INTERNATIONAL STANDARD

ISO 8039

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Optics and optical instruments — Microscopes — Magnification

Optique et instruments d'optique — Microscopes — Grossissement

Foreword

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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.

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Optics and optical instruments — Microscopes — Magnification

1 Scope

This International Standard specifies a series of values for the magnification of imaging components of light microscopes and defines a number of magnifying systems to which they apply.

2 Definitions

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

2.1
magnification

act or process of changing the apparent dimensions of an object by optical methods

NOTE 1 The type of magnification such as visual or lateral should always be specified.

NOTE 2 The more general term “magnifying power” as a measure of the ability of an optical system to produce visual magnification and lateral magnification under specified operating conditions has been replaced in this International Standard by “magnification”, due to the more established use of this term in practical work.

2.2
visual magnification

ratio of the tangents of the viewing angle of an object when observed through a magnifying system with the image at infinity to that of the object when observed by the naked eye at the reference viewing distance (250 mm)

NOTE - This ratio should be expressed in a numerical form with a multiplication sign, e.g. 10 ×.

2.3
lateral magnification

ratio of a given distance in the real image normal to the optical axis to the corresponding distance in the object

NOTE - This ratio should be expressed in a proportional form, e. g. 10:1.

2.4 Magnification of an objective

2.4.1
magnification of an objective with finite primary image distance

lateral magnification at the primary image formed at the distance from the objective specified in the design of the objective

2.4.2
magnification of an objective with infinite primary image distance in combination with the normal tube lens

lateral magnification at the real image produced by the combination of the objective and the ‘normal’ tube lens (i.e. the tube lens with which the objective is designed to operate)

NOTE — See 4.1.

2.5
tube factor

factor by which the lateral magnification at the primary image is changed by an intermediate lens or lens system inserted between the objective and the primary image

NOTE — Intermediate lenses can be fixed, interchangeable or associated with accessories having their own tube factors (see 4.2).

2.6
magnification of an eyepiece

visual magnification at the virtual image formed from the primary image by the eyepiece

NOTE — See 4.3.

2.7
projection factor

factor by which the total magnification of a microscope is changed when forming a real image of the object onto a detecting device, such as the photographic emulsion in a camera

NOTE — The image can be formed in different ways (see 4.4).

2.8
total magnification of a microscope used for visual observation

visual magnification at the virtual image formed by the microscope

NOTE — See 4.5.

2.9
total magnification of a microscope used to produce a real image

lateral magnification at the real image

NOTE — See 4.5.

3 Symbols for magnification of imaging components

Table 1 gives the symbols that shall be used when referring to the magnification of imaging components and combinations thereof and gives examples of methods of expression.

4 Methods of calculation

4.1 Magnification of an objective

The value of the magnification of an objective corrected for an infinite primary image distance is given by the ratio of the focal length of the normal tube lens to that of the objective, i. e.

$$M_{O\infty} = f_{NTL}/f_{O\infty}$$

where

$M_{O\infty}$ is the magnification of the objective corrected for an infinite primary image distance;
f_{NTL} is the focal length of the normal tube lens, in millimetres;
$f_{O\infty}$ is the focal length of the objective, in millimetres.

4.2 Tube factor

4.2.1 When intermediate lenses are used, the total tube factor is the product of individual factors of the intermediate lenses.

4.2.2 In the case of objectives corrected for infinite primary image distance, the value of the tube factor of a tube lens used instead of the normal tube lens, with which the objective is designed to operate, is given by the ratio of its focal length to that of the normal tube lens, i. e.

$$q = f_{TL}/f_{NTL}$$

where

q is the total tube factor;
f_{TL} is the focal length of the tube lens, in millimetres;
f_{NTL} is the focal length of the normal tube lens, in millimetres.

4.3 Magnification of an eyepiece

The value of the magnification of an eyepiece is the ratio of the reference viewing distance to the focal length of the eyepiece, i. e.

$$M_E = 250/f_E$$

where

M_E is the visual magnification of the eyepiece;
f_E is the focal length of the eyepiece, in millimetres;
250 is the reference viewing distance, in millimetres.

4.4 Projection factor

The calculation of the projection factor depends on how the image is formed.

4.4.1 If the real image is formed using a normal eyepiece intended for visual observation together with an infinitely corrected camera or projection lens focused at infinity, the value of the projection factor is given by the ratio of the focal length of the camera/projection lens to the reference viewing distance, i. e.

$$p = f_{PROJ}/250$$

where

p is the projection factor;
f_{PROJ} is the focal length of the camera/projection lens, in millimetres;
250 is the reference viewing distance, in millimetres.

