INTERNATIONAL STANDARD

ISO 11151-1

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Lasers and laser-related equipment — Standard optical components —

Part 1: Components for the UV, visible and near-infrared spectral ranges

Lasers et équipements associés aux lasers — Composants optiques standards —

Partie 1: Composants pour les plages spectrales UV, visible et proche de l'infrarouge

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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 part of ISO 11151 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 11151-1 was prepared by Technical Committee ISO/TC 172, *Optics and optical instruments*, Subcommittee SC 9, *Electro-optical systems*.

ISO 11151 consists of the following parts, under the general title *Lasers and laser-related equipment — Standard optical components*:

— *Part 1: Components for the UV, visible and near-infrared spectral ranges*

— *Part 2: Components for the infrared spectral range*

Annex A of this part of ISO 11151 is for information only.

Introduction

Lasers are used in a wide variety of applications, including medicine, materials processing, information technology and metrology. Most lasers contain optical windows and mirrors (intracavity) and most laser systems use a variety of windows, beamsplitters, deflectors, mirrors and lenses. Those components used in high power laser applications must withstand high peak power and/or energy densities to avoid laser-induced damage, thus their component specifications are more demanding than those used in low power applications.

Lasers and laser-related equipment — Standard optical components —

Part 1:
Components for the UV, visible and near-infrared spectral ranges

1 Scope

This part of ISO 11151 specifies requirements for laser components used in the near ultra-violet, visible and near infrared spectral ranges, from wavelengths 190 nm to 2 100 nm, and facilitates the supply of spare parts

— by specifying preferred dimensions and tolerances, thereby reducing the variety of types;

— by standardizing the specifications and removing barriers to trade;

— by establishing an agreed designation for item orders.

This part of ISO 11151 covers planar, plano-spherical and spherical substrates, lenses and optical components that are designed specifically as standardized optical components normally offered via catalogue from suppliers and intended for use with lasers.

This part of ISO 11151 includes component descriptions, materials employed, physical dimensions and manufacturing tolerances (including surface finish, figure and parallelism). Although most, but not all, of these components are coated (fully reflecting, partially reflecting or anti-reflecting) before incorporation into the laser system, this part of ISO 11151 does not include recommendations for the specification of coatings.

NOTE For optical components used in the infrared spectral range (> 2 100 nm), refer to ISO 11151-2. For the specification and testing of optical coatings, refer to the ISO 9211 series.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 11151. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 11151 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 9211-1:1994, *Optics and optical instruments — Optical coatings — Part 1: Definitions.*

ISO 9211-2:1994, *Optics and optical instruments — Optical coatings — Part 2: Optical properties.*

ISO 10110-1:1996, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 1: General.*

ISO 11151-2:2000, *Lasers and laser-related equipment — Standard optical components — Part 2: Components for the infrared spectral range*.

3 Code for components covered

Table 1 specifies codes for the components to which this part of ISO 11151 is applicable.

Table 1 — Component codes

Component form	Code
Optical flats	OF
Circular windows — flat	WC
Elliptical windows — flat	WE
Rectangular windows — flat	WR
Output couplers — flat	OC
Mirrors — flat	MF
Mirrors — convex	MX
Mirrors — concave	MV
Plano-convex lenses	PX
Plano-concave lenses	PV
Symmetric biconvex lenses	BX
Symmetric biconcave lenses	BV

4 Materials

This part of ISO 11151 is applicable to components employed in the near ultra-violet, visible and near infrared wavelength regions, 190 nm to 2 100 nm. A wide range of materials may be used, such as:

— borosilicate crown glass;

— fused silica;

— UV-grade fused silica;

— calcium fluoride.

In view of the wide variety of materials available, the use of specific code numbers for each material has not been formalized. Manufacturers and designers shall therefore specify the exact materials used/required. The material specification shall be given as stated in subclause 4.7 of ISO 10110-1:1996. If birefringent materials are used/specified, the orientation of the optical axis relative to the geometric axes of the components shall be stated.

5 Requirements for quality

Preferred specifications and classes for material and surface quality are set out in Tables 2 to 6, using terminology in accordance with parts 1 to 7 of ISO 10110. The standard of quality for components to be used with lasers is in general higher than for general optics. There is also a quality requirement for optics to be used inside a laser cavity (intracavity use) distinctly different from that for optics used outside the laser cavity, due to the extremely high power and energy densities developed inside the laser cavity and the possibility of laser-induced damage.

