INTERNATIONAL STANDARD

ISO 11151-2

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Lasers and laser-related equipment — Standard optical components —

Part 2: Components for the infrared spectral range

Lasers et équipements associés aux lasers — Composants optiques standards —

Partie 2: Composants pour la plage spectrale infrarouge

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ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

Foreword

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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 on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 172, *Optics and photonics*, Subcommittee SC 9, *Electro-optical systems*.

This second edition cancels and replaces the first edition (ISO 11151-2:2000), which has been technically revised with the following changes:

— Clause 1, note was revised;

— new normative references in Clause 2 were added;

— Clause 4 was revised;

— footnotes were added in Tables 5 and 6;

— Bibliography was revised;

— Figure 1 was revised.

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, beam splitters, 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 2: Components for the infrared spectral range

1 Scope

This part of ISO 11151 specifies requirements for laser components used from near-infrared to mid-infrared, from wavelengths 2,1 µm to 15,0 µm, 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, and

— 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 through a 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 will be 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 The optical components used in the ultraviolet, visible, and near infrared spectral ranges (170 nm to 2 100 nm) is referred to ISO 11151-1. The specification and testing of optical coatings is referred to ISO 9211 (all parts).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9211-1, *Optics and photonics — Optical coatings — Part 1: Definitions*

ISO 9211-2, *Optics and photonics — Optical coatings — Part 2: Optical properties*

ISO 10110-1:2006, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 1: General*

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

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

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

ISO 10110-5[1)], *Optics and photonics — Preparation of drawings for optical elements and systems — Part 5: Surface form tolerances*

ISO 10110-6[1)], *Optics and photonics — Preparation of drawings for optical elements and systems — Part 6: Centring tolerances*

ISO 10110-7, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 7: Surface imperfection tolerances*

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	IOF
Circular windows — flat	IWC
Elliptical windows — flat	IWE
Rectangular windows — flat	IWR
Output couplers — flat	IOC
Mirrors — flat	IMF
Mirrors — convex	IMX
Mirrors — concave	IMV
Plano-convex lenses	IPX
Plano-concave lenses	IPV
Symmetric biconvex lenses	IBX
Symmetric biconcave lenses	IBV

4 Materials

This part of ISO 11151 covers components employed in the infrared wavelength region from 2,1 µm to 15 µm. A wide range of materials may be used, such as

— zinc selenide, ZnSe,

— potassium chloride, KCl,

— germanium, Ge,

— calcium fluoride, CaF_2,

— silicon, Si,

— copper, Cu, and

— Sapphire, Al_2O_3.

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 ISO 10110-1:2006, 4.7. If birefringent materials are used/specified, the orientation of the optical axis relative to the geometric axes of the components shall be stated.

1) Currently under revision.

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 ISO 10110-1 to ISO 10110-7. The same quality standards apply to all components of a given diameter, except that the material tolerances are inapplicable in the case of total reflector substrates.

The requirement of quality for components to be used with infrared lasers is in general high; therefore this part of ISO 11151 only promulgates one class of quality.

NOTE 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 the surface imperfections is described in ISO 14997.

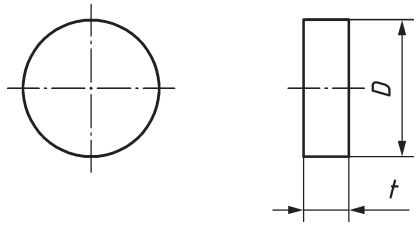
For this reason, there is no difference between a flat circular window, IWC, specification and an output coupler, IOC, specification in this waveband. It should be noted that the surface dig and pit critical dimensions for laser-induced damage are $\lambda/10$ to 10λ, where λ is the wavelength of operation of the laser.

