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**Microscopes — Interfacing  
dimensions for imaging components**

*Microscopes — Dimensions d'interfaçage pour composants d'imagerie*

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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](http://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](http://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](http://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 first edition of ISO 9345 cancels and replaces ISO 8038:2013, ISO 9345-1:2012, ISO 9345-2:2014, and ISO 10937:2000.

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](http://www.iso.org/members.html).

# Microscopes — Interfacing dimensions for imaging components

## 1 Scope

This document specifies optically and mechanically related dimensions for imaging components of a microscope such as

- a) the dimensions related to objective, eyepiece and tube lens,
- b) the dimensions of screw thread types for connecting a microscope objective to the nosepiece, and
- c) the diameters of interchangeable eyepieces and corresponding viewing tubes of microscopes.

## 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 10934-1, *Optics and optical instruments — Vocabulary for microscopy — Part 1: Light microscopy*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10934-1 and the following 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

#### parfocalizing distance of the objective

$l_1$

distance in air between the object plane (i.e. the uncovered surface of the object) and the locating flange of the objective, when the microscope is in its working position

Note 1 to entry: See [Figure 1](#), [Figure 2](#) and Footnote b in [Table 1](#).

[SOURCE: ISO 10934-1:2002, 2.80.2.4; modified — the symbol  $l_1$  added in the definition; Note from ISO 10934-1:2002 omitted, and Note 1 to entry added.]

### 3.2

#### objective to primary image distance

$l_2$

distance in air between the objective locating surface (of the nosepiece) and the primary image plane

Note 1 to entry: It commonly has a value either 150 mm or infinity. It is a hypothetical value applied to microscopes designed for infinity-corrected objectives.

Note 2 to entry: See [Figure 1](#), [2](#) and [Table 1](#).

[SOURCE: ISO 10934-1:2002, 2.80.2.1, modified — the symbol  $l_2$  added, Note 1 to entry modified, and Note 2 to entry added.]

**3.3**  
**focal length of the normal tube lens**

$f_{\text{NTL}}$   
focal length related to the magnification and the focal length of the objectives which are designed to operate with this tube lens

Note 1 to entry: See [Figure 2](#).

**3.4**  
**mechanical tube length**

$l_4$   
distance in air between the objective-locating surface of the nosepiece and the eyepiece-locating surface of the viewing tube

Note 1 to entry: It is the length of the tube in its simplest form without any intermediate lenses for objectives corrected for a finite primary image distance.

Note 2 to entry: It commonly has a value of 160 mm. See [Figure 1](#).

Note 3 to entry: For infinity-corrected objectives, the mechanical tube length is hypothetically considered to be infinite.

**3.5**  
**parfocalizing distance of the eyepiece**

$l_3$   
distance between the locating flange of the eyepiece and the plane upon which the eyepiece is focused

Note 1 to entry: The plane upon which the eyepiece is focused is coincident with the plane of the final real image of the microscope when the eyepiece is mounted in the viewing tube. The parfocalizing distance of the eyepiece is one of the optical interfacing dimensions, and is commonly 10 mm.

Note 2 to entry: This plane is coincident with the primary image plane of the microscope when the eyepiece is mounted in the viewing tube. See [Figure 1](#) and [Figure 2](#).

[SOURCE: ISO 10934-1:2002, 2.80.2.3, modified — the symbol  $l_3$  added, and Note 2 to entry added.]

**3.6**  
**image distance of the tube lens**

$l_{\text{NTL}}$   
distance between the primary image plane and the locating flange of the tube lens

Note 1 to entry: It depends on the optical and mechanical design concept and is an important dimension for OEM use.

**3.7**  
**distance between objective and tube lens**

$d_{\infty}$   
distance between the locating flange of the objective and the locating flange of the tube lens

Note 1 to entry: It depends on the optical and mechanical design concept. To ensure correct optical performance for OEM the indication of the minimum and maximum value is recommended.

## 4 Requirements

### 4.1 Nominal dimensions and tolerances of main imaging components

The nominal dimensions and tolerances of imaging components shall be as given in [Table 1](#) and as illustrated in [Figure 1](#) and [Figure 2](#).

A specific combination of eyepiece, objective, and tube lens is frequently used to correct aberrations. Therefore, there is a possibility that the combination of an objective from one manufacturer and the

tube lens or eyepiece from another manufacturer, although conforming to this document, causes errors in magnification and/or in optical performance.

