INTERNATIONAL STANDARD

ISO 7004

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Photography — Industrial radiographic films — Determination of ISO speed, ISO average gradient and ISO gradients *G*2 and *G*4 when exposed to X- and gamma-radiation

Photographie — Films pour radiographie industrielle — Détermination de la sensibilité ISO, du contraste moyen ISO et des contrastes ISO G2 et G4 après exposition à des rayons X ou gamma

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 7004 was prepared by Technical Committee ISO/TC 42, *Photography*.

This second edition cancels and replaces the first edition (ISO 7004:1987), of which it constitutes a technical revision.

Annexes A to F of this International Standard are for information only.

Introduction

This International Standard specifies methods for measuring the ISO speed, ISO average gradient and ISO gradients *G*2 and *G*4 of industrial radiographic film systems when exposed directly to X- and γ-radiation. Many countries have had national standards relating to this subject for many years and may provide values which are different from those obtained by following the procedure specified in this International Standard. Because the photographic characteristics of a film system are dependent on the energy distribution in the wavelength spectrum, four representative sources are specified for determining sensitometric characteristics. To minimize the differences between national standards and this International Standard, the minimum requirements for X-ray tubes and X-ray generators have been considered mandatory and have been clearly specified in the subclause on radiation quality (5.3.3). This International Standard imposes limiting specifications on the thickness of the metallic screens often used in conjunction with the film as specified in the basic rules for good radiographic practice in ISO 5579.

Photographic results are also dependent on the chemical process used to develop the film. This International Standard does not attempt to specify the processing method; therefore, when ISO speed or ISO gradient values are given for a film system, it is necessary to specify not only the radiation quality used but also the process. This will permit the comparison of systems consisting of film and film processing.

Photography — Industrial radiographic films — Determination of ISO speed, ISO average gradient and ISO gradients *G*2 and *G*4 when exposed to X- and gamma-radiation

1 Scope

This International Standard specifies methods for determining sensitometric curve shape, ISO speed, ISO average gradient and ISO gradients *G*2 and *G*4 for industrial radiographic systems consisting of film and film processing when exposed directly to X-rays and γ-rays. The measurement of characteristics of film systems used in industrial radiography with fluorescent intensifying screens is not specified in this International Standard.

NOTE Units of measured energy are given for information in annex A.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 5-2: 2001, *Photography — Density measurements — Part 2: Geometric conditions for transmission density*

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

ISO 4037-1:1996, *X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy — Part 1: Radiation characteristics and production methods*

ISO 5579: 1998, *Non-destructive testing — Radiographic examination of metallic material by X- and gamma rays — Basic rules*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1
radiographic film
transparent plastic sheet coated on one or both sides with a photographically sensitive layer

3.2
film system
system consisting of a radiographic film, the film processing and, when in use, the lead foil(s) and film holder

3.3
system type
all film systems manufactured in the same way and of the same specification, but without consideration of the format

NOTE A particular system type is specified by the type of film, type of processing and, when in use, the type of lead foil(s) and film holder.

3.4
film/screen combination
radiographic film in direct contact with metallic screen(s) during exposure to X- or γ-radiation

NOTE Within the scope of this International Standard, the screens are lead foils.

3.5
radiation quality
characteristic of ionizing radiation, determined by its spectral distribution with respect to energy

3.6
exposure technique
radiation source and filtration of the radiation beam in order to obtain a specified radiation quality at the source side of the film or film/screen combination holder

3.7
minimum density
D_{min}

ISO standard visual diffuse transmission density, D_T, of an unexposed and processed sample of the film under test

3.8
net density

D_N
ISO standard visual diffuse transmission density, D_T, of an exposed and processed film minus the minimum density, D_{min}, of the film under test

3.9
speed
quantitative measure of the response of the photographic material to radiant energy for specified conditions of exposure, processing and image measurement

3.10
average gradient
$\bar{G}$
slope of the straight line joining two specified points on a sensitometric curve

3.11
gradient
Gx
slope $dD/d \log K$ of the tangent to the sensitometric curve at a specified net density $D_N = x$

NOTE It is a measure of the contrast obtainable with the film system.

3.12
gray
Gy
special name for the unit of air kerma and the unit of absorbed dose, which is joule per kilogram

NOTE 1 Gy = 1 J/kg of air. 1 Gy is equivalent to 114,5 R or is equivalent to 0,029 5 C/kg.

4 Sampling and storage

In determining the sensitometric curve, ISO speed, ISO average gradient and ISO gradients *G*2 and *G*4 of a film system, it is important that the samples evaluated yield the average results obtained by users. This will require evaluating several different batches periodically under conditions specified in this International Standard. Prior to evaluation, the samples shall be stored according to the manufacturer's recommendations for a length of time that simulates the average age at which the product is normally used. Several independent evaluations shall be made to ensure the proper calibration of equipment and processes. The basic objective in selecting and storing samples as described above is to ensure that the film characteristics are representative of those obtained by a consumer at the time of use.

5 Method of test

5.1 Principle

Samples are exposed and processed as specified in 5.3 and 5.4. Measurements are obtained from the resultant images to produce a sensitometric curve from which values are taken and used to determine ISO speed, ISO average gradient and ISO gradients *G*2 and *G*4.

5.2 Safelights

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

5.3 Exposure

5.3.1 Film holders

Film/screen combinations shall be exposed in holders which provide less than 2 % absorption of the radiation specified (without taking into account lead screens).

5.3.2 Sample condition

During exposure, the samples shall be at a temperature of 23 °C ± 5 °C and in equilibrium with air at a relative humidity of 50 % ± 20 %.

