International Standard 5799

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Photography — Direct-exposure medical and dental radiographic film/process combinations — Determination of ISO speed and average gradient

Photographie — Ensembles film/traitement destinés à la radiographie médicale sans écran et à la radiographie dentaire — Détermination de la sensibilité ISO et du contraste moyen

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 5799 was developed by Technical Committee ISO/TC 42, *Photography*, and was circulated to the member bodies in July 1978.

It has been approved by the member bodies of the following countries :

Australia	Italy	Switzerland
Belgium	Japan	United Kingdom
Canada	Korea, Rep. of	USA
Czechoslovakia	Mexico	USSR
Egypt, Arab Rep. of	Netherlands	Yugoslavia
France	Poland	
Germany, F.R.	Spain	

No member body expressed disapproval of the document.

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Photography — Direct-exposure medical and dental radiographic film/process combinations — Determination of ISO speed and average gradient

1 Scope and field of application

This International Standard specifies methods for determining the ISO speed and average gradient of the film/film-process combinations used in medical and dental radiography other than mammography. Sensitometric procedures are described for films exposed directly to X-rays. The purpose of this International Standard is to provide a method for the measurement of ISO speed and average gradient so that the characteristics of the film/film-process system can be obtained reproducibly and can also be compared with those of other systems. Standard process formulae and cycles are intended primarily for those applications where specification or comparison work must include a specific published set of formulae and cycle characteristics.

This International Standard is not intended to specify the only method permissible for exposing and processing dental and medical X-ray film. Other methods are permissible provided that it can be demonstrated that a correlation to the standard method specified herein exists.

2 References

ISO 5, *Photography — Determination of diffuse transmission density.*

ISO/R 209, *Composition of wrought products of aluminium and aluminium alloys — Chemical composition (percent).*

ISO 418, *Photographic grade sodium sulphite, anhydrous — Specification.*

ISO 420, *Photographic grade potassium bromide — Specification.*

ISO 422, *Photographic grade p-methlylaminophenol sulphate — Specification.*

ISO 423, *Photographic grade hydroquinone — Specification.*

ISO 3300, *Photographic grade sodium thiosulphate, anhydrous — Specification.*

ISO 3620, *Photographic grade aluminium potassium sulphate, dodecahydrate — Specification.*

ISO 3627, *Photographic grade sodium metabisulphite, anhydrous — Specification.*

ISO 3628, *Photographic grade boric acid — Specification.*

ISO 3942, *Photographic grade sodium carbonate, monohydrate — Specification.*

ISO 3943, *Photographic grade sodium acetate, anhydrous — Specification.*

ISO 4037, *X and γ reference radiations for calibrating dosemeters and dose ratemeters and for determining their response as a function of photon energy.*

3 Definitions

3.1 exposure, X : The quantity of the X-radiation incident on the film expressed in coulombs per kilogram (C/kg) of air.[1)]

3.2 ISO speed : The value obtained from the following formula where X_s is the exposure required to produce a density of 1,00 above base plus fog density :

$$\text{ISO speed} = \frac{2{,}58 \times 10^{-4}}{X_s}$$

3.3 ISO average gradient, $\bar{G}$: The photographic term for the slope of the straight line drawn between the two points 0,25 and 2,00 above base plus fog density on the characteristic curve.

4 General conditions

4.1 Film orientation

This International Standard applies to medical and dental radiographic films exposed directly to X-rays. Medical films shall be exposed in holders which provide less than 2 % absorption. Dental films shall be exposed in the original packet or a wrapping of equivalent absorption.

If the film packet contains two films, the film toward the side with the radiation source shall be used. If the packet contains lead backing, the backing shall be away from the radiation source.

1) 1 coulomb per kilogram (C/kg) = 3 876 roentgens (R)

4.2 Safelights

Since films differ in their sensitivity to safelight illumination, all films shall be handled in light-tight enclosures prior to exposure and processing shall be done in complete darkness to avoid distortion of the sensitometric curve due to latensification and fogging.

5 Standard exposing conditions

5.1 Temperature and moisture content of film during exposure

The sample shall be at a temperature of 20 ± 5 °C and relative humidity of 50 ± 20 % during exposure.

5.2 Radiant energy quality

5.2.1 Tubes and filters

Films under test shall be exposed to X-rays from tungsten target tubes. The X-ray tube shall fulfil all reproduction conditions for radiation as specified in ISO 4037. Inherent filtration of the tube plus an additional aluminium [1] filter located as close to the target as possible shall provide a total filtration equivalent to 7,0 ± 0,5 mm of aluminium.