**Table 1 — Nominal dimensions and tolerances of imaging components**

Feature	Used for imaging system	Symbol	Nominal value/ range mm	Numerical aperture	Tolerance mm
parfocalizing distance of the objective <sup>a b</sup>	both with 160 mm mechanical tube length and infinity-corrected	$l_1$	$45 + 15 k$ ( $k = -1, 0, 1, 2, 3, 4$ )	$\leq 0,1$	$\pm 0,2^c$
				$> 0,1$ to $\leq 0,25$	$\pm 0,06$
				$> 0,25$ to $\leq 0,45$	$\pm 0,03$
				$> 0,45$	$\pm 0,01$
objective to primary image distance	with 160 mm mechanical tube length	$l_2$	150		$\pm 0,5$
	with infinity-corrected optical systems (in combination with a tube lens to produce an image) <sup>d</sup>	$l_2$	$\infty$		
focal length of the normal tube lens <sup>e</sup>	with infinity-corrected	$f_{NTL}$	$150 \leq f_{NTL} \leq 250$		
parfocalizing distance of the eyepiece	both with 160 mm mechanical tube length and infinity-corrected	$l_3$	10		$\pm 0,2$
mechanical tube length	with 160 mm mechanical tube length	$l_4$	160		$\pm 0,5$

NOTE 1 Examples of values with infinity-corrected imaging components in use by the several microscope manufacturers are given in the informative [Annex A](#).

NOTE 2 In case of adaptation of infinity-corrected objectives and tube lenses to instruments and equipment other than the microscopes of the manufacturer, the user of these components needs additional dimensional information from the manufacturer for proper assembly, which are described in the informative [Annex C](#).

<sup>a</sup> The choice of a parfocalizing distance for an objective depends on the design concept of the microscope as a whole. The parfocalizing distance,  $l_1 = 45$  mm of objectives, has become the standard value for microscopes with tube length 160 mm and has been adopted for various existing infinity-corrected microscope systems.

<sup>b</sup> The parfocalizing distance,  $l_1$ , shown in [Figure 1](#), [Figure 2](#) and [Table 1](#), is intended to apply to objectives when used with uncovered objects (specimens). Objectives for use with objects covered by a cover glass shall have the following parfocalizing distance, to allow for the virtual displacement of the object by the cover glass (see also informative [Annex B](#) and [Figure B.1](#)):

$$l_1 + t(n - 1)/n \text{ mm}$$

where

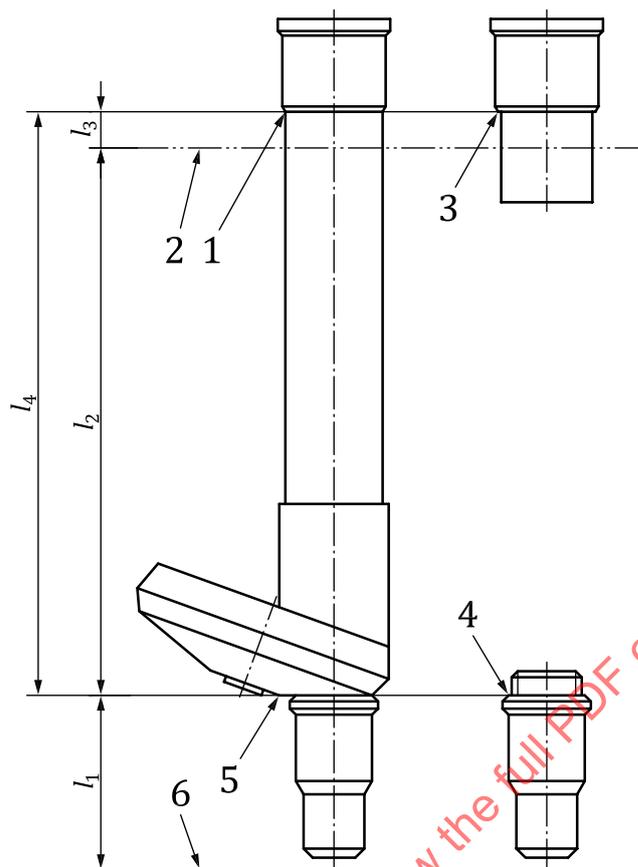
$t$  is the thickness of cover glass;

$n$  is the refractive index of the cover glass.

