
**Photography — Sensitometry of screen/film
systems for medical radiography —**

Part 3:

Determination of sensitometric curve shape,
speed and average gradient for mammography

*Photographie — Sensitométrie des ensembles film/écran pour la
radiographie médicale —*

*Partie 3: Détermination de la forme de la courbe sensitométrique, de la
sensibilité et du contraste moyen pour la mammographie*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 9236-3 was prepared by Technical Committee ISO/TC 42, *Photography*.

ISO 9236 consists of the following parts, under the general title *Photography — Sensitometry of screen/film systems for medical radiography*:

- *Part 1: Determination of sensitometric curve shape, speed and average gradient*
- *Part 2: Determination of the modulation transfer function (MTF)*
- *Part 3: Determination of sensitometric curve shape, speed and average gradient for mammography*

Annexes A and B of this part of ISO 9236 are for information only.

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Introduction

This part of ISO 9236 provides methods for determining the sensitometric curve shape, the average gradient and the speed of radiographic screen/film/filmholder/processing systems used in mammography.

The sensitometric curve, which is also needed for the determination of other properties (as, for example, the modulation transfer function) is measured under low-scatter conditions via intensity scale X-ray sensitometry, using a sensitometer which is mainly based on the photometric inverse square law. For the determination of the sensitometric curve shape, the irradiation of the screen/film/filmholder combination need be measured only in relative units.

While the average gradient is determined from the sensitometric curve shape, speed has to be measured in a separate way, since the exposure conditions should simulate as closely as possible those which are used in practice. Therefore, scattered radiation is included, accompanied by a slight change of beam quality compared to the beam quality used for intensity scale sensitometry. The clinical exposure is simulated by using both an appropriate phantom and tube voltage. The screen/film/filmholder combination is exposed behind the phantom. The exposure shall be measured in absolute units (gray, Gy) in order to determine the speed.

Speed is generally dependent on X-ray energy, the amount of scattered radiation and the exposure time. Therefore, some variation in speed values may be expected under practical conditions. However, as the range of tube voltages applied in screen/film mammography is small, this part of ISO 9236 describes only one beam quality for speed measurement. The measurement conditions described in this part of ISO 9236 provide values for speed and average gradient which are representative of those found under practical conditions.

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Photography — Sensitometry of screen/film systems for medical radiography —

Part 3:

Determination of sensitometric curve shape, speed and average gradient for mammography

1 Scope

This part of ISO 9236 specifies methods for determination of the sensitometric curve shape, average gradient and speed of a single sample of a screen/film/filmholder/processing system in mammography.

The filmholder may be any means which ensures close screen/film contact and prevents the film from being exposed to ambient light. In particular, the filmholder may be a light-tight vacuum bag, as often used in the laboratory, or a radiographic cassette as used in mammography.

NOTE — Hereafter, screen/film/filmholder combinations will be referred to as “combinations”, and will be referred to as “systems” when the processing is included.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 9236. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 9236 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 5-2:1991, *Photography — Density measurements — Part 2: Geometric conditions for transmission density*.

ISO 5-3:1995, *Photography — Density measurements — Part 3: Spectral conditions*.

ISO 554:1976, *Standard atmospheres for conditioning and/or testing — Specifications*.

3 Definitions

For the purposes of this part of ISO 9236, the following definitions apply.

3.1 air kerma, K : Energy which is transferred by ionizing radiation (for instance X-rays) to air molecules divided by the mass of air in that volume where the energy is released. The unit is the gray (Gy).

3.2 sensitometric curve: Plot of the density of a processed photographic film as a function of the logarithm of the exposure.

3.3 speed, S : Quantitative measure of the response of the screen/film system to radiant energy for the specified conditions of exposure, processing, and density measurement.

3.4 average gradient, \bar{G} : Slope of the straight line joining two specified points on a sensitometric curve.

3.5 net density D : Density of an exposed and processed film minus the density of an unexposed and processed sample of that film.

4 General requirements

4.1 Storage and handling conditions

The films and screens shall be stored according to the manufacturers' recommendations. Before and during exposures, the temperatures of the films and screens shall be maintained at (23 ± 2) °C (see ISO 554) and the moisture content of the film shall be such that it will be in equilibrium at a relative humidity of (50 ± 20) %.

4.2 Safelights

To eliminate the possibility of safelight illumination affecting the sensitometric results, all films shall be kept in total darkness during handling, exposure and processing.