The kilovoltage [2] of the X-ray tube shall be adjusted until the half value in aluminium is 3,0 ± 0,2 mm, i.e. the exposure rate of the X-ray beam with a total filtration equivalent to 10,0 mm aluminium shall be one-half the value obtained with the total filtration equivalent to 7,0 mm of aluminium. The 3,0 mm aluminium half-value layer absorber shall be placed midway between the X-ray target and the ion chamber.

5.2.2 Secondary X-rays

To minimize secondary radiation when exposing test films, X-ray beams shall be diaphragmed to as small a size as will properly include the exposure area for the films (and the measuring device, if included). The amount of secondary radiation reaching the film and measuring device shall be less than 3 % of that resulting from direct X-rays. Constructing the supports for the film, filters and ion chamber from low atomic number materials and making such structures as light as possible will minimize secondary radiation.

The presence of excessive scattering may be tested by plotting the inverse square root of the exposure rate as a function of distance from the source. This distance should be at least 10 times the greatest linear dimension of the target. Absence of significant scattering is indicated when the resulting plot is a straight line passing through the origin. Scattering is excessive if the point corresponding to the observed intensity at the distance used for film exposures is more than 3 % below the best straight line from the origin among the plotted points. Measurements should be made at enough distances to provide a reliable indication of secondary radiation reaching the exposure plane.

5.3 Exposure uniformity

The exposure over the working area of each exposure step (with the 3 mm Al removed) shall be uniform to within 3 %. It may be desirable to measure the radiation at the exposure plane and expose the film simultaneously. In this case the irradiated field needs to be large enough to include the measuring device (usually an ion chamber). A beam-defining aperture placed between the X-ray source and exposure plane may be necessary to achieve the required uniformity and level of secondary radiation specified in this International Standard.

5.4 Exposure scale

The film should be given a graduated series of exposures such as will result in a series of densities above base and fog ranging from 0,20 to at least 2,30. Exposure increments should not exceed 0,20 log exposure units. Each exposure shall be measured in coulombs per kilogram by using an ionization chamber calibrated for radiant energy quality and exposure rate used for exposing the film [3]. An area of the film shall be left unexposed for measuring inherent base plus fog density.

6 Processing

6.1 Delay before processing

In order to minimize any effects due to latent-image instability, the film samples shall be processed not less than 30 min nor more than 8 h after exposure. Between exposure and processing, the temperature of the film shall be 20 ± 5 °C and moisture content shall be such that the film will be in equilibrium at a relative humidity of 50 ± 20 %.

6.2 Process specifications

No processing specifications are described in this International Standard in recognition of the wide range of chemicals and equipment used. Speed values provided by film manufacturers generally apply to the film when it is processed in accordance with their recommendations which produce the photographic characteristics specified for the process. Process information

1) Any grade in table 1 of ISO/R 209 may be used (the ISO symbols are Al 99,0 — Al 99,5 — Al 99,7 — Al 99,8).

2) In consant potential equipment, a value between 50 and 55 kVcp is required. In equipment without electrical smoothing, approximately 60 kVp is satisfactory.

3) If the instrument can be calibrated only at certain half-value layers close to but not identical with those specified in 5.2, then an interpolation at the specified half-value layer from a plot of the calibrations over a bracketing range of half-value layers is permissible. Annex A lists suitable radiant energy qualities for such an interpolation. Suitable calibration services are generally available from national physical laboratories or national standards bodies.

shall be available from the film manufacturers or others who quote speed and average gradient values. This shall specify the chemicals, times, temperatures, agitation, equipment and procedure used for each of the processing steps, and any additional information required to obtain the sensitometric results described. The values for speed and average gradient obtained using various processing procedures may differ significantly. Although different speeds for a particular film may be achieved by varying the processes, the user should be aware that changes in other characteristics usually accompany the speed changes.

7 Densitometry

ISO standard opal visual diffuse densities of the exposed and unexposed portions of the film after processing shall be determined in accordance with ISO 5 and plotted against the common logarithm of the exposure measured in coulombs per kilogram as shown in the figure.

8 Evaluation

8.1 Base plus fog density

Base plus fog density shall be determined from an unexposed sample of film processed simultaneously with the film exposed for determining the sensitometric characteristic curve.