4.4.2 If the real image is formed using only a normal eyepiece intended for visual observation, the value of the projection factor is given by the ratio of the distance *a*, from the back focal point of the eyepiece to the projected image, to the reference viewing distance, i. e.

$$p = a/250$$

where

p is the projection factor;
a is the distance from the back focal point of the eyepiece to the projected image, in millimetres;
250 is the reference viewing distance, in millimetres.

4.4.3 If the real image is formed using a lens specially designed for projection as in photomicrography, this lens can be assigned a magnification for producing the image in a given plane. This value of the magnification of the photographic projection lens, M_{PHOT}, is used to calculate the total magnification of the microscope used to produce the real image and a projection factor p is not usually applicable since the normal eyepiece is not involved in forming the image.

4.5 Total magnification

4.5.1 The value of the visual magnification of a microscope is given by the product of the magnification of the objective, the total tube factor and the visual magnification of the eyepiece, i.e.

$$M_{TOT\ VIS} = M_O \cdot q \cdot M_E$$

where

$M_{TOT\ VIS}$ is the total (visual) magnification of the microscope;
M_O is the magnification of the objective;
q is the total tube factor;
M_E is the (visual) magnification of the eyepiece.

4.5.2 The value of the total magnification of a microscope used to produce a real image using a normal eyepiece intended for visual observation, or a photographic projection lens whose projection factor has been calculated, is given by the product of the magnification of the objective, the total tube factor, the magnification of the eyepiece and the projection factor, i. e.

$$M_{TOT\ PROJ} = M_O \cdot q \cdot M_E \cdot p$$

where

$M_{TOT\ PROJ}$ is the total (lateral) magnification of the microscope;
M_O is the magnification of the objective;
q is the total tube factor;
M_E is the (visual) magnification of the eyepiece;
p is the projection factor.

4.5.3 The value of the total magnification of a microscope used to produce a real image using a specially designed photographic lens is given by the product of the magnification of the objective, the total tube factor and the magnification of the photographic projection lens, i. e.

$$M_{TOT\ PROJ} = M_O \cdot q \cdot M_{PHOT}$$

where

$M_{TOT\ PROJ}$	is the total (lateral) magnification of the microscope;
M_O	is the magnification of the objective;
q	is the total tube factor;
M_{PHOT}	is the (lateral) magnification of the photographic projection lens.

5 Values and tolerances for magnification

5.1 Values for magnification

The values for the magnification of imaging components or systems shall be one of the values given in table 2. The products of quotients of any two values in the table are also to be considered as values within the table. The table may be extended by a factor of 10 per row.

Formulae for the calculation of values for specific components are given in clause 4.

5.2 Tolerances on values of magnification for specific components

Tolerances on the values of magnification shall be as given in table 3.

Table 1 — Symbols for magnification and methods of expression

System/component	Symbol	Methods of expression	
		Preferred	Alternative
Objective: a) corrected for finite primary image distance b) corrected for infinite primary image distance	M_O M_{O_∞}	M_O = 25 : 1 M_{O_∞} = 25 ×	25 : 1 or 25 25 ×
Eyepiece	M_E	M_E = 10 ×	10 ×
Tube factor	q	q = 1,25 ×	1,25
Projection factor for real image	p	p = 0,32 ×	0,32
Photographic projection lens	M_{PHOT}	M_{PHOT} = 2,5 ×	2,5 ×
Total magnification of microscope a) for visual observation b) for real image	$M_{TOT\ VIS}$ $M_{TOT\ PROJ}$	$M_{TOT\ VIS}$ = 500 × $M_{TOT\ PROJ}$ = 500 : 1	500 × 500 : 1

Table 2 — Values for magnification

				..0,32		0,4	0,5	0,63	0,8
1	1,25	1,6	2	2,5	3,2	4	5	6,3	8
10	12,5	16	20	25	32	40	50	63	80
100	125	160	200	250	320	400	500	630	800
1000	1250	1600	2000...						

NOTE 1 The values have been taken from the R10 series in ISO 3:1973, *Preferred numbers — Series of preferred numbers.*

NOTE 2 The value 0,32 has been rounded from its R10 series value.

NOTE 3 Besides the values in this table the following values are also in use:
1,5 - 15 - 30 - 60 - 150

Table 3 — Tolerances on magnification

System/component	**Tolerance,** %
Objective	± 5
Tube factor	± 2
Projection factor	± 2
Eyepiece	± 5