INTERNATIONAL STANDARD

ISO 11551

First edition
1997-07-15

Optics and optical instruments — Lasers and laser-related equipment — Test method for absorptance of optical laser components

Optique et instruments d'optique — Lasers et équipements associés aux lasers — Méthode d'essai du facteur d'absorption des composants optiques pour lasers

Reference number
ISO 11551:1997(E)

Contents

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Internet central@iso.ch
X.400 c=ch; a=400net; p=iso; o=isocs; s=central

Printed in Switzerland

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.

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.

International Standard ISO 11551 was prepared by Technical Committee ISO/TC 172, *Optics and optical instruments*, Subcommittee SC 9, *Electro-optical systems*.

Annex A forms an integral part of this International Standard.

Introduction

To characterize an optical component, it is important to know its absorptance. When radiation impinges upon a component, a part of that radiation is absorbed, increasing the temperature of the component. If enough energy is absorbed, the optical properties of the component may be changed, and the component may even be destroyed. Absorptance is the ratio of the radiant flux absorbed to the radiant flux of the incident radiation.

In the procedures described in this International Standard, the absorptance is determined calorimetrically as the ratio of power or energy absorbed by the component to the total power or energy, respectively, impinging upon the component. The assumption is made that the absorptance of the test sample is constant within the temperature fluctuations experienced by the component during the measurement, is constant within the volume of the component and is independent of the power density of the impinging radiation. (However, several infrared materials exhibit a strong dependence of absorptance on temperature, especially at high temperatures.)

Optics and optical instruments — Lasers and laser-related equipment — Test method for absorptance of optical laser components

1 Scope

This International Standard specifies procedures and techniques for obtaining comparable values for the absorptance of optical laser components.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 31-6:1992, *Quantities and units — Part 6: Light and related electromagnetic radiations.*

ISO 11145:1994, *Optics and optical instruments — Lasers and laser-related equipment — Vocabulary and symbols.*

ISO 14644-1:—[1]), *Cleanrooms and associated controlled environments — Part 1: Classification of airborne particulate cleanliness for cleanrooms and clean zones.*

3 Definitions

For the purposes of this International Standard, the terms defined in ISO 11145 and ISO 31-6 apply.

1) To be published.

4 Symbols and units of measure

Symbol	Term	Unit
α	absorptance	
c_{pi}	thermal capacity of test sample, holder, etc.	J/(kg·K)
β	angle of incidence	rad
λ	wavelength	m
m_i	mass of test sample, holder, etc.	kg
P	cw power	W
P_{av}	average laser power for continuous pulse mode operation	W
t_B	duration of irradiation	s
Δt	time interval	s
ΔT	temperature difference	K
d_x, d_y	beam widths on test sample	m
dT/dt	slope of temperature graph	K/s

5 Preparation of test sample and measuring arrangement

Storage, cleaning and the preparation of the test samples are carried out in accordance with the manufacturer's instructions for normal use.

The environment of the testing place consists of dust-free filtered air with less than 60 % relative humidity. The residual dust is reduced in accordance with cleanroom class 7 as defined in ISO 14644-1. In this connection, an environment free from draught is very important to keep the heat loss by convection as small as possible.

Concerning particular components with low absorption or special cases of application, it is possible to measure the absorption in a vacuum (pressure lower than 100 Pa). This is especially recommended when the tested sample has low thermal conductivity and its thickness is much smaller (more than an order of magnitude) than its width/diameter.

NOTE — Both the ambient atmosphere and the vacuum pressure can affect the measured absorption. For instance Ge, ZnS and ZnSe all absorb water. Some of this can be drawn off simply by lowering the vacuum pressure. Surface cleaning and treatment can also alter the absorption markedly (e.g. isopropyl alcohol removes both the water and, for a time, the water-absorbing layer from many surfaces).

A laser shall be used as the radiation source. To keep errors as low as possible, the laser power chosen for measurements is as high as possible without causing any deterioration to the component. An analysis for the minimum laser power for the preferred pulse method is given in annex A.

Wavelength, angle of incidence and state of polarization of the laser radiation used for the measurement shall correspond to the values specified by the manufacturer for the use of the test sample. If ranges are accepted for these three quantities, any combination of wavelength, angle of incidence and state of polarization may be chosen out of those ranges.