<sup>c</sup> The tolerance  $\pm 0,2$  mm for the parfocalizing distance of objectives with numerical aperture  $\leq 0,1$  does not necessarily apply to objectives with magnifications lower than  $4\times$ .

<sup>d</sup> In infinity-corrected optical systems, the primary image is always produced by the objective in combination with a tube lens. The distance between the locating flange of the objective and the tube lens depends on the design of the microscope. The microscope shall have such a design that, in combination with objectives and tube lenses in accordance with this document, the primary image is produced 10 mm below the eyepiece-locating surface of the viewing tube.

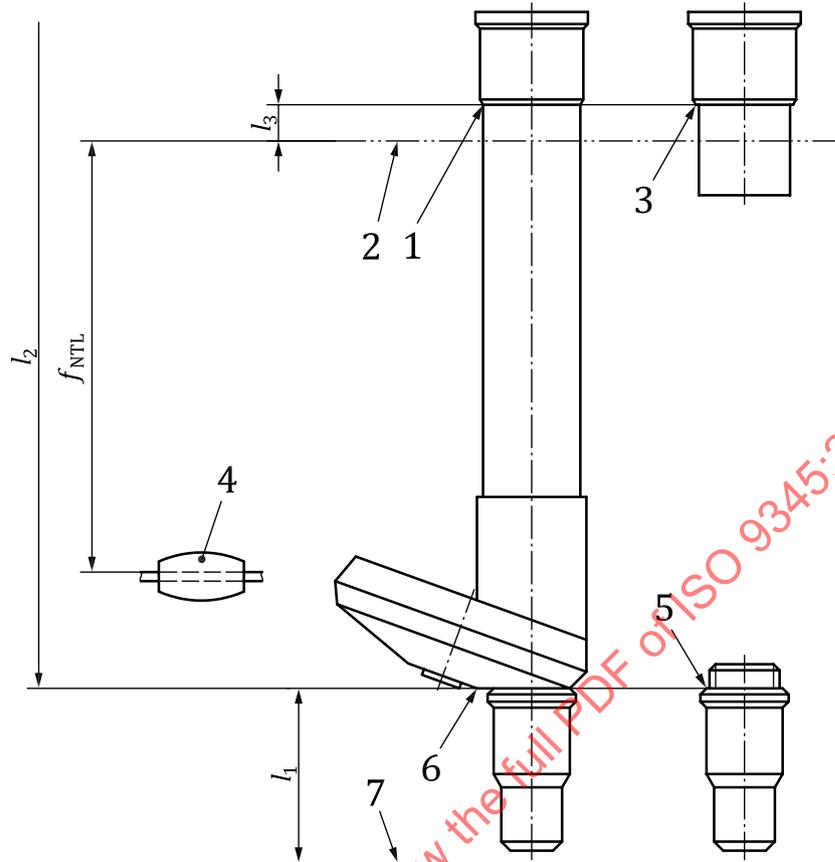
<sup>e</sup> The choice of focal length for a "normal" tube lens depends on the design concept of the microscope system. Its value shall be in the range of  $150 \text{ mm} \leq f_{NTL} \leq 250 \text{ mm}$ .



**Key**

- |   |   |
|---|---|
| 1 eyepiece-locating surface of the viewing tube | 4 locating flange of the objective            |
| 2 primary image plane                           | 5 objective-locating surface of the nosepiece |
| 3 locating flange of the eyepiece               | 6 object plane                                |

**Figure 1 — Locating surfaces, reference planes and imaging distances with 160 mm mechanical tube length**



#### Key

- |   |   |   |   |
|---|---|---|---|
| 1 | eyepiece-locating surface of the viewing tube | 5 | locating flange of the objective            |
| 2 | primary image plane                           | 6 | objective-locating surface of the nosepiece |
| 3 | locating flange of the eyepiece               | 7 | object plane                                |
| 4 | tube lens                                     |   |   |

**Figure 2 — Locating surfaces, reference planes, and imaging distances with infinity-corrected imaging components**

Many microscopes have built-in prisms and lenses to change the position and/or the magnification of the image. In this case, the microscope shall have a construction such that, in combination with objectives conforming to this document, the primary image is produced 10 mm below the eyepiece-locating surface of the viewing tube.