In consequence this part of ISO 11151 promulgates two classes of quality[1)]. Class A optics are designed for intra-cavity optics, output couplers and for components used in areas of extremely high power (energy) density. Class A optics have significantly tighter form tolerance (3/...) and surface imperfection tolerance (5/...) figures than do Class B optics. It should also be noted that the surface dig and pit critical dimensions for laser-induced damage are $\lambda/10$ to 10λ, where λ is the wavelength of operation of the laser.

The differences between the material/fabrication tolerances for flat circular windows, WC, flat output couplers, OC, and flat mirrors, MF, and those for optical flats, OF, are due to the far higher fabrication tolerances for the latter and the fact that there is only one fabrication tolerance irrespective of the component diameter. The parallelism fabrication tolerances are $(0 \pm 10)''$ (angular seconds) for optical flats, while they are $15\ ^{+5}_{-1}{}'$ (angular minutes) for the other components. This is because optical flats are designed to generate constructive interference within the component, while the others aim to minimize this effect.

Table 2 — Material and surface fabrication tolerances for lenses

Diameter	Material tolerances			Working tolerances				
mm	Stress birefringence 0/...	Bubbles and inclusions 1/...	Inhomo-geneity and striae 2/...	Class A surface form 3/...	Class B surface form 3/...	Centring 4/...	Class A surface imperfection 5/...	Class B surface imperfection 5/...
5 to 15	10	2 × 0,063	2;4	–(0,2/0,2)	–(0,4/0,4)	2′	1 × 0,016	1 × 0,063
> 15 to 30	10	3 × 0,063	2;4	–(0,3/0,3)	–(0,6/0,6)	2′	1 × 0,016	1 × 0,063
> 30 to 51	10	3 × 0,100	2;3	–(0,5/0,5)	–(1,0/1,0)	2′	2 × 0,016	2 × 0,063
> 51 to 102	10	5 × 0,100	2;3	–(0,6/0,6)	–(1,0/1,0)	2′	3 × 0,016	3 × 0,063

Table 3 — Material and surface fabrication tolerances for mirrors (except output couplers)

Diameter	Material tolerances			Working tolerances				
mm	Stress birefringence 0/...	Bubbles and inclusions 1/...	Inhomo-geneity and striae 2/...	Class A surface form 3/...	Class B surface form 3/...	Centring 4/...	Class A surface imperfection 5/...	Class B surface imperfection 5/...
5 to 15	10	NA	NA	–(0,2/0,2)	–(0,4/0,4)	2′	1 × 0,010	1 × 0,040
> 15 to 30	10	NA	NA	–(0,2/0,2)	–(0,6/0,6)	2′	2 × 0,010	2 × 0,040
> 30 to 51	10	NA	NA	–(0,3/0,3)	–(1,0/1,0)	2′	3 × 0,010	3 × 0,040
> 51 to 102	10	NA	NA	–(0,5/0,5)	–(1,0/1,0)	2′	5 × 0,010	5 × 0,040
NA: not applicable.								

1) The quoted grade values assume that most of the incident radiation is scattered out of the beam by the imperfection. This is the case where the radiometric obscuration equals the area obscuration. If the imperfection is partially transmitting, its actual area could be larger than is suggested by these values. A method for measuring surface imperfections is described in ISO 14997 (see Bibliography).

Table 4 — Material and surface fabrication tolerances for flat output couplers

Diameter mm	Material tolerances			Working tolerances		
	Stress birefringence 0/...	Bubbles and inclusions 1/...	Inhomogeneity and striae 2/...	Class A surface form 3/...	Class A surface imperfection 5/...	Parallelism
5 to 15	10	2 × 0,063	2;4	–0,2(0,2/0,2)	1 × 0,010	15′
> 15 to 30	10	2 × 0,063	2;4	–0,3(0,3/0,3)	2 × 0,010	15′
> 30 to 51	10	3 × 0,100	2;3	–0,5(0,5/0,5)	3 × 0,010	15′
> 51 to 102	10	5 × 0,100	2;3	–0,6(0,6/0,6)	5 × 0,010	15′

Table 5 — Material and surface fabrication tolerances for optical flats

Diameter mm	Material tolerances			Working tolerances		
	Stress birefringence 0/...	Bubbles and inclusions 1/...	Inhomogeneity and striae 2/...	Class A surface form 3/...	Class A surface imperfection 5/...	Parallelism
5 to 102	10	2 × 0,063	2;4	0,2(0,2/0,2)	1 × 0,010	± 10″

