
**Optics and photonics — Medical
endoscopes and endotherapy
devices —**

**Part 5:
Determination of optical resolution of
rigid endoscopes with optics**

*Optique et photonique — Endoscopes médicaux et dispositifs
d'endothérapie —*

*Partie 5: Détermination de la résolution optique des endoscopes
optiques rigides*

PROOF / ÉPREUVE



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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 172 *Optics and photonics*, Subcommittee SC 5, *Microscopes and endoscopes*.

This second edition cancels and replaces the first edition (ISO 8600-5:2005), which has been technically revised.

The main changes compared to the previous edition are as follows:

- document has been restructured;
- [Clause 2](#) added;
- [Clause 3](#) revised and updated;
- quality characteristics “Contrast Transfer Function” and “Modulation Transfer Function” as measurement methods are introduced;
- Measurement with limiting resolution moved to informative [Annex A](#);
- informative [Annex B](#) added;
- informative [Annex C](#) added;
- normative [Annex D](#) added;
- informative [Annex E](#) added;
- informative [Annex F](#) added;
- informative [Annex G](#) added.

A list of all parts in the ISO 8600 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Optics and photonics — Medical endoscopes and endotherapy devices —

Part 5:

Determination of optical resolution of rigid endoscopes with optics

1 Scope

This document applies to rigid endoscopes designed for use in the practice of medicine. Endoscopes having a fibre-optic or opto-electronic imaging system are excluded. It specifies a test method for determining the optical resolution of endoscopes.

This document provides a measurement method for characterizing three aspects of the optical resolution of a rigid endoscope. Characteristic A is used to provide a simple measurement of the limiting resolution of the endoscope image. Characteristic B provides a measurement of low spatial frequency resolution and characterizes the sharpness, or contrast, of the endoscope image. Characteristic C provides a measurement of the spatial frequency response of the endoscope image.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9334, *Optics and photonics — Optical transfer function — Definitions and mathematical relationships*

ISO 12233:2017, *Photography — Electronic still picture imaging — Resolution and spatial frequency responses*

ISO 15529:2010, *Optics and photonics — Optical transfer function — Principles of measurement of modulation transfer function (MTF) of sampled imaging systems*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

angular limiting resolution

smallest angle whose vertex is at the entrance pupil (can be approximated by the distal window surface if the target distance from the distal window is significantly larger than the distance between the distal window surface and the entrance pupil) of the endoscope at which a line pair (lp) at a given working distance d can just be resolved with normal visual acuity, with the unit of degrees/lp

Note 1 to entry: Angular limiting resolution is calculated using the formula

$$\alpha = \arctan \frac{1}{d \cdot r(d)}$$

where $r(d)$ is the limiting resolution.

**3.2
camera**

image detector used in the measurement, which is connected to the endoscope under test via coupling optics

Note 1 to entry: As used in this standard, the camera includes an image detector (typically CCD or CMOS image sensor), supporting electronics, and firmware/software used to obtain a digital sampling of the image formed by the coupling optics.

**3.3
contrast**

ratio of the difference between the intensities of the brightest and the darkest regions of a bar test target with square-wave modulation or its image divided by the sum of the intensities of the brightest and the darkest regions of the target or its image, and subsequently multiplied by 100 to measure as a percentage

Note 1 to entry: Contrast is given by

$$C(\%) = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}} \times 100$$

where I_{\max} and I_{\min} are the intensities of the brightest and darkest regions of the target or its image, respectively.

**3.4
contrast transfer function**

C_{TF}
plot of *contrast* (3.3) transfer factor, C_{TF} , as a function of *spatial frequency* (3.13), u

Note 1 to entry: Contrast transfer function is given by

$$C_{TF}(u) = \frac{C(u)_{\text{out}}}{C(u)_{\text{in}}}$$

where $C(u)_{\text{out}}$ is the output contrast (i.e. the image contrast) and $C(u)_{\text{in}}$ is the input contrast (i.e. the target contrast).

Note 2 to entry: If the target has high contrast so that $C(u)_{\text{in}}$ is close to one, $C_{TF}(u)$ can be approximated by $C(u)_{\text{out}}$. If C_{TF} is normalized to 1 at zero frequency, constant $C(u)_{\text{in}}$ will get factored out in the normalization. The C_{TF} of an endoscope can be obtained by measuring a series of square-wave bar targets with different *spatial frequencies*. The low-frequency contrast of the target as imaged through the endoscope may be measured with target patches of light and dark large enough that the intensity profile through the patch clearly reaches a steady value.

Note 3 to entry: For the purposes of the test specified in Characteristic B of this document, the “targets” will be the bar test targets specified in 4.2.5.2 and the measured results will be the C_{TF} .