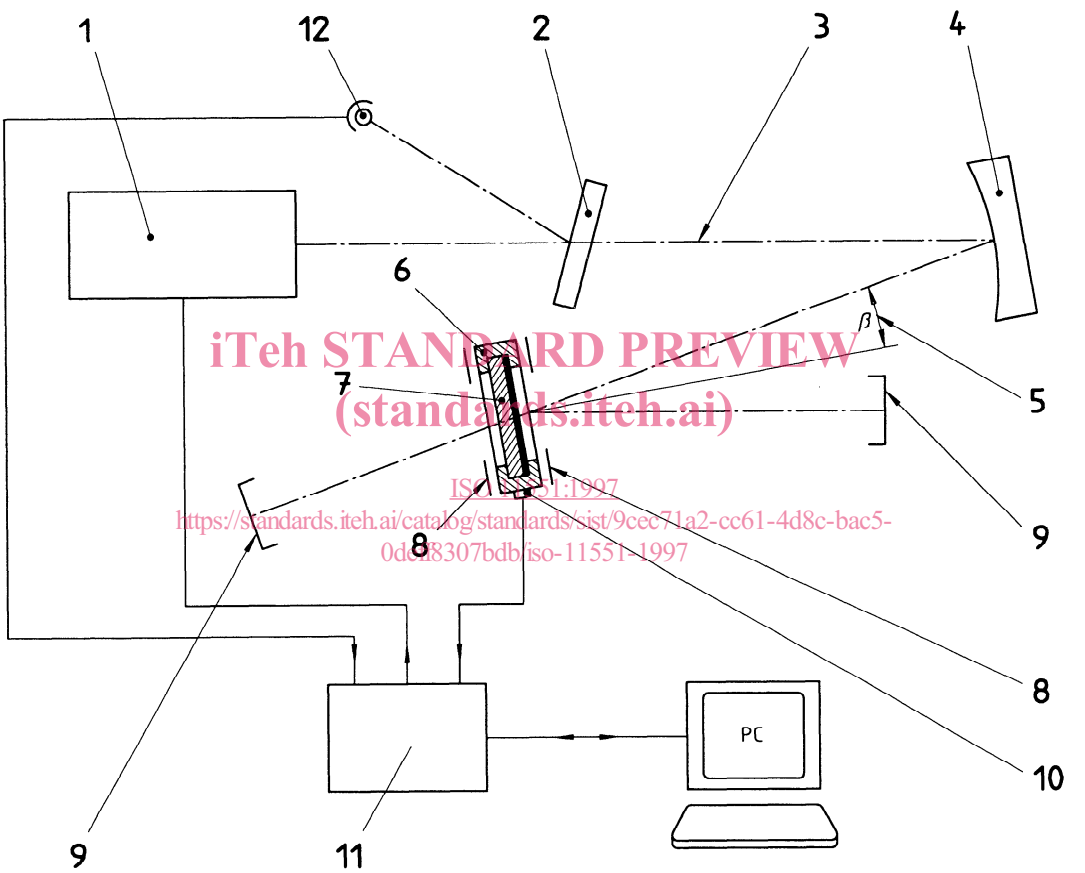
The test sample is mounted in a holder carrying a calibrated thermal sensor, for instance a platinum resistor Pt 100. A good thermal contact between the test sample and the thermal sensor is required.

Generally, for measuring in air, the thermal conduction of the air between the component and the support is sufficient if the component is clamped tightly into a holder. Concerning measuring in vacuo, it is possible to get contact by using, for instance, a non-creeping thermal conductive paste. The support itself shall be insulated thermally from the surrounding.

Special attention shall be given to ensure that the temperature measurement itself does not cause a change in the sample temperature.

Suitable diaphragms should be placed in the beam path in front of and behind the test sample to ensure that only the test sample is irradiated by the measuring beam and that reflected or stray radiation will not strike the holder.

Figure 1 shows a schematic measuring arrangement. The curved folding mirror M1 is recommended for imaging the laser output window onto the sample in order to avoid diffracted radiation and etalon effects.