Table 6 — Material and surface fabrication tolerances for windows

Diameter mm	Material tolerances			Working tolerances				
	Stress birefringence 0/...	Bubbles and inclusions 1/...	Inhomogeneity and striae 2/...	Class A surface form 3/...	Class B surface form 3/...	Class A surface imperfection 5/...	Class B surface imperfection 5/...	Parallelism
5 to 15	10	2 × 0,063	2;4	–(0,2/0,2)	2(0,4/0,4)	1 × 0,010	1 × 0,040	15′
> 15 to 30	10	2 × 0,063	2;4	–(0,3/0,3)	3(0,6/0,6)	2 × 0,010	2 × 0,040	15′
> 30 to 51	10	3 × 0,100	2;3	–(0,5/0,5)	5(1,0/1,0)	3 × 0,010	3 × 0,040	15′
> 51 to 102	10	5 × 0,100	2;3	–(0,6/0,6)	6(1,0/1,0)	5 × 0,010	5 × 0,040	15′

6 Dimensional tolerances

6.1 Preferred dimensions

It is strongly recommended that all dimensions for components be specified in metric units. However it is recognized that, at least for the time being, there is also a market for components whose dimensions are specified in imperial units. Preferred dimensions for this latter class are given in annex A.

It should be noted that while the nomenclature (see clause 8) has been designed so that non-preferred dimensions can be included if strictly necessary, it is strongly recommended that both designers and manufacturers adopt the

preferred dimensions. The preferred (metric) dimensions and dimensional tolerances are listed in Tables 7, 8 and 9 using reference terminology as defined in Figure 1. Note that all components shall have protective bevels.

Table 7 — Preferred dimensions for circular or rectangular flat components [see Figure 1 a) to c)]

Dimensions in millimetres

Diameter or minor edge length	Major edge length	Tolerance of diameter or edge length	Thickness ± 0,2
4	6,5	–0,10	1 or 2
5	8	–0,10	1 or 2
6	10	–0,10	1 or 2
8	13	–0,10	2 or 4
10	16	–0,10	2 or 4
15	24	–0,15	2 or 4
20	32	–0,15	4 or 8
25	40	–0,15	4 or 8
30	48	–0,15	4 or 8
40	63	–0,15	4 or 8
50	80	–0,15	4 or 8
60	100	–0,20	4 or 8
75	120	–0,20	10 or 20
80	130	–0,20	10 or 20
100	160	–0,20	10 or 20

Table 8 — Standardized lens dimensions [see Figure 1 d)]

Dimensions in millimetres

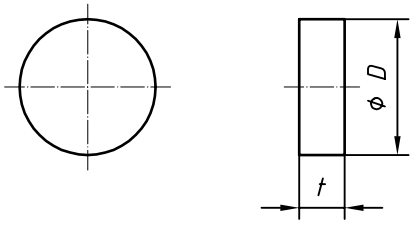
Diameter	Diameter tolerance	Edge thickness [a]	
		Convex ± 0,2	Concave ± 0,2
5	– 0,10	2	4
8	– 0,10	2	4
10	– 0,10	2	4
15	– 0,15	3	7
20	– 0,15	3	7
25	– 0,15	3	7
30	– 0,15	4	15
40	– 0,15	4	15
50	– 0,15	4	15
75	– 0,20	5	25
100	– 0,20	5	25

[a] For plano-convex and plano-concave lenses only (see 6.5).

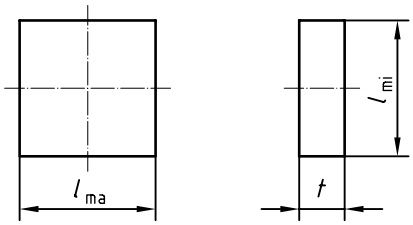
Table 9 — Standardized plano-concave mirror dimensions [see Figure 1 e)]

Dimensions in millimetres

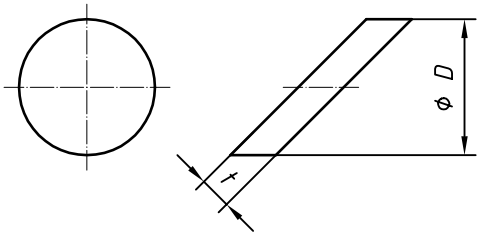
Diameter or minor edge length	Tolerance of diameter or edge length	Edge thickness ± 0,2
6	– 0,10	4
8	– 0,10	4
10	– 0,10	6,3
15	– 0,15	10
20	– 0,15	10
25	– 0,15	10
30	– 0,15	15
40	– 0,15	15
50	– 0,15	15
60	– 0,20	15
75	– 0,20	20
80	– 0,20	20
100	– 0,20	20