Table 2 — Material and surface fabrication tolerances for lenses, windows and beamsplitters

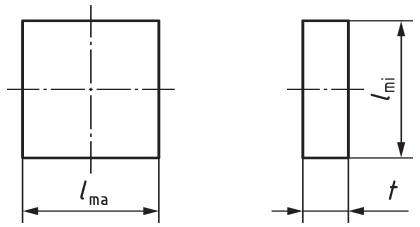
Diameter mm	**Stress birefringence** 0/...	**Bubbles and inclusions** 1/...	**Inhomogeneity and striae** 2/...	**Surface form** 3/...	**Centring** 4/...	**Surface imperfection** 5/...
5 to 15	15	3 × 0,063	0;2	–(0,4/0,4)	3'	2 × 0,025
>15 to 30	15	4 × 0,063	0;2	–(0,6/0,6)	3'	3 × 0,040
>30 to 51	15	4 × 0,100	0;2	–(1,0/1,0)	3'	4 × 0,063
>51 to 102	15	5 × 0,100	0;2	–(1,0/1,0)	3'	5 × 0,100

Table 3 — Material and surface fabrication tolerances for total reflector substrates

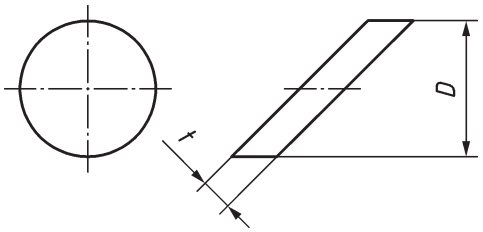
Diameter mm	**Stress birefringence** 0/...	**Bubbles and inclusions** 1/...	**Inhomogeneity and striae** 2/...	**Surface form** 3/...	**Centring** 4/...	**Surface imperfection** 5/...
5 to 15	NA	NA	NA	–(0,4/0,4)	5'	2 × 0,025
>15 to 30	NA	NA	NA	–(0,6/0,6)	5'	3 × 0,040
>30 to 51	NA	NA	NA	–(1,0/1,0)	5'	4 × 0,063
>51 to 102	NA	NA	NA	–(1,0/1,0)	5'	5 × 0,100
NOTE NA: not applicable.						



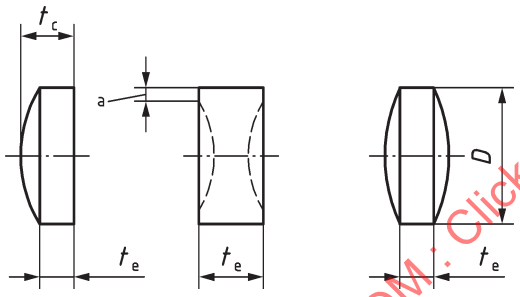
a) Form IWC (i.e. circular window, flat)



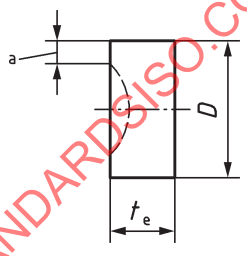
b) Form IWR (i.e. rectangular window, flat)



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



d) Forms IPX, IBV, and IBX



e) Form IMV

Key

D	diameter
l_{ma}	major edge length
l_{mi}	minor edge length
t	thickness
t_c	center thickness
t_e	edge thickness
a	Annulus width may be specified.

Figure 1 — Schematic presentation of different component types

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 preferred dimensions. The preferred (metric) dimensions and dimensional tolerances are listed in Table 4 using reference terminology as defined in Figure 1.

6.2 Diameter of circular optical components

These include circular windows, mirrors and lenses. The preferred diameters are given in Table 4.

6.3 Mirror and output coupler curvature

Although many laser mirrors and windows are optically flat, it is also recognized that there can 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 %

6.4 Rectangular and elliptical windows

The preferred dimensions and tolerances are listed in Table 4 using 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 all linear dimensions are 0,00/ -0,20 mm.

Table 4 — Standardized dimensions for the diameter of circular components and edge length of rectangular components

Dimensions in millimetres

Diameter or minor edge length	Major edge length	Edge thickness	Tolerance of diameter or edge length
12,5	20	a	–0,20
25	40	a	–0,20
30	48	a	–0,20
40	63	a	–0,20
50	80	a	–0,20
75	120	a	–0,20
100	160	a	–0,20

a Shall be specified separately depending on the material (see 6.6).

6.5 Focal length

The manufacturer shall specify the effective focal length as an element of the designation. The effective focal length shall be specified, in millimetres, at 10,6 µm. The standard tolerance is ±2 %.

Preferred values for the effective focal lengths of lenses are given in Table 5, and for the radii of curvature of total reflector substrates in Table 6. The edge thickness is standardized for plano-convex and plano-concave lenses only. For other lenses the edge thickness can be specified differently.

