

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

Part 14: Wavefront deformation tolerance

ICS 01.100.20; 37.020

National foreword

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Summary of pages

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

Part 14: Wavefront deformation tolerance

*Optique et instruments d'optique — Indication sur les dessins pour
éléments et systèmes optiques —*

Partie 14: Tolérance de déformation des fronts d'onde



Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Tolerances for wavefront deformation	5
5 Non-circular test areas	5
6 Specification of tolerances for wavefront deformation	6
6.1 General	6
6.2 Units	6
6.3 Wavelength	6
6.4 Target aberrations.....	6
6.5 Cemented (or optically contacted) elements	6
7 Indication in drawings	6
7.1 General	6
7.2 Code number	7
7.3 Form of the indication	8
7.4 Location	9
7.5 Indication of type of illumination.....	10
7.6 Specification of the image-point location.....	10
7.7 Indication of target aberrations	11
8 Examples of tolerance indications	11
Annex A (informative) Method for the analysis of wavefronts using digital interferogram analysis	13
Annex B (informative) Visual interferogram analysis	19

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.

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

ISO 10110 consists of the following parts, under the general title *Optics and optical instruments — 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 16: Aspheric diffractive surfaces*
- *Part 17: Laser irradiation damage threshold*

Introduction

This part of ISO 10110 makes it possible to specify a functional tolerance for the performance (expressed in wavelengths of single-pass wavefront deformation) for an optical system. This tolerance therefore includes the effect of surface deformations, inhomogeneities, and possible interactions among the various individual errors.

The quality of an optical system depends not only on the quality of the surfaces, but also on several other factors, such as the homogeneity of the optical material and how the optical surfaces of the system interact with each other. Because of this effect, the selection of tolerances for individual degradations (such as surfaces and inhomogeneity) may be difficult. For instance, the effect of glass inhomogeneities upon the optical quality of a prism depends greatly upon the form and orientation of the inhomogeneities; this is particularly true when light passes through the glass in more than one direction, as in the case of a pentaprism. In the case of a thin optical element, it often happens that the deformations of the rear surface correspond closely to those of the front surface, due to bending of the system during fabrication. Unfortunately, it is usually not known in advance that this will be the case, and for this reason, in the absence of a wavefront deformation tolerance, the tolerances for the individual surfaces of a system must often be very tight to guard against the possibility that the deformations might add to each other rather than cancel one another.

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 individual surfaces of the element, and is free, for instance, to allow the surface 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 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.

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

Part 14: Wavefront deformation tolerance

1 Scope

International Standard ISO 10110 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 provides rules for the indication of the allowable 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 ("Nominal theoretical wavefront"). 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 deformation according to ISO 10110-5. If tolerances for both the surface deformation and the wavefront deformation are given, they must both be upheld.

NOTE In this part of ISO 10110, the term "wavefront" used alone stands for either "transmitted wavefront" or "reflected wavefront", according to the type of system to be specified.

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 7944:1998, *Optics and optical instruments — Reference wavelengths*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

wavefront deformation

distance between a wavefront transmitted and/or reflected once through, or in the case of reflective optics, reflected once from, the optical element or assembly under test and the nominal theoretical wavefront, measured normal to the nominal theoretical wavefront

NOTE 1 See also 3.13.

NOTE 2 The illuminating wavefront may be specified to