5.3.3 Radiation quality

5.3.3.1 General

Four specific exposing sources (two X-ray sources and two γ-ray sources) are recognized in this International Standard to cover the range of exposing conditions used in practice. The selection of which of the four sources is used to determine ISO speed, ISO average gradient and ISO gradients *G*2 and *G*4 depends on how the film system is used.

To improve the reproducibility of exposures when X-ray tubes are used, the X-ray generator shall fulfil the following requirements (based on ISO 4037-1):

a) X-radiations shall be produced by an X-ray unit of the constant-voltage type;

b) during an irradiation, the main value of the high voltage shall be stable within ± 1 %; it should be possible to display the mean value of the high voltage with a tolerance of ± 1 %;

c) the target of the X-ray tube shall be made of tungsten and shall be of the reflection type; the target angle should be about 22°.

5.3.3.2 X-rays from a low potential source

The film/screen combination under test shall be exposed to X-rays from tungsten target tubes. Inherent filtration of the tube, plus an additional copper filter located as close to the target as possible shall provide a filtration equivalent to 2,0 mm ± 0,1 mm of copper. All copper filters specified in this International Standard shall be made of 99,9 % pure copper.

The potential across the X-ray tube shall be adjusted until the half-value absorption is obtained with 1,0 mm ± 0,1 mm of copper (i.e. the intensity of the X-ray beam with a filtration equivalent to 3,0 mm shall be one-half the value obtained with the total filtration equivalent to 2,0 mm of copper).

A potential of approximately 120 kV generally meets this requirement. No lead screens shall be used.

This is designated source (1).

5.3.3.3 X-rays from a high potential source

The film/screen combination under test shall be exposed to X-rays from tungsten target tubes. Inherent filtration of the tube, plus an additional copper filter located as close to the target as possible shall provide a filtration equivalent to 8,00 mm ± 0,05 mm of copper. The potential across the X-ray tube shall be adjusted until the half-value absorption is obtained with 3,5 mm ± 0,2 mm of copper.

A potential of approximately 220 kV generally meets this requirement.

Film/screen combinations shall be exposed without interleaving paper and shall be between lead-foil screens. A trial exposure should be made to make sure that the lead-foil screens do not produce streaks or other obvious defects.

The front and back lead-foil screens shall be between 0,020 mm and 0,150 mm thick.

It should be noted that changes in screen thickness may result in changes in the sensitometric characteristics. Therefore, screen thickness shall be reported when quoting ISO speeds.

Single-coated films shall be exposed with the emulsion-coated surface facing the X-ray tube. To obtain sufficient contact, vacuum cassettes or pressure shall be used.

This is designated source (2).

5.3.3.4 Gamma rays from an iridium-192 (^{192}Ir) source

A filtration of 8,0 mm of copper near the source is required. Film thickness shall be between lead-foil screens with a thickness between 0,02 mm and 0,2 mm.

A trial exposure should be made to make sure that the lead-foil screens do not produce streaks or other obvious defects. It should be noted that changes in screen thickness may result in changes in the film speed. Therefore, screen thickness shall be reported when quoting ISO speeds.

This is designated source (3).

5.3.3.5 Gamma rays from a cobalt-60 (^{60}Co) source

Lead-foil screens shall be between 0,10 mm and 0,50 mm thick.

A trial exposure should be made to make sure that the lead-foil screens do not produce streaks or other obvious defects.

It should be noted that changes in screen thickness may result in changes in film speed. Therefore, screen thickness shall be reported when quoting ISO speeds.

This is designated source (4).

5.3.4 Scattered radiation

To minimize scattered radiation when exposing test film/screen combinations, X-ray and γ-ray beams shall be diaphragmed and collimated to as small a size as will permit a uniform exposure field for the films (and the measuring device, if included). The amount of scattered radiation reaching the film and measuring device shall be no greater than 6 % of the primary radiation. Constructing the supports for the film system, filters and ion chamber from materials of low atomic number and making such structures as light in mass as possible will minimize scattered radiation (see informative annex B).

5.3.5 Modulation

To determine speed and gradient values, it is necessary to provide exposures that will result in a minimum of 12 data points distributed between the densities of 1,0 and 5,0 above minimum density. In practice, this is carried out by changing the exposure time, step by step, combined with a gradual change in radiation dose. The exposure over the useful area of each exposure step shall be uniform to within 3 %.

For each exposure, the air kerma, in grays, shall be measured by using an ionization chamber calibrated for the radiant energy quality and intensity used for exposing the film. (See annexes C and D for additional information.) A separate sample of the film shall be left unexposed for measuring inherent minimum density.

5.4 Processing

5.4.1 Conditioning of samples

In the time interval between exposure and processing, the samples shall be kept at 23 °C ± 5 °C and in equilibrium with air at a relative humidity of 50 % ± 20 %.

The processing shall be started between 30 min and 8 h after exposure.

5.4.2 Processing specifications

No processing specifications are described in this International Standard in recognition of the wide range of chemicals and equipment used. ISO speed and ISO gradient data provided by the film manufacturer generally apply to the film when it is processed in accordance with the manufacturer's recommendations to produce the photographic characteristics specified for the process.

Process information shall be available from the film manufacturer or others who quote ISO speed and ISO gradients. 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 and average gradients for a particular film may be achieved by varying the process, the user should be aware that other sensitometric and physical changes may also accompany the speed and gradient changes.

5.5 Densitometry

ISO standard visual diffuse transmission density of the processed images shall be measured using a densitometer complying with the geometric requirements specified in ISO 5-2 and the spectral requirements specified in ISO 5-3.

Readings shall be made in a uniform area of the image. Typically, this is at least 1 mm from the edge of the exposed area.