8.2 Measurement of ISO speed

The method of determining ISO speed is illustrated in the figure. ISO speed is calculated from the exposure in coulombs per kilogram, X_s, required to produce a density of 1,0 above base plus fog density :

$$\text{ISO speed} = \frac{2{,}58 \times 10^{-4}}{X_s}$$

8.3 Measurement of average gradient

The average gradient $\bar{G}$ is the slope of the straight line joining points on the density-log exposure curve having densities of 0,25 and 2,00 above base and fog density (see the figure) :

$$\bar{G} = \frac{D_2 - D_1}{\log_{10} X_2 - \log_{10} X_1} = \frac{1{,}75}{\log_{10} X_2 - \log_{10} X_1}$$

where

D_1 is a density of 0,25 above base plus fog density;

D_2 is a density of 2,00 above base plus fog density;

X_1 is the exposure in coulombs per kilogram required to produce a density of 0,25 above base and fog density;

X_2 is the exposure in coulombs per kilogram required to produce a density of 2,00 above base and fog density.

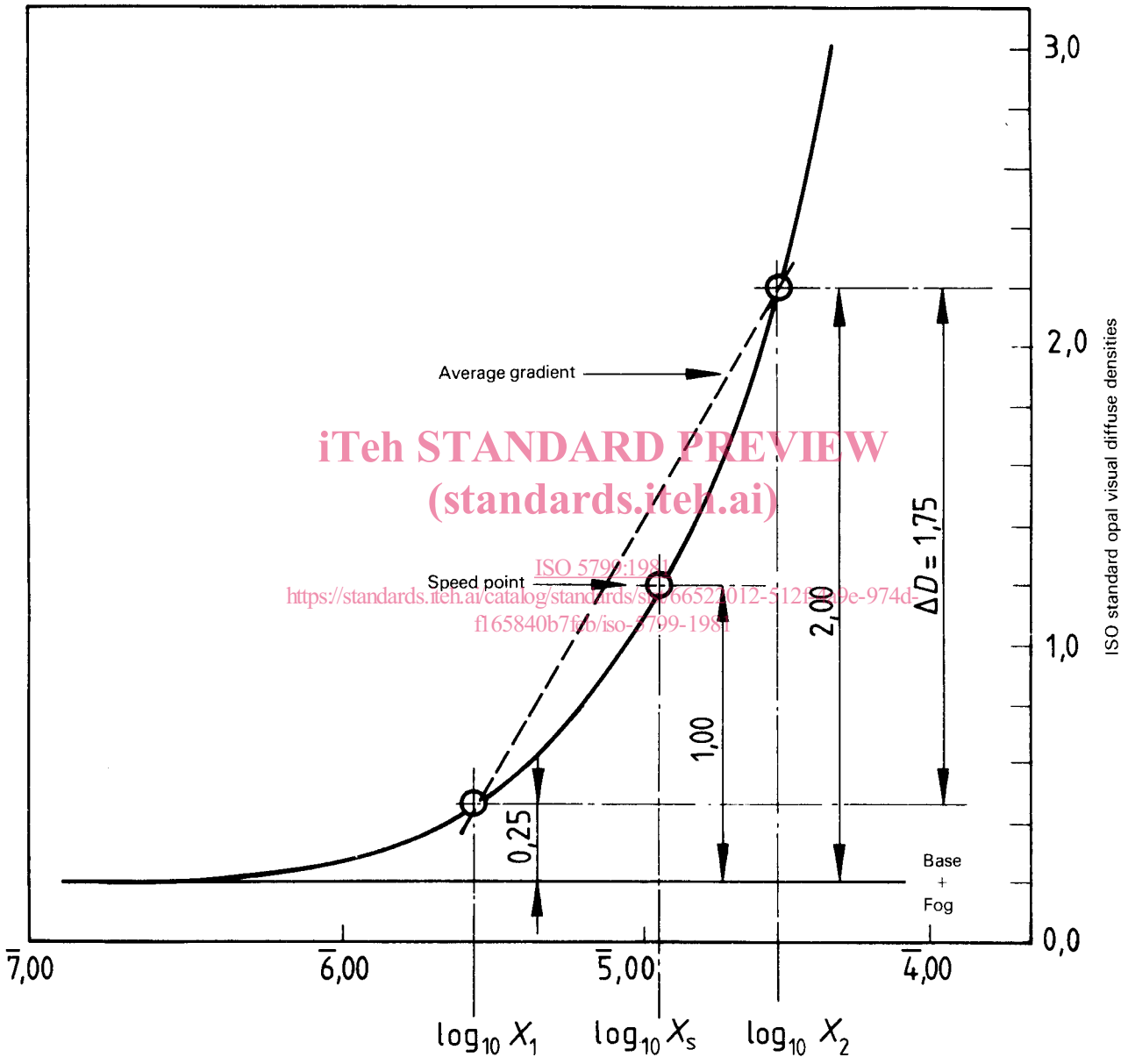

Figure — Method for determining ISO speed and average gradient

Annex A

Calibration of ionization chambers

(This annex does not form part of the standard.)

