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Optics and photonics — Preparation of drawings for optical elements and systems —

Part 14: Wavefront deformation tolerance

Optique et photonique — Préparation des dessins pour éléments et systèmes optiques —
Partie 14: Tolérance de déformation du front d'onde

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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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10110-14 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 1, *Fundamental standards*.

This second edition cancels and replaces the first edition (ISO 10110-14:2003) which has been technically revised.

ISO 10110 consists of the following parts, under the general title *Optics and photonics — Preparation of drawings for optical elements and systems*:

— *Part 1: General*

— *Part 2: Material imperfections — Stress birefringence*

— *Part 3: Material imperfections — Bubbles and inclusions*

— *Part 4: Material imperfections — Inhomogeneity and striae*

— *Part 5: Surface form tolerances*

— *Part 6: Centring tolerances*

— *Part 7: Surface imperfection tolerances*

— *Part 8: Surface texture*

— *Part 9: Surface treatment and coating*

— *Part 10: Table representing data of optical elements and cemented assemblies*

— *Part 11: Non-toleranced data*

— *Part 12: Aspheric surfaces*

— *Part 14: Wavefront deformation tolerance*

— *Part 17: Laser irradiation damage threshold*

Introduction

This part of ISO 10110 makes it possible to specify a functional tolerance for the performance (expressed as single-pass wavefront deformation) of an optical system, which may have optical power or contain powered optical elements. This tolerance therefore includes the effect of surface form deformations, inhomogeneities, and possible interactions among the various individual errors.

It should be noted that it is possible to specify a tolerance on the wavefront deformation only, without specifying tolerances on the individual surfaces. In this case, the manufacturer must ensure that the wavefront satisfies the specified tolerance, but is not bound by tolerances on the form of the individual surfaces of the element, and is free, for instance, to allow the surface form deformations to be large provided they cancel each other.

It is also possible to supply a tolerance for the wavefront deformation, according to this part of ISO 10110, in addition to tolerances on the form of the individual surfaces and/or inhomogeneity (according to ISO 10110-5 and ISO 10110-4, respectively). In this case, the manufacturer must ensure that all of the individual tolerances (surface deformations and inhomogeneity) are upheld, as well as ensuring that the wavefront is of the specified quality.

Optical elements are often tested in a “double-pass” configuration, in which the wavefront passes through or, in the case of reflective optics, reflects from the element under test twice, as shown in ISO/TR 14999-1:2005, Figure 18.

In the case of double-pass testing, the additional wavefront deformation caused by the second transmission through the element must be accounted for when comparing the measurement results with the specified tolerances. If the wavefront is not severely deformed by passing once through the element under test, and reflects from a high quality mirror, so that it returns through the identical portion of the test element to the interferometer, then the observed deformation of the wavefront is twice the (single-pass) wavefront deformation (defined in 3.2.3 of ISO 14999-4:2007). That is, the wavefront deformation is one-half the observed wavefront deformation.

If the wavefront is severely deformed by the element under test, then the individual rays do not pass through the same positions in the element under test on their return path, and the wavefront deformation is not exactly twice that of the single path case.

If the measurement wavelength is not the specification wavelength, care must be taken. At least the wavefront deformation is to be recalculated.

Optics and photonics — Preparation of drawings for optical elements and systems —

Part 14: Wavefront deformation tolerance

1 Scope

The ISO 10110 series applies to the presentation of design and functional requirements for optical elements and assemblies in technical drawings used for manufacturing and inspection.

This part of ISO 10110 gives rules for the indication of the permissible deformation of a wavefront transmitted through or, in the case of reflective optics, reflected from an optical element or assembly.

The deformation of the wavefront refers to its departure from the desired shape. The tilt of the wavefront with respect to a given reference surface is excluded from the scope of this part of ISO 10110.

There is no requirement that a tolerance for wavefront deformation be indicated. If such a tolerance is specified, it does not take precedence over a tolerance for the surface form according to ISO 10110-5. If tolerances for both the surface form and the wavefront deformation are given, they must both be upheld.

2 Normative references

The following referenced documents are indispensable for the application 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 10110-1:2006, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 1: General*

ISO/TR 14999-2, *Optics and photonics — Interferometric measurement of optical elements and optical systems — Part 2: Measurement and evaluation techniques*

ISO 14999-4:2007, *Optics and photonics — Interferometric measurement of optical elements and optical systems — Part 4: Interpretation and evaluation of tolerances specified in ISO 10110*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14999-4 apply.

NOTE ISO 14999-4 provides the definitions for all the deformation functions.

4 Specification of tolerances for wavefront deformation

4.1 General

The tolerances for wavefront deformation are indicated by specifying the maximum permissible values of the sagitta deviation, irregularity, and/or rotationally invariant irregularity. In addition, tolerances for three root-mean-square measures of wavefront deformation (rms total, rms irregularity and rms rotationally varying wavefront deviation) may be specified. See 3.3 of ISO 14999-4:2007 for definitions.

NOTE 1 The sagitta deviation is meaningful only when the location of the image is specified. If the location of the image is unspecified, the sagitta deviation is defined to be zero.

NOTE 2 Methods for determining the amount of sagitta deviation, irregularity and rotationally invariant irregularity of a given wavefront are given in ISO 14999-4.

It is not necessary that tolerances be specified for all types of wavefront deformation.