#### 4.2 Nominal dimensions and tolerances of connecting screw threads of objective and nosepiece

Recommended nominal dimensions and tolerances of connecting screw threads of objective and nosepiece are given in [Table 2](#) to [Table 7](#) and illustrated in [Figure 3](#) and [Figure 4](#).

Table 2 — Basic dimensions of the screw thread

Dimensions	Symbol	Value				
		Whitworth screw		Metric screw		
		RMS <sup>a</sup>	W26	M25	M27	M32
angle of thread	$\alpha$	55°	55°	60°	60°	60°
pitch	$P$	0,706 mm	0,706 mm	0,75 mm	0,75 mm	0,75 mm
height of fundamental triangle	$H$	0,678 mm	0,678 mm	0,65 mm	0,65 mm	0,65 mm
nominal diameter	$D$	20,320 mm	26 mm	25 mm	27 mm	32 mm

<sup>a</sup> With the exception of the length of the thread lug (see Figure 3), the values of the RMS thread conform to the internationally used screw thread defined by Reference [2].

Table 3 — Limit of size and tolerances of RMS

Dimensions in millimetres

Dimensions for		Major diameter		Pitch diameter		Minor diameter		Calculated play between internal and external threads		Allowances	Tolerance	Thread lug
internal thread	max.	$D$	20,396	$D_2$	19,944	$D_1$	19,492	minimum play	maximum play	+0,076	0,076	—
	min.		20,320		19,868		19,416			0,000		—
external thread	max.	$d$	20,274	$d_2$	19,822	$d_1$	19,370	0,046	0,198	-0,046	0,076	5,000
	min.		20,198		19,746		19,294			-0,122		—

Table 4 — Limit of size and tolerances of W26

Dimensions in millimeters

Dimensions for		Major diameter		Pitch diameter		Minor diameter		Calculated play between internal and external threads		Allowances	Tolerance	Thread lug
internal thread	max.	$D$	—	$D_2$	25,660	$D_1$	25,300	minimum play	maximum play	+0,204	0,100	—
	min.		26,000		25,580		25,200			+0,104		—
external thread	max.	$d$	25,930	$d_2$	25,520	$d_1$	25,070	0,060	0,220	-0,070	0,100	5,000
	min.		25,830		25,440		24,940			-0,170		—

Table 5 — Limit of size and tolerances of M25

Dimensions in millimeters

Dimensions for		Major diameter		Pitch diameter		Minor diameter		Calculated play between internal and external threads		Allowances	Tolerance	Thread lug
internal thread	max.	$D$	—	$D_2$	24,659	$D_1$	24,378	minimum play	maximum play	+0,190	0,190	—
	min.		—		24,513		24,188			0,000		—
external thread	max.	$d$	24,978	$d_2$	24,491	$d_1$	—	0,022	0,279	-0,022	0,140	5,000
	min.		24,838		24,380		—			-0,162		—