Key

1 Laser
2 Beam splitter
3 Optical axis
4 Mirror M1
5 Angle of incidence
6 Sample holder
7 Test sample
8 Diaphragm
9 Beam stop
10 Thermal sensor
11 Control unit
12 Power detector

Figure 1 — Arrangement for measurement of the absorptance

6 Characteristic features of the laser radiation

The following physical quantities are needed for characterizing the laser radiation used for the test:

- wavelength λ;
- angle of incidence β;
- state and degree of polarization;
- beam widths on the test sample d_x, d_y;
- laser power P for cw lasers or P_{av} for continuously pulsed laser;
- duration of irradiation t_B.

7 Test procedure

The absorptance of optical components is determined calorimetrically by means of a measuring arrangement as shown in figure 1. Determine the duration of irradiation (30 s to 180 s for pulse method) depending on the laser power and the procedure of evaluation (see annex A).

Two test methods are given below. The *pulse method* (see 8.2) shall be used when sufficient laser power is available to rapidly heat the sample to test temperature. The *gradient method* (see 8.3) shall be used only when higher power lasers are unavailable.

Prior to the examination of the component to be tested, carry out a measurement with an empty holder and verify that the measuring arrangement is not influenced by reflected or stray radiation. Repeat this test regularly, and whenever the measuring arrangement is altered.

Record the temperature of the thermal sensor versus time. Indicate the beginning and the end of the irradiation period and continue the recording until the test is completed as follows:

- pulse method: 200 s after irradiation ceases;

or

- gradient method: time sufficient to do the evaluation according to 8.3.

8 Evaluation

8.1 General

The masses m_i of the components heated during the irradiation (test sample, holder, etc.) are determined by weighing. Thermal capacities are taken from tables. The laser power is determined by calibrating the power detector with a calibrated power meter at the sample location. This should be done regularly.

8.2 Pulse method

With this method the energy input to the sample is Pt_B or $P_{av}t_B$. Adjustments must be made to account for the inevitable losses of convection and thermal conduction in ΔT. To calculate the absorptance α, use the following procedure.

a) Determine the irradiation time t_B.

b) Determine ΔT by using the decay time of the recording. Extrapolate backwards to the temperature at time $t_B/2$ as shown in figure 2.

c) Compute the absorptance using the formula

$$\alpha = \frac{\sum_i m_i c_{pi} \Delta T}{P t_B} \quad \ldots (1a)$$

or

$$\alpha = \frac{\sum_i m_i c_{pi} \Delta T}{P_{av} t_B} \quad \ldots (1b)$$

NOTES

1 The temperature increase of the test sample should be ⩽ 10K. Adapt the duration of irradiation to achieve this result.

2 During the calibration or setting up procedure, it is useful to make measurements at various pulse durations and to compare the resultant absorptance values. This allows both the accuracy and the linearity of the measurement to be ascertained. In general the most accurate results are obtained at pulse durations between 5 s and 150 s. In practice the pulse duration should be set in a region where the absorptance values measured are not affected by the pulse duration.

8.3 Gradient method

This method should only be used if the laser available does not have sufficient power to rapidly elevate the temperature of the sample.

a) Determine the slope $(dT/dt)_h$ of the time-temperature function of the sample at a time t_1 near to, but less than the total irradiation time, t_B. (Approximately 80 % of t_B is recommended.) Note the temperature T_{12} at that point at time t_1 (see figure 3).

b) Determine the slope $(dT/dt)_c$ of the cool-down portion of the time-temperature function of the sample at the point the temperature reaches T_{12} at time t_2 (see figure 3).

c) Compute the absorptance α of the sample using the following formula:

$$\alpha = \frac{\sum_i m_i c_{pi}}{P} \times \left(\left| \frac{dT}{dt} \right|_h + \left| \frac{dT}{dt} \right|_c \right) \quad \ldots (2a)$$

or

$$\alpha = \frac{\sum_i m_i c_{pi}}{P_{av}} \times \left(\left| \frac{dT}{dt} \right|_h + \left| \frac{dT}{dt} \right|_c \right) \quad \ldots (2b)$$

NOTE — If the slope of the time-temperature function is varying rapidly at the selected points, an average slope should be used.