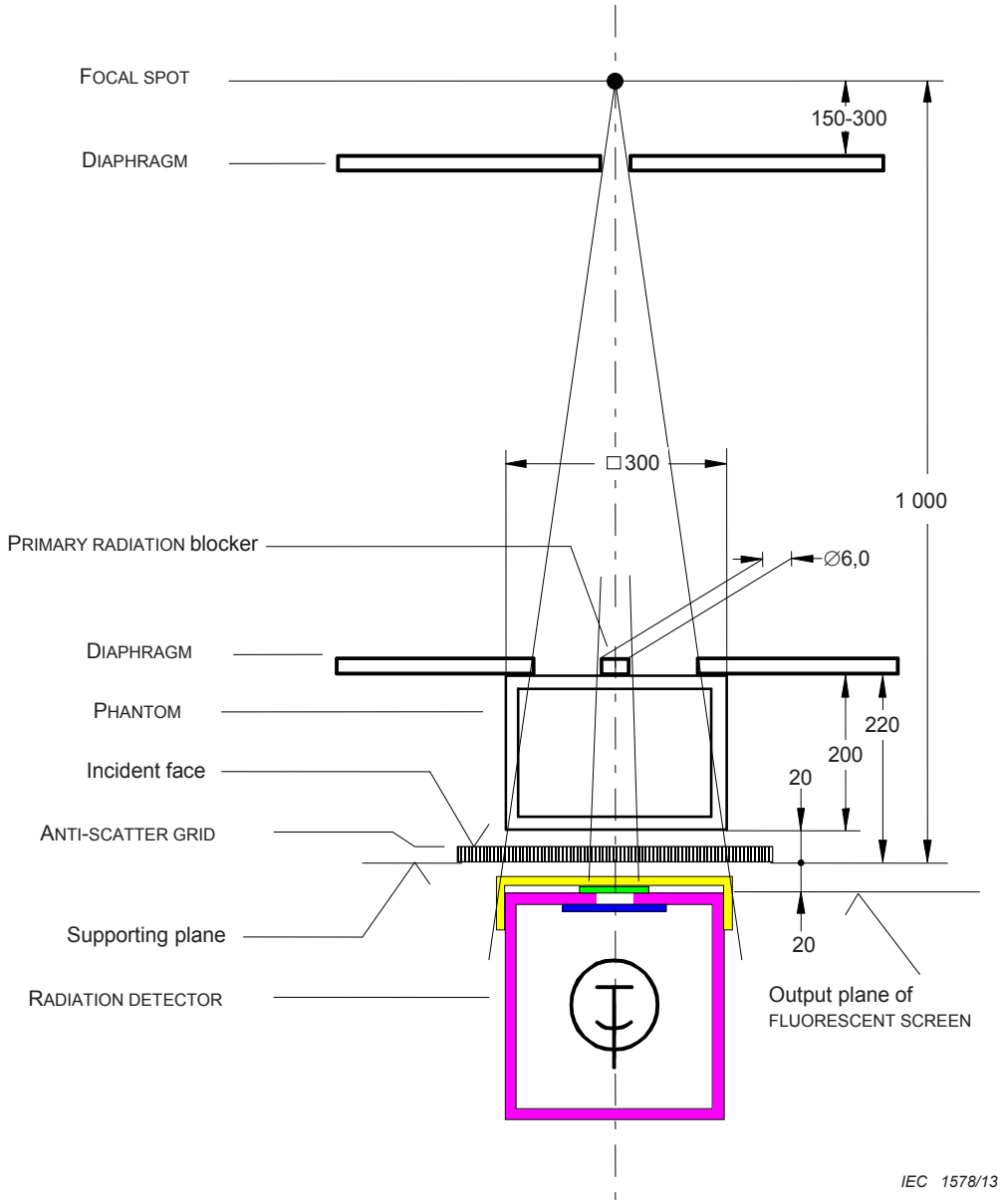


Figure 4 – Measurement arrangement for general-purpose ANTI-SCATTER GRIDS with BROAD BEAM CONDITION (determination of the TRANSMISSION OF SCATTERED RADIATION)