4.3 X-ray equipment

For all tests described in this part of ISO 9236 a 6-pulse, 12-pulse, high frequency (multipulse), or constant-potential generator shall be used.

For dosimetry, a measuring detector shall be used that is calibrated to measure air kerma for the beam quality applied. The accuracy of readings shall be better than ± 5 % for collimated beams without scatter, and better than ± 7 % for radiation measurements behind the phantom when scattered radiation is included.

NOTE — A spherical ionization chamber is recommended for measurements where scattered radiation is involved. The centre of the spherical chamber is to be considered the reference point; the stem of the spherical chamber should point in a direction opposite to the focal spot direction.

4.4 Processing

Screen/film systems including either manual or automatic processing may be tested in accordance with this part of ISO 9236. Processing should be carried out in accordance with the film manufacturer's recommendations. Nothing shall be construed to require the disclosure of proprietary information.

No processing specifications are described in this part of ISO 9236, in recognition of the wide range of chemicals and equipment used. Speed and average gradient values provided by film manufacturers generally apply to the system when the film is processed in accordance with their recommendations so that the photographic characteristics specified for the process are produced. Processing information shall be provided by the film manufacturer or others who quote speed and average gradient values and shall specify the processing chemicals, times, temperatures, agitation, equipment and procedures 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 other processing procedures may differ significantly. The processing conditions selected by a person using this part of ISO 9236 are, in any case, part of the system being tested. Different speeds for a particular film may be achieved by varying the processes, but the user should be aware that other changes may accompany the speed changes.

In order to minimize any effects due to latent-image instability or process variability, all film samples shall be processed together, neither less than 30 min nor more than 4 h after exposure. Between exposure and processing,

the temperature of the film shall be maintained at $(23 \pm 2) ^\circ\text{C}$, and its moisture content shall be such that the film will be in equilibrium at a relative humidity of $(50 \pm 20) \%$.

Since films are generally processed in practice a few minutes after exposure, the speed observed in practice may differ from that determined by this part of ISO 9236 due to latent-image fading of some films. Therefore, the speed measured with a time delay of 30 min to 4 h between exposure and processing shall be corrected to the value one would obtain if the film were processed soon after exposure. For the purposes of this part of ISO 9236, a time delay of 5,0 min is used for computing speed.

NOTES

1 The information about the necessary correction may easily be gained by exposing film strips in a light sensitometer and varying the time between exposure and processing. In the case of double-emulsion films, care should be taken that both front and back emulsions are exposed equally by the sensitometer.

2 Since the time required for the many individual exposures to obtain the sensitometric curve is comparatively long, a time delay of at least 30 min between exposure and processing is prescribed. That time delay is considered to be sufficient to minimize any differences in latent-image fading for the individual exposures.

The following processing information and accuracies shall be specified:

- a) trade designations of all chemicals, if proprietary; otherwise, the formula;
- b) temperature of the developer to within $\pm 0,3 ^\circ\text{C}$;
- c) temperature of other solutions to within $\pm 2 ^\circ\text{C}$;
- d) immersion times in the developer solution to within 3 %;
- e) whether the developer is fresh or "seasoned" (if "seasoned", the type and amount of film used for seasoning), the density of the processed film and the replenishment procedure;
- f) agitation specifications, in terms of volume of solution recirculated or rate at which a gas is used;
- g) drying temperature to within $\pm 5 ^\circ\text{C}$;
- h) trade designation of processing equipment.

NOTE — The term "seasoned developer" means that the developer is no longer unused or fresh, but is already used and in a "normal working condition".

4.5 Densitometry

ISO standard visual diffuse transmission density of the processed images shall be measured using a densitometer complying with the geometric conditions specified in ISO 5-2 and spectral conditions specified in ISO 5-3. Readings shall be made in a uniform area of the image. The densities, D , shall be measured with an accuracy of $\Delta D/D = \pm 0,02$ or $\Delta D = \pm 0,02$, whichever is the greater.

5 Determination of sensitometric curve shape

In this part of ISO 9236, intensity scale sensitometry is described to determine curve shape. The intensity is modified by a change of the distance between the radiation source and the combination. As a consequence of secondary radiation sources in the beam, and due to beam attenuation by the air, the relationship between exposure and distance does not exactly obey the inverse-square law. Therefore that relationship shall be calibrated.