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

NOTE 1 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 formula 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 formula is

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

For thick lenses, see relevant text books.

NOTE 2 Effective focal length in the direction of beam propagation (application direction) is calculated for homogeneous irradiation of 90 % of the diameter of the aperture.

Table 5 — Preferred effective focal lengths for lenses

Effective focal length[a] mm								
25	50	75	100	125	150	200	250	500
[a] Focal length of curvature values are example values.								

Table 6 — Preferred radii of curvature of total reflector substrates

Radius of curvature[a] mm										
250	500	750	1 000	2 000	2 500	5 000	10 000	15 000	20 000	30 000
[a] Radii of curvature values are example values.										

6.6 Thickness

This part of ISO 11151 does not specify the thickness of lenses and mirrors used in the infrared because of the range of thermomechanical properties of the substrate materials. However, the manufacturer shall specify the edge thickness as an element of the designation (see Clause 8). The edge thickness is measured in millimetres. The standard tolerance for lens and mirror edge thickness is ±0,3 mm.

7 Testing area

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

8 Designation for ordering

The designation system is composed as follows:

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

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 11151-2/IWC25//10

This designation is made up in the following fashion:

Designation	**Meaning**
IWC**//**	Component code for an IR-transmitting flat circular window
***25//**	Specifies 25 mm diameter, 0,00/–0,20 mm tolerance
*****//10	Specifies 10,0 mm thickness, ±0,3 mm tolerance

EXAMPLE 2 The designation of a symmetric bi-convex lens with 50 mm diameter, 500 mm effective focal length, and 4 mm edge thickness is

ISO 11151-2/IBX50/500/4

This designation is made up thus:

Designation	**Meaning**
IBX**/***/*	Component code for symmetric biconvex lens for use in the IR
50//*	Specifies 50 mm diameter, 0,00/–0,20 mm tolerance
*****/500/*	Specifies 500 mm effective focal length, ±2 % tolerance
*****/***/4	Specifies 4 mm edge thickness, ±0,3 mm tolerance

EXAMPLE 3 The designation of a 15 mm (minor diameter) flat elliptical window, with 24 mm major edge length, 2 mm thick, is

ISO 11151-2/IWE15/57°/2

This designation is made up thus:

Designation	**Meaning**
IWE**/**/*	Component code for an IR-transmitting flat elliptical window
***15/**/*	Specifies 15 mm minor dimension, 0,00/–0,20 mm tolerance
*****/57°/*	Specifies use at 57 ° angle of incidence
*****/**/2	Specifies 2 mm thickness, ±0,3 mm tolerance

EXAMPLE 4 The designation of a flat rectangular window with dimensions of 10 mm × 16 mm × 2 mm is

ISO 11151-2/IWR10/16/2

This designation is made up thus:

Designation	**Meaning**
IWR**/**/*	Component code for an IR-transmitting flat rectangular window
***10/**/*	Specifies 10 mm minor dimension, 0,00/–0,20 mm tolerance
*****/16/*	Specifies 16 mm major dimension, 0,00/–0,20 mm tolerance

Designation	Meaning
*****/**/2	Specifies 2 mm thickness, ±0,3 mm tolerance

EXAMPLE 5 The designation of a concave laser cavity mirror of 25 mm diameter, 10 mm thickness with a radius of curvature of 50 mm is

ISO 11151-2/IMV25/50/10

This designation is made up thus:

Designation	Meaning
IMV**/**/**	Component code for concave laser cavity mirror
***25/**/**	Specifies 25 mm diameter, 0,00/−0,20 mm tolerance
*****/50/**	Specifies 50 mm radius of curvature, ±2 % tolerance
*****/**/10	Specifies 10 mm edge thickness, ±0,3 mm tolerance

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 be covered in accordance with ISO 9211-1 and ISO 9211-2.

10 Packaging

Some infrared optical materials are hazardous, toxic, and/or hygroscopic. In consequence, all optical components shall be carefully packaged in accordance with legal regulations and additionally be labelled with the following information:

a) component designation;

b) material;

c) coating details (if applied);

d) handling and storage instructions;

e) potential hazards (e.g. toxic/carcinogenic).

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