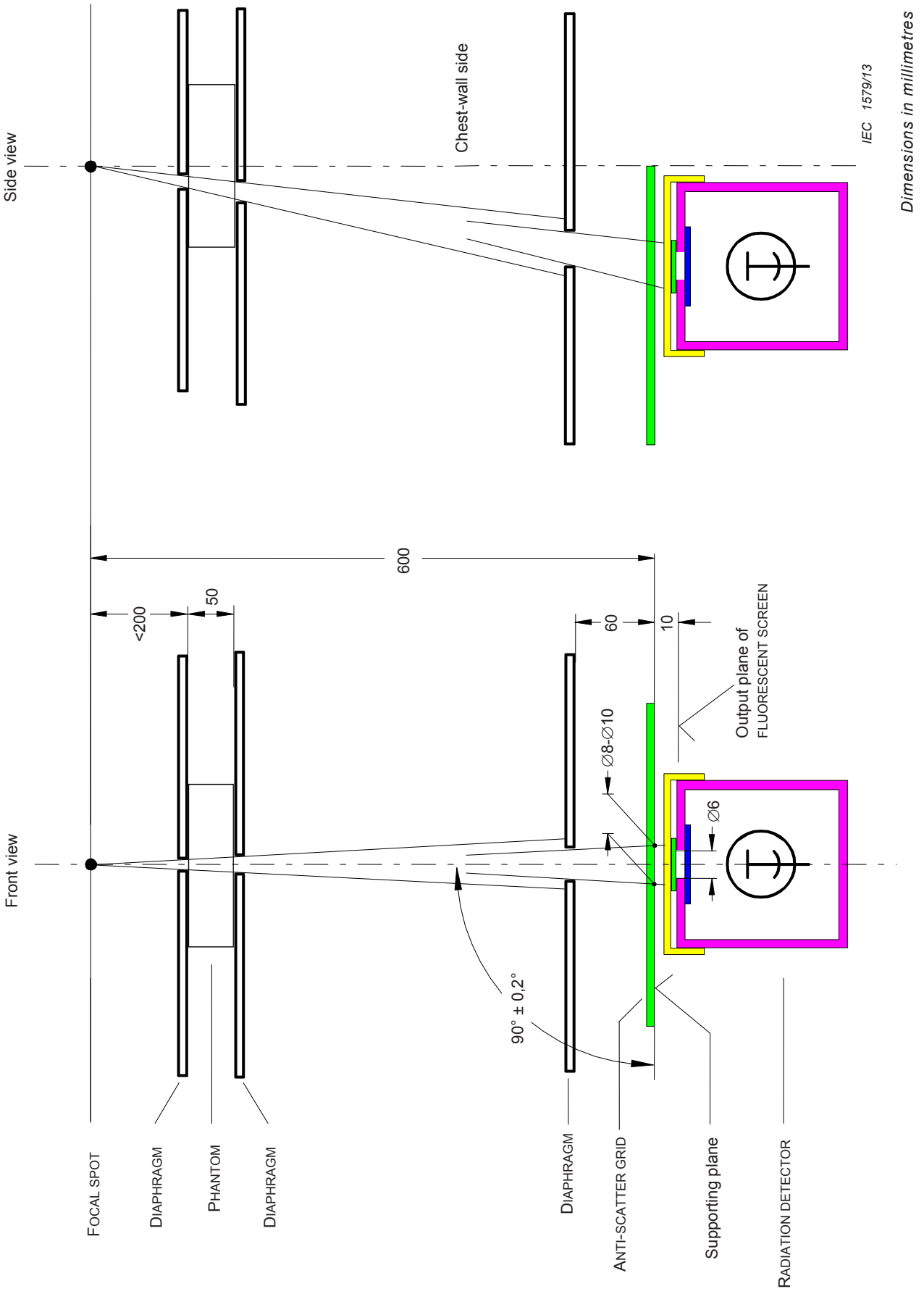


Figure 5 – Measurement arrangement for MAMMOGRAPHIC ANTI-SCATTER GRIDS with NARROW-BEAM CONDITION (determination of the TRANSMISSION OF PRIMARY RADIATION)