Table 6 — Limit of size and tolerances of M27

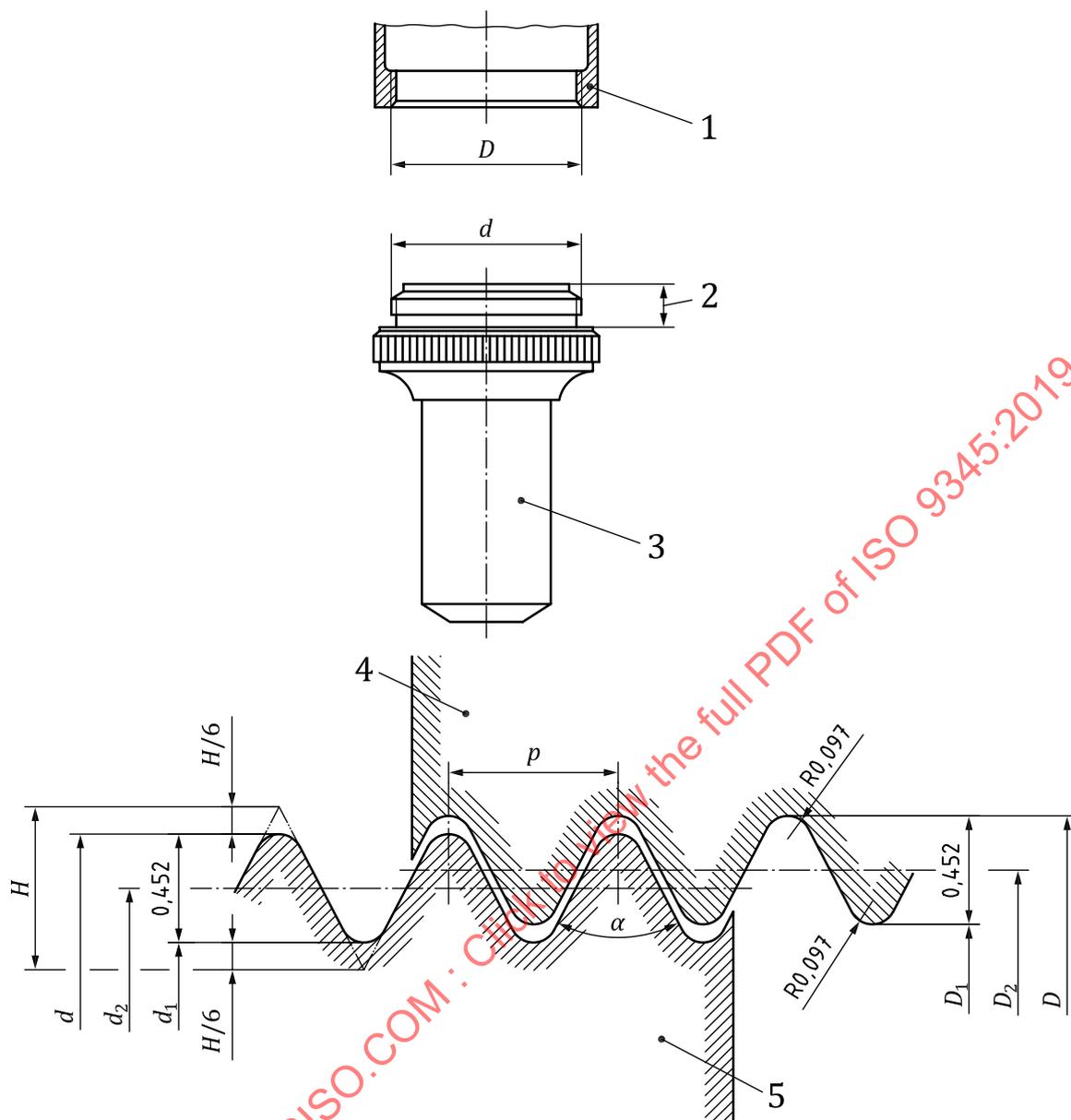
Dimensions in millimeters

Dimensions for		Major diameter		Pitch diameter		Minor diameter		Calculated play between internal and external threads		Allowances	Tolerance	Thread lug
internal thread	max.	$D$	—	$D_2$	26,660	$D_1$	26,378	minimum play	maximum play	+0,190	0,190	—
	min.		—		26,513		26,188			0,000		—
external thread	max.	$d$	26,978	$d_2$	26,491	$d_1$	—	0,022	0,281	-0,022	0,140	4,500
	min.		26,838		26,379		—			-0,162		—