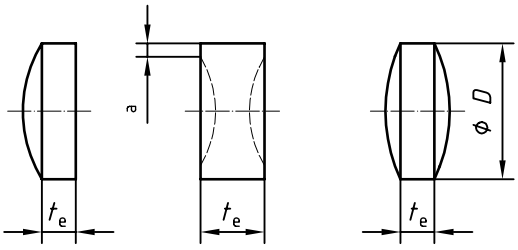
a) Form WC (i.e. circular window, flat)



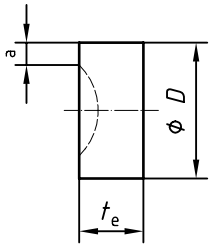
b) Form WR (i.e. rectangular window, flat)



c) Form WE (i.e. elliptical window, flat)



d) Forms PX, BV and BX



e) Form MV

Keys

D	Diameter
t	Thickness
l_{mi}	Minor edge length
l_{ma}	Major edge length
t_e	Edge thickness

[a] Annulus width may be specified.

Figure 1 — Schematic presentation of different component types

6.2 Diameter of circular optical components

These include circular optical flats, output couplers, windows, mirrors and lenses. The preferred diameters and associated tolerances are given in Table 7.

6.3 Mirror and output coupler curvature

Although most laser mirrors and output couplers are optically flat, it is also recognized that there may be a requirement for both plano-convex and plano-concave components. These should be specified using the radius of curvature (half the equivalent lens focal length). The radius of curvature is the 'second dimension' as specified in clause 8. There are no basic limits on the radius of curvature, except it cannot be smaller than the substrate radius. The standard tolerance for the radius of curvature is ± 2 %. All intracavity mirrors and windows shall be specified as class A (code C1) or suffer the possibility of premature laser-induced damage.

6.4 Rectangular and elliptical windows

The preferred dimensions and tolerances are given in Table 7 using the terminology specified in Figure 1. The minor dimension is specified together with the diameter of circular components, and the major dimension is specified as the second dimension. In the case of elliptical windows, this second dimension is the angle at which the component is to be used. The tolerances for the major edge length are the same as for the minor dimensions.

6.5 Focal length

This part of ISO 11151 does not specify preferred values for the focal length of lenses, however the manufacturer shall specify the focal length as an element of the designation. The focal length shall be specified, in millimetres, at the Hg e-line, wavelength 546,1 nm. The standard tolerance is ± 2 %. The preferred dimensions are listed in Table 8. The edge thickness is standardized for plano-convex and plano-concave lenses only. For other lenses the edge thickness may be specified differently.

The manufacturer shall additionally state the back focal length (distance from the secondary vertex to the rear focal point).

NOTE There are no basic limits on the focal length, except that the radii of curvature cannot be less than half the lens diameter. For simple plano-concave and plano-convex lenses, the equation relating the refractive index, n, and the radius of curvature, r, to the focal length, f, (in air) is, in the case of a thin lens:

$$r = (n - 1)\, f$$

For simple symmetric biconcave and biconvex lenses, the equation is:

$$r = 2(n - 1)\, f$$

For thick lenses, see relevant text books.

7 Testing area

The testing area of the surface quality, specified in Tables 2 to 6 is the central area of the optical component defined by 90 % of the component diameter (side length for rectangular and elliptical components).

8 Designation for ordering

The designation system is composed as follows:

ISO 11151-1 / (component code) (diameter) / (2nd dimension) / (edge thickness) / (quality code)

In addition to this designation, the component material shall be specified (see clause 4). Further specifications, such as coating(s) (see clause 9), laser-damage threshold and absorptance may be given.

EXAMPLE 1 The designation of a flat circular window for use within a laser cavity of 25 mm diameter and 10 mm thickness is ISO 11151-1/WC25//10/A. This designation is made up thus:

Designation	**Meaning**
WC**//**/*	Component code for a flat circular window
25///*	Specifies 25 mm diameter, 0,00/–0,15 mm tolerance
****//10/*	Specifies 10,0 mm thickness, ± 0,2 mm tolerance
****//**/A	Specifies class A quality for intracavity use

EXAMPLE 2 The designation of a symmetric biconvex lens with 50 mm diameter, 500 mm focal length, and 4 mm edge thickness is ISO 11151-1/BX50/500/4/B. This designation is made up thus:

BX**/***/*/*	Component code for symmetric biconvex lens
50/*/*/*	Specifies 50 mm diameter, 0,00/–0,15 mm tolerance
****/500/*/*	Specifies 500 mm focal length, ± 2 % tolerance
****/***/4/*	Specifies 4 mm edge thickness, ± 0,2 mm tolerance
****/***/*/B	Specifies class B quality for non-critical laser use