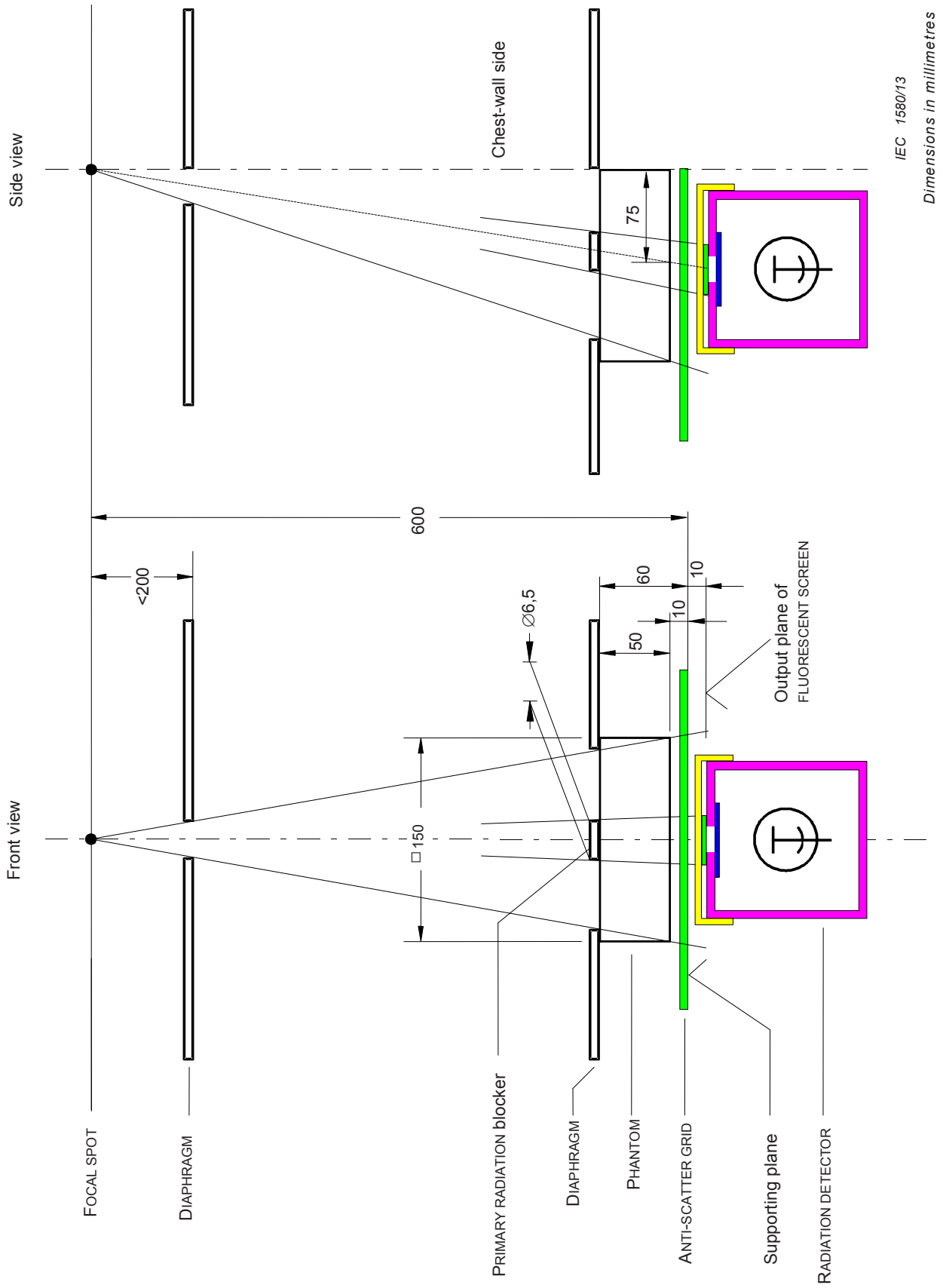


Figure 6 – Measurement arrangement for MAMMOGRAPHIC ANTI-SCATTER GRIDS with BROAD BEAM CONDITION (determination of the TRANSMISSION OF SCATTERED RADIATION)

Annex A
(normative)

Calculation of the APPLICATION LIMITS

A.1 DEFOCUSING and DECENTRING of FOCUSED GRIDS

FOCUSED GRIDS consist of a plurality of absorbing strips which converge to a virtual straight line at the FOCUSING DISTANCE. If the FOCAL SPOT of an X-RAY TUBE is located on this line, the TRANSMISSION OF PRIMARY RADIATION is at its maximum because the projection of the absorbing strips on the IMAGE RECEPTION AREA is minimal.