4.2 Units

The maximum permissible values for sagitta deviation, irregularity, rotationally invariant irregularity and, if applicable, any target aberrations should be specified in units of nanometres. If wavelengths are to be used, the wavelength shall also be indicated on the drawing.

NOTE 1 These quantities are defined with reference to a wavefront passing once through the element under test (single-pass).

If a specification is to be given for one or more rms wavefront deformation types, the specification shall also be in units of nanometres or wavelengths (single-pass, see NOTE 1).

NOTE 2 One "wavelength" is 1 × the wavelength (in nanometres) in which the wavefront deformation is specified.

NOTE 3 The specification of a tolerance for an rms deformation type requires that the optical system be analysed digitally.

4.3 Wavelength

If wavelength units are to be used, the wavelength shall also be indicated on the drawing in order to reduce confusion. If none is provided, the wavelength is assumed to be 546,07 nm.

4.4 Target aberrations

Frequently, the nominal theoretical wavefront is spherical or planar. In some cases, to allow for the presence of small amounts of residual aberration in the design of an optical system, non-zero target values may be specified for polynomial aberration types.

4.5 Cemented (or optically contacted) elements

If two or more optical elements are to be cemented (or optically contacted), the wavefront deformation tolerances given for the individual elements apply also for the elements after assembly, i.e. after cementing (or optically contacting), unless otherwise specified. See 4.8.3 of ISO 10110-1:2006.

5 Indication in drawings

5.1 General

In all cases in which a tolerance for wavefront deformation is to be indicated, the optical axis of the element shall be indicated on the drawing according to 4.2 of ISO 10110-1:2006.

The location of the stop surface or pupil shall be indicated according to 5.3 of ISO 10110-1:2006. See Figure 1.

The tolerance for wavefront deformation shall be indicated by a code number (see 5.2) and the tolerances for sagitta deviation, irregularity, rotationally invariant irregularity and rms deformation types shall be indicated as appropriate (see 5.3).

Wavefront deformation should be specified in nanometres. However if wavelength units are to be used, the wavelength should also be indicated. All quantities shall have their units specified. If no unit is indicated then wavelength units are implied.

No provision is given for the specification of a PV-tolerance for the total wavefront deformation (that is, including both the sagitta deviation and the irregularity). If such a specification is necessary, this information shall be given in a note on the drawing, for example: “Total wavefront deformation shall not exceed 0,25 wavelengths” or “Total wavefront deformation shall not exceed 150 nm.”

NOTE Such a specification might, for example, be useful for optical elements to be used in interferometers.

See Clause 6 for examples of tolerance indications.

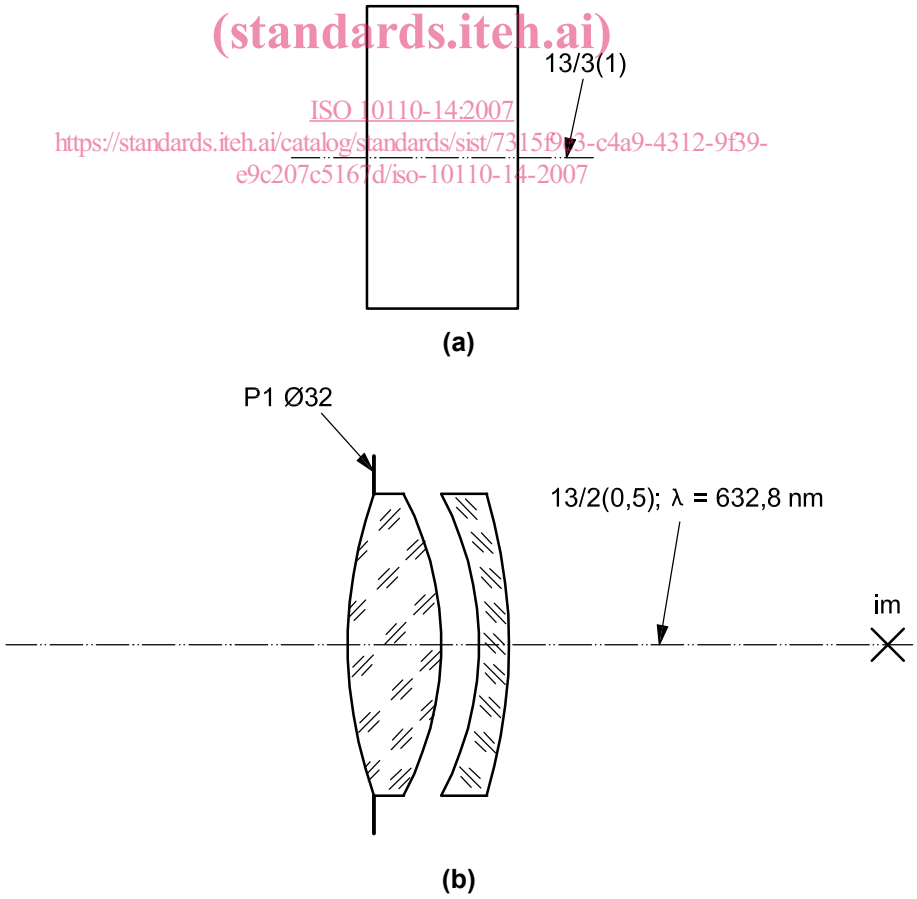

Figure 1 — Examples of an indication of a tolerance for wavefront deformation, with planar illumination