Table 7 — Limit of size and tolerances of M32

Dimensions in millimeters

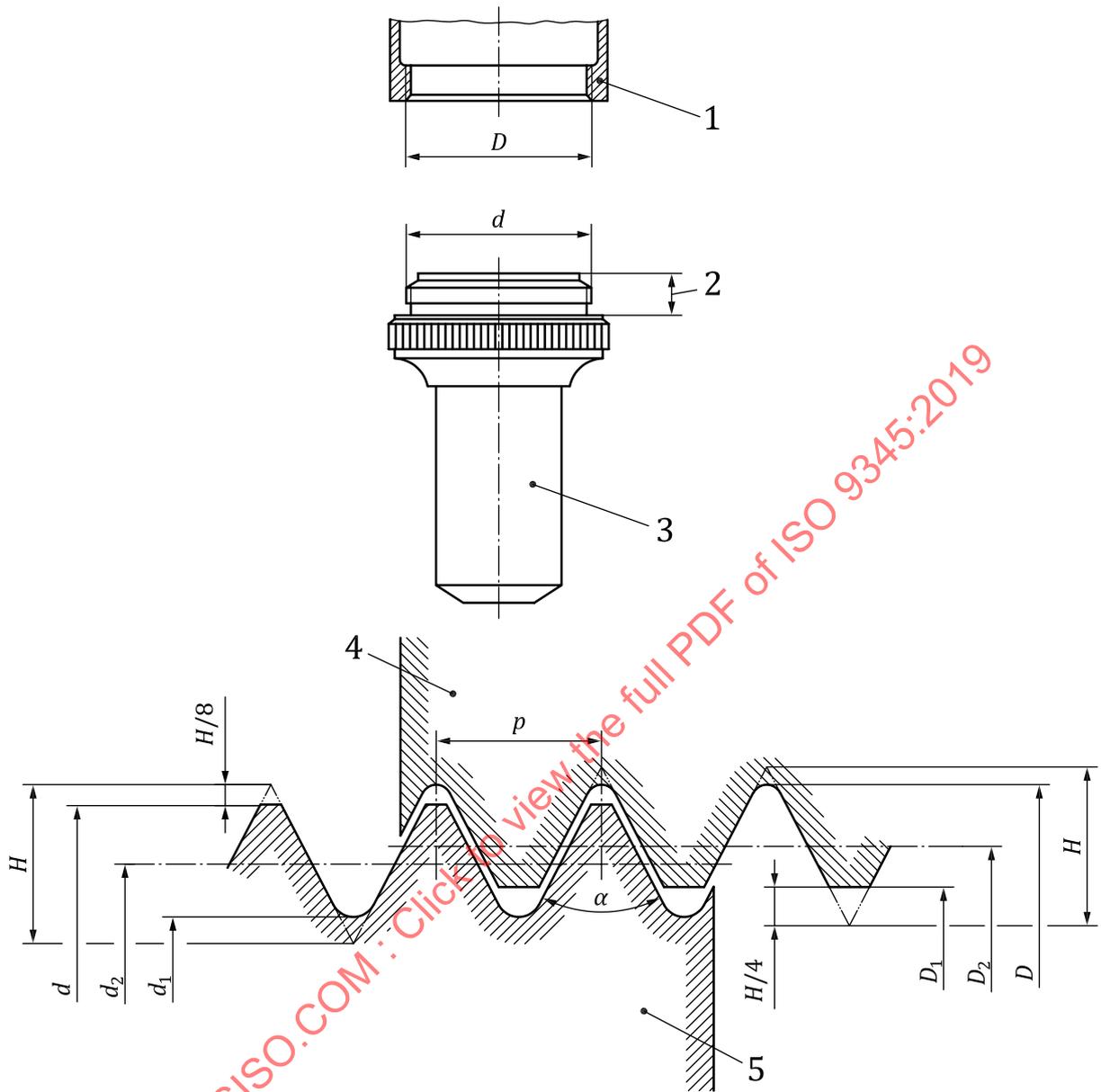
Dimensions for		Major diameter		Pitch diameter		Minor diameter		Calculated play between internal and external threads		Allowances	Tolerance	Thread lug
internal thread	max.	$D$	—	$D_2$	31,663	$D_1$	31,378	minimum play	maximum play	+0,190	0,190	—
	min.		—		31,513		31,188			0,000		—
external thread	max.	$d$	31,978	$d_2$	31,491	$d_1$	—	0,022	0,286	-0,022	0,140	5,000
	min.		31,838		31,377		—			-0,162		—



**Key**

- |   |                                 |   |                 |
|---|---------------------------------|---|-----------------|
| 1 | tube, objective nosepiece, etc. | 4 | internal thread |
| 2 | thread lug                      | 5 | external thread |
| 3 | objective                       |   |                 |

**Figure 3 — Definitions and basic dimensions of Whitworth screw threads, RMS and W26**



**Key**

- |   |                                 |   |                 |
|---|---------------------------------|---|-----------------|
| 1 | tube, objective nosepiece, etc. | 4 | internal thread |
| 2 | thread lug                      | 5 | external thread |
| 3 | objective                       |   |                 |

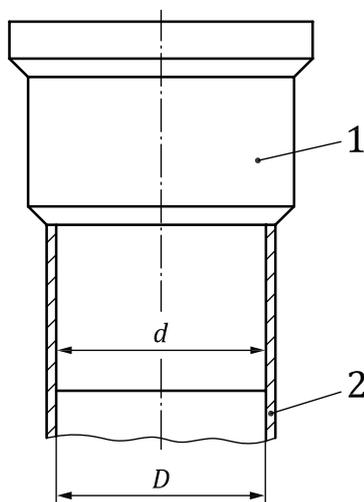
**Figure 4 — Definitions and basic dimensions of Metric screw threads, M25, M27 and M32**

**4.3 Nominal dimensions and tolerances on diameters of eyepieces and viewing tubes**

Nominal dimensions and tolerances on diameters of eyepieces and viewing tubes are given in [Table 8](#) and illustrated in [Figure 5](#).