Any deviation of the FOCAL SPOT from this virtual line at the FOCUSING DISTANCE results in an enhanced projection of the absorbing strips on the IMAGE RECEPTION AREA and hence in a reduction of the TRANSMISSION OF PRIMARY RADIATION. This deviation may be in the vertical direction and/or parallel to the plane of the ANTI-SCATTER GRID.

Deviations in the vertical direction result in a difference between the FOCAL SPOT to grid distance and the FOCUSING DISTANCE of the FOCUSED GRID. This difference is called the DEFOCUSING and causes a non-uniform reduction of the TRANSMISSION OF PRIMARY RADIATION. The TRANSMISSION OF PRIMARY RADIATION decreases in the direction from the TRUE CENTRAL LINE to the edges of the grid.

Deviations parallel to the plane of the ANTI-SCATTER GRID (in the direction perpendicular to the absorbing strips) result in a difference between the perpendicular projection of the FOCAL SPOT on the grid surface and the TRUE CENTRAL LINE of the FOCUSED GRID. This difference is called the DECENTRING and causes a uniform reduction of the TRANSMISSION OF PRIMARY RADIATION over the entire grid area.

MOVING GRIDS show an oscillating DECENTRING when they are moved to avoid the imaging of the absorbing strips in the X-RAY PATTERN. The maximum amount of the DECENTRING is used for the calculation of the APPLICATION LIMITS and is given by the maximum distance between the perpendicular projection of the FOCAL SPOT on the grid surface and the position of the TRUE CENTRAL LINE of the MOVING GRID. For symmetric movement, this distance coincides with the maximum movement of the MOVING GRID from its central position.

The reduction of the TRANSMISSION OF PRIMARY RADIATION caused by DEFOCUSING and/or DECENTRING of a FOCUSED GRID is limited to an acceptable level according to 6.2.

A.2 Calculation of the APPLICATION LIMITS f_1 and f_2

The method for the determination of the APPLICATION LIMITS f_1 and f_2 is presented here and assumes an ANTI-SCATTER GRID of exact geometrical form. See also [2] and [3]. In the formulae presented below, the MANUFACTURER may choose

– to use the GRID RATIO r under the assumption of total absorption of PRIMARY RADIATION through the absorbing strips; or
– to replace this ratio with the adapted grid ratio r^* taking into account the partial absorption of PRIMARY RADIATION through the absorbing strips.

The adapted grid ratio r^* is defined by

$$r^* = r\left(1 - \frac{2}{\mu h}\right) \tag{A.1}$$

where

h is the height of the absorbing strips; and

μ is the average linear attenuation coefficient of the highly absorbent material of the strips for RADIATION CONDITION RQN 6.

NOTE 1 This adaptation is only relevant to general purpose ANTI-SCATTER GRIDS which are applied under conditions with X-RAY TUBE VOLTAGES above 60 kV.

NOTE 2 Using the adapted grid ratio r* results in a wider and more realistic range of the APPLICATION LIMITS.

NOTE 3 The average linear attenuation coefficient of lead for RADIATION CONDITION RQN 6 is approximately equal to $\mu = 8\ mm^{-1}$. This value can be used for calculation purposes.