As stated in the footnote to 5.4, it may not be possible to have ionization chambers calibrated with the radiant energies specified in 5.2. In such a case, ionization chamber response at the required radiant energies may be determined by interpolation on a plot of calibrations over a bracketing range of half-value layers.

Ionization chamber response for the half-value layer specified in 5.2 may be determined by interpolation on a plot of half-value layer against chamber response to radiant energies as given in table 1.

Table 1 — Calibration parameters

Constant potential	Inherent filter, approx.	Added filter	First half-value layer, approx.
kV	(mm Al)	(mm Al)	(mm Al)
60	1,5	2,5	2,79
75	1,5	2,5	3,41
100	1,5	3,5	5,05

In the determination of film speeds as specified in clause 8, it is permissible to calibrate the working instrument, with which the film exposures are measured, against an instrument calibrated by a standardizing organization. This may be necessary when the standardizing organization is not equipped to calibrate an ionization chamber of the most useful range for determining exposures of films.

Annex B

Manual processing with standard chemicals

(This annex does not form part of the standard.)

B.1 Chemicals

Photographic grade chemicals meeting the requirements of the appropriate International Standard should be used throughout.

B.2 Development

B.2.1 Developer composition

The developer composition shall be according to table 2.

Table 2 — Developer composition

Chemical	International Standard	Amount
Distilled water at 50 ± 5 °C	—	500 ml
p-Methylaminophenol sulphate	ISO 422	2,2 g
Sodium sulphite, anhydrous	ISO 418	72,0 g
Hydroquinone (1,4-*di*hydroxy-benzene)	ISO 423	8,8 g
Sodium carbonate monohydrate	ISO 3942	56,0 g
Potassium bromide	ISO 420	4,0 g
Distilled water to make	—	1 000 ml

Dissolve chemicals in the order given. Each chemical should be completely dissolved before the next one is added. Use without dilution. The developer shall be used fresh or up to 7 days old if stored in full, airtight containers.

B.2.2 Developer temperature

The developer temperature should be 20 ± 0,3 °C.

B.2.3 Development time

Development time should be 5 min ± 5 s.

B.2.4 Development agitation

Agitation shall be provided manually by a rapid movement of the film or chemicals during the first 15 s after immersion and for 5 s each minute thereafter.

B.3 Stop bath

To terminate development, the film shall be immersed for 30 s with vigorous agitation in a stop bath consisting of 3 % (*V*/*V*) acetic acid at a temperature of 20 ± 2 °C.

B.4 Fixation

B.4.1 Fixing bath composition

The fixing bath composition shall be according to table 3.

Table 3 — Fixing bath composition

Chemical	International Standard	Amount
Distilled water at 50 ± 5 °C	—	600 ml
Sodium thiosulphate, anhydrous	ISO 3300	225,0 g
Sodium metabisulphite, anhydrous	ISO 3627	10,0 g
Boric acid (crystals)	ISO 3628	10,0 g
Sodium acetate, anhydrous	ISO 3943	30,0 g
Aluminium potassium sulphate (alum)	ISO 3620	30,0 g
Distilled water to make	—	1 000 ml

Dissolve chemicals in the order given. Each chemical should be completely dissolved before the next one is added. Use without dilution.

B.4.2 Fixing temperature

The temperature of the fixing bath should be 20 ± 2 °C.

B.4.3 Fixing time

Films shall be agitated vigorously during the first 30 s of immersion. The time of fixation shall not be less than twice the time required to clear the film or more than 15 min.

B.5 Washing

Films shall be washed in running water at 20 ± 2 °C for at least 30 min, with a flow sufficient to produce at least eight renewals per hour. The wash shall be sufficiently free of dissolved and suspended solids to leave no appreciable deposit in the dried films.

B.6 Drying

Film shall be air dried at 40 °C or lower. Hot air above 40 °C shall not be used because of the possible effects of high drying rates on the final film density.