EXAMPLE 3 The designation of a 15 mm (minor dimension) flat elliptical window, with 24 mm major edge length, 2 mm thick, is ISO 11151-1/WE15/57°/2/A. This designation is made up thus:

WE**/**/*/*	Component code for a flat elliptical window
15//*/*	Specifies 15 mm minor dimension, 0,00/–0,15 mm tolerance
****/57°/*/*	Specifies use at 57° angle of incidence
****/**/2/*	Specifies 2 mm thickness, ± 0,2 mm tolerance
****/**/*/A	Specifies class A quality for critical component use

EXAMPLE 4 The designation of a flat rectangular window with dimensions of 10 mm × 16 mm × 2 mm is ISO 11151-/WR10/16/2/B:

WR**/**/*/*	Component code for a flat rectangular window
10//*/*	Specifies 10 mm minor dimension, 0,00/–0,10 mm tolerance
****/16/*/*	Specifies 16 mm major dimension, 0,00/–0,10 mm tolerance
****/**/2/*	Specifies 2 mm thickness, ± 0,2 mm tolerance
****/**/*/B	Specifies class B quality for extra-cavity use

EXAMPLE 5 The designation of a concave laser cavity mirror of 20 mm diameter, 10 mm edge thickness with a radius of curvature of 50 mm is ISO 11151-1/MV20/50/10/A. This designation is made up thus:

MV**/**/**/*	Component code for concave mirror
20//**/*	Specifies 20 mm diameter, 0,00/–0,15 mm tolerance
****/50/**/*	Specifies 50 mm radius of curvature, ± 2 % tolerance
****/**/10/*	Specifies 10 mm edge thickness, ± 0,2 mm tolerance
****/**/**/A	Specifies class A quality for intracavity use

It will be seen that some parts of the designation are redundant, e.g. in the case of the code for the 50 mm diameter symmetric biconvex lens, the preferred edge thickness is 4 mm (see Table 8), so this does not have to be strictly incorporated in the code.

9 Coating

The designation put forward in clause 8 does not specifically mention the coating of the lens, window or mirror. This coating, unless an uncoated substrate is desired, shall be specified in detail. Minimum specifications include coating type (anti-reflectance, partial reflectance, total reflectance), wavelength, reflectance, angle of incidence and absorption characteristics. These aspects shall covered in accordance with ISO 9211-1 and ISO 9211-2.

10 Packaging

All optical components shall be carefully packaged in accordance with legal regulations and in addition be labelled with the following information:

a) component designation;

b) material;

c) coating details (if applicable);

d) handling and storage instructions;

e) potential hazards (e.g. toxicity/carcinogenicity).

If coatings or components are either toxic, hazardous or hygroscopic, this shall be clearly indicated on the label.

Annex A
(informative)

Imperial units

It is strongly recommended that all designers and manufacturers use metric units. This is particularly important in avoiding duplication of manufacturing facilities and to minimize component fabrication costs. However, it is realized that certain countries/firms have designs, jigs and components in accordance with dimensions in imperial units. The preferred imperial dimensions and tolerances for components covered by this part of ISO 11151 are set out in Table A.1.

Table A.1 — Preferred dimensions and diameter tolerances

Imperial dimension	**Metric equivalent**	**Diameter tolerances**
inches	mm	mm
1/4	6,35	– 0,10
3/10	7,75	– 0,10
3/8	9,53	– 0,10
1/2	12,7	– 0,10
3/4	19,0	– 0,15
1	25,4	– 0,15
1 1/2	38,0	– 0,15
2	50,8	– 0,15
3	76,2	– 0,20
4	101,6	– 0,20

EXAMPLE of a designation using imperial units: The designation of a flat circular window for use within a laser cavity of 1 inch diameter and 0,25 inch thickness is:

ISO 11151-1/WC25,4//6,3/A

Bibliography

[1] ISO 10110-2:1996, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 2: Material imperfections — Stress birefringence*.

[2] ISO 10110-3:1996, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 3: Material imperfections — Bubbles and inclusions.*

[3] ISO 10110-4:1997, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 4: Material imperfections — Inhomogeneity and striae.*

[4] ISO 10110-5:1996, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 5: Surface form tolerances.*

[5] ISO 10110-6:1996, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 6: Centring tolerances.*

[6] ISO 10110-7:1996, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 7: Surface imperfection tolerances.*

[7] ISO 14997:—[2)], *Optics and optical instruments — Test methods for surface imperfections of optical elements.*

2) To be published.

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