The APPLICATION LIMITS for a FOCUSED GRID without DECENTRING shall be determined according to

$$f_1 = \frac{f_0}{1 + \frac{f_0 V_1}{r c}} \qquad f_2 = \frac{f_0}{1 - \frac{f_0 V_2}{r c}} \tag{A.2}$$

The APPLICATION LIMITS for a FOCUSED GRID with DECENTRING and the APPLICATION LIMITS for a MOVING GRID shall be determined according to

$$f_1 = \frac{c + z}{\frac{c}{f_0} + \frac{V_1}{r}} \qquad f_2 = \frac{c - z}{\frac{c}{f_0} - \frac{V_2}{r}} \tag{A.3}$$

The APPLICATION LIMITS for a PARALLEL GRID shall be determined according to

$$f_1 = \frac{rc}{V_1} \qquad f_2 = \infty \quad . \tag{A.4}$$

In the formulae (A.2) to (A.4)

c is the distance from the TRUE CENTRAL LINE to the border of the effective area;

f_0 is the FOCUSING DISTANCE;

f_1 is the lower APPLICATION LIMIT;

f_2 is the upper APPLICATION LIMIT;

r is the GRID RATIO or the adapted grid ratio r^* according to (A.1);

V_1 is the loss of TRANSMISSION OF PRIMARY RADIATION at the lower APPLICATION LIMIT;

V_2 is the loss of TRANSMISSION OF PRIMARY RADIATION at the upper APPLICATION LIMIT;

z is the value of DECENTRING of a FOCUSED GRID or a MOVING GRID.

NOTE 4 For general-purpose ANTI-SCATTER GRIDS, V_1 and V_2 are equal to 0,4 according to 6.2 a).

NOTE 5 For MAMMOGRAPHIC ANTI-SCATTER GRIDS, V_1 and V_2 are equal to 0,2 according to 6.2 b).

NOTE 6 Without DECENTRING (z=0) the expressions (A.3) reduce to those of (A.2).

A.3 Indication of the APPLICATION LIMITS

The values of the APPLICATION LIMITS shall be given in centimetres.

Non-integer values of f_1 shall be raised to the next higher integer.

Non-integer values of f_2 shall be decreased to the next lower integer.

If the calculation of f_2 according to formula (A.2) or (A.3) results in a negative value, the value of f_2 shall be set to infinity.

Annex B
(informative)

Influence of scatter fraction on the physical characteristics

The measurements necessary for the determination of the physical characteristics of general purpose ANTI-SCATTER GRIDS require the use of a PHANTOM of 20 cm thickness. See 5.1.3 a). The obtained physical characteristics are representative for PATIENTS of medium/average size. Considering the increase in PATIENT thickness over the past decades, it is desirable to gain insight how these physical characteristics will change with increasing scatter fraction [4-5]. This insight can be obtained through additional measurements or by calculations.

When additional measurements are performed, it is recommended to use the same method and arrangements as described in 5.1 with the following adaptations:

- The PHANTOM should be made according to 5.1.3 a) but with a height of 300 mm ± 1 mm.
- For the measurements in NARROW-BEAM CONDITIONS (see Figure 3), the PHANTOM should be positioned with its top surface against the upper DIAPHRAGM so that its bottom surface and the extra DIAPHRAGM are 100 mm more away from the FOCAL SPOT.
- For the measurements in BROAD BEAM CONDITIONS (see Figure 4), the top surface of the PHANTOM and the lower DIAPHRAGM should be positioned 100 mm closer to the FOCAL SPOT so that its bottom surface is at a distance of 20 mm from the supporting plane of the grid.

The physical characteristics are subsequently determined by the same method and formulae as given in 5.2.

When calculations are performed, it is recommended to use the following approach. For a given ANTI-SCATTER GRID, the TRANSMISSION OF PRIMARY RADIATION T_p and the TRANSMISSION OF SCATTERED RADIATION T_s have different values due to the special grid design. As a consequence, the TRANSMISSION OF TOTAL RADIATION T_t depends on the scatter fraction of the incident RADIATION BEAM. The expressions below are derived for one RADIATION CONDITION (e.g. RQR 6) and under the assumption that both T_p and T_s are independent of the scatter fraction and the quality of the RADIATION BEAM. See also [4] and [5].

When the fraction of SCATTERED RADIATION in the incident RADIATION BEAM (the scatter fraction) is denoted by SF, the fraction of PRIMARY RADIATION is given by 1-SF and the TRANSMISSION OF TOTAL RADIATION can be calculated as

$$T_t = T_p(1-\mathrm{SF}) + T_s\mathrm{SF} \tag{B.1}$$

The amount of SCATTERED RADIATION in the incident RADIATION BEAM is sometimes expressed as the scatter-to-primary ratio SPR = SF/(1-SF).