**3.5
limiting resolution**

$r(d)$
maximum number of line pairs per mm (lp/mm) which can be resolved at a given working distance d of the endoscope

Note 1 to entry: The limiting resolution is only applicable to Characteristic A.

3.6**maximum image height**

radius of a circle which circumscribes the image

Note 1 to entry: If the image is rectangular, the maximum image height is half of the diagonal.

Note 2 to entry: If the image is circular, the maximum image height is the radius of the image circle.

3.7**maximum object height**

radius of a circle which circumscribes the portion of the object which can be imaged by the endoscope

Note 1 to entry: If the image is rectangular, the maximum object height is half of the distance between the object points which map to the corners of the image rectangle.

Note 2 to entry: If the image is circular, the maximum object height is the radius of the object space circle which maps to the image circle.

3.8**modulation**

M

ratio of the difference between the intensities of the brightest and the darkest regions of a sinusoidal test target or its image divided by the sum of the intensities of the brightest and the darkest regions of the target or its image, and subsequently multiplied by 100 to measure as a percentage

Note 1 to entry: Modulation is given by

$$M(\%) = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}} \times 100$$

where I_{\max} and I_{\min} are the intensities of the brightest and darkest regions of the image, respectively.

3.9**modulation transfer function**

M_{TF}

plot of the *modulation* (3.8) transfer factor, M_{TF} , as a function of *spatial frequency* (3.13) u , for a sine-wave target

Note 1 to entry: M_{TF} is a measure of the transfer of modulation from the object to the image.

Note 2 to entry: Modulation transfer factor is given by

$$M_{TF}(u) = \frac{M(u)_{\text{out}}}{M(u)_{\text{in}}}$$

where $M(u)_{\text{out}}$ is the output modulation (i.e. the image modulation) and $M(u)_{\text{in}}$ is the input modulation (i.e. the target modulation).

Note 3 to entry: If the target has high contrast so that $M(u)_{\text{in}}$ is close to one, $M_{TF}(u)$ can be approximated by $M(u)_{\text{out}}$. On the other hand, M_{TF} curves are always normalized to 1 at zero frequency, which make a constant $M(u)_{\text{in}}$ negligible. The M_{TF} of an endoscope can be obtained by measuring a series of sinusoidal targets with different spatial frequencies, or by other methods such as a slanted-edge target as discussed in 4.2.5.3.

3.10**off-axis limiting resolution**

limiting resolution (3.5) at an image point at 70 % of the *maximum image height* (3.6)

Note 1 to entry: See [Figure A.1](#).

3.11 on-axis limiting resolution

limiting resolution (3.5) at the image centre

Note 1 to entry: See Figure A.1.

3.12 optical resolution

numerical measure of the image quality of an optical system

3.13 spatial frequency

u

measure of how often a structure (e.g., sine-wave or square-wave bars) on the target or image repeats per unit distance or angle

Note 1 to entry: Spatial frequency has different units (e.g. lp/mm, lp/degree, lp/pixel), depending on whether the target period is measured in distance or angle units.

Note 2 to entry: The narrower definition of spatial frequency only refers to the sinusoidal components of the structure.

Note 3 to entry: The units of lp and cycles are often used interchangeably; in this standard, the unit of lp is used when referring to a square-wave or bar target (limiting resolution and C_{TF} measurement), and cycles are used when referring to sine wave components (M_{TF}) and to spatial frequencies in general.

3.14 working distance

d

design distance defined by the manufacturer between the object and distal end of the endoscope

Note 1 to entry: For the purposes of the test specified in this document the “object” will be the resolution target specified in 4.2.5.

4 Test method

4.1 General

Three characteristics of endoscope resolution are given in the method below. At least one characteristic should be measured. Table 1 may be used as a guide to determine the appropriate characteristic. See Annex A, B and C for acceptable test methods. Other methods of measuring the characteristics are allowed; if an alternative method is used, it shall be described in the test report.

Table 1 — Characteristics and measuring

Characteristic	Where Appropriate
A – Limiting Resolution	A single-valued subjective metric for rapid manufacturing testing, quality assurance (e.g. in end of line endoscope assembly testing), or for providing a simple metric that can be easily understood by end users. See Annex A for information on the measurement procedure.
B – Contrast Transfer Function (C_{TF})	A multi-valued objective metric for device validation and verification. It is less scientifically sophisticated than M_{TF} , but it is mathematically simple, can be easily understood by end users, and can be measured with a square-wave target that can be easily produced. Multiple target images are needed to obtain C_{TF} measurements at different spatial frequencies. See Annex B for information on the measurement procedure.