Table 8 — Nominal dimensions and tolerances

Feature	Symbol	Nominal values mm	Tolerance
diameter of viewing tube	$D$	23,2 or 30,0	F8
diameter of eyepiece	$d$		h8

**Key**

- 1 eyepieces
- 2 viewing tube

Figure 5 — Diameters of eyepieces and viewing tubes

**5 Marking**

If the magnification of the primary image is changed by built-in optical systems, the tube factor shall be marked on the magnification changing component (stand, tube, etc.); e.g. 1,25×

## Annex A (informative)

### Examples of values with infinity-corrected imaging system in use

Depending on the optical and mechanical design concept, the several microscope manufacturers adopt different parfocalizing distances of the infinity-corrected objective and the focal length of the normal tube lens. [Table A.1](#) shows the nominal values  $l_1$ ,  $l_2$ ,  $l_3$ , and  $f_{\text{NTL}}$  with infinity-corrected imaging system used by the several microscope manufacturers (in alphabetical order) at the time of publication of this document (see [Figure 2](#)).

**Table A.1 — Examples of dimensions  $l_1$ ,  $l_2$ ,  $l_3$  and  $f_{\text{NTL}}$  in use**

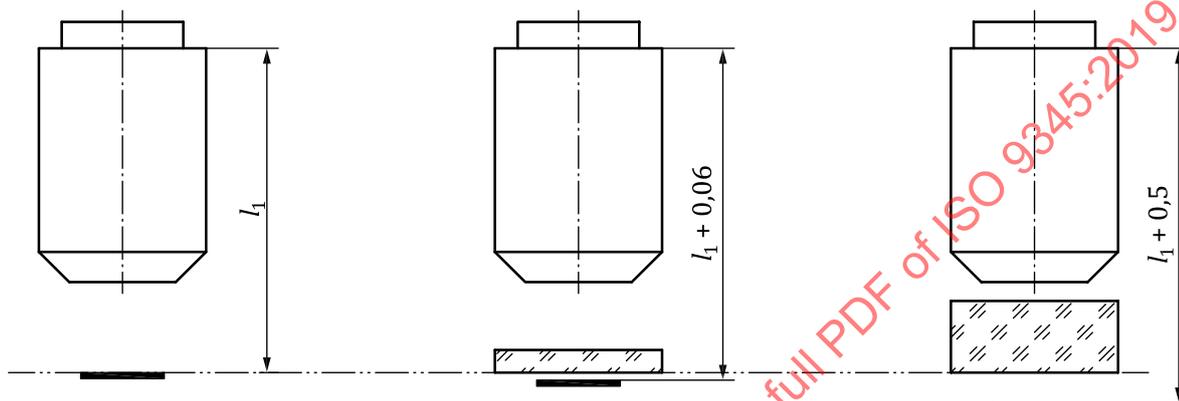
Dimensions in millimeters

Feature	Leica	Nikon	Olympus	Zeiss
parfocalizing distance of objective, $l_1$	45	45/60	45	45
objective to primary image distance, $l_2$	$\infty$	$\infty$	$\infty$	$\infty$
parfocalizing distance of eyepiece, $l_3$	10	10	10	10
focal length of normal tube lens, $f_{\text{NTL}}$	200	200	180	164,5

## Annex B (informative)

### Examples of parfocalizing distances as function of cover glass thickness

Figure B.1 illustrates the influence of different cover glass thicknesses on the parfocalizing distance.



Uncovered object $t = 0 \text{ mm}$	Object with cover glass $t = 0,17 \text{ mm thickness}$ $n = 1,5$	Object with culture chamber $t = 1,5 \text{ mm bottom thickness}$ $n = 1,5$
$l_{CG} = l_1^a$	$l_{CG} = l_1 + 0,06 \text{ mm}^a$	$l_{CG} = l_1 + 0,5 \text{ mm}^a$
<sup>a</sup> $l_{CG}$ is the resulting parfocalizing distance due to different cover glass thickness.		

**Figure B.1 — Examples of parfocalizing distances as function of cover glass thickness**