The physical characteristics of the ANTI-SCATTER GRID as function of the scatter fraction are derived by substitution of (B.1) into the equations of 5.2.4 to 5.2.7. This results in the following expressions, namely

- the GRID SELECTIVITY

$$\Sigma = \frac{T_p}{T_s} \tag{B.2}$$

- the CONTRAST IMPROVEMENT RATIO

$$K = \frac{T_p}{T_t} = \frac{T_p}{T_p(1-SF) + T_s SF} \quad (B.3)$$

- the GRID EXPOSURE FACTOR

$$B = \frac{1}{T_t} = \frac{1}{T_p(1-SF) + T_s SF} \quad (B.4)$$

- and the IMAGE IMPROVEMENT FACTOR

$$Q = \frac{T_p^{\,2}}{T_t} = \frac{T_p^{\,2}}{T_p(1-SF) + T_s SF} \quad (B.5)$$

A graphical representation of these physical characteristics as function of the scatter fraction is shown in Figure B.1 for a general purpose ANTI-SCATTER GRID with given TRANSMISSION OF PRIMARY RADIATION T_p = 0,65 and given TRANSMISSION OF SCATTERED RADIATION T_s = 0,15. Typical scatter fractions are about 0,85 for a water-filled PHANTOM of 20 cm thickness and about 0,92 for a water-filled PHANTOM of 30 cm thickness [4-5].

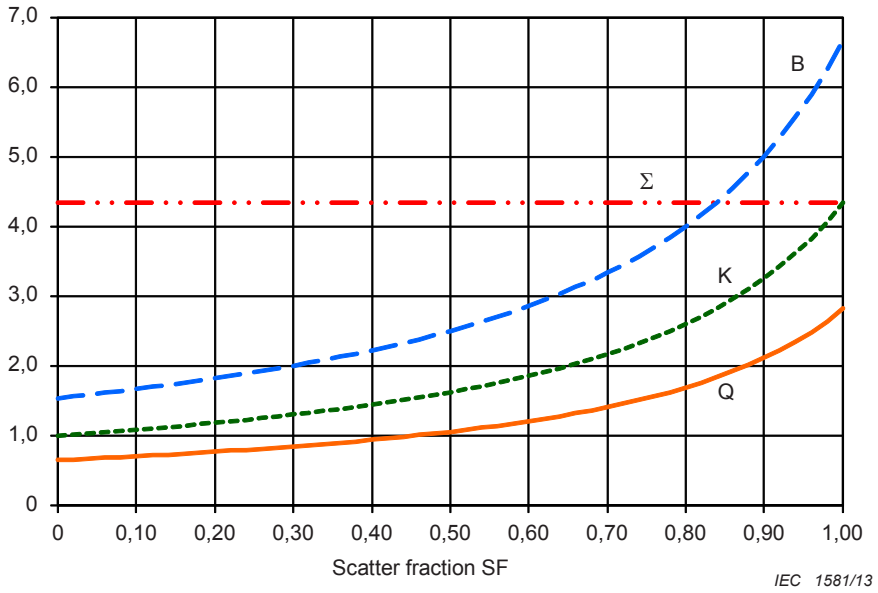


Figure B.1 – Physical characteristics as function of scatter fraction: SELECTIVITY Σ (dash-dotted line), CONTRAST IMPROVEMENT RATIO *K* (dotted line), GRID EXPOSURE FACTOR *B* (dashed line), and IMAGE IMPROVEMENT FACTOR *Q* (solid line)

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Index of defined terms used in this standard

NOTE In the present standard only terms defined either in IEC 60601-1:2005+A1:2012, IEC 60601-1-3:2008+A1:2013, IEC/TR 60788:2004 or in Clause 3 of this standard were used. The definitions used in these standards may be looked up at http://std.iec.ch/glossary.

RADIATION ..... IEC 60601-1-3:2008+A1:2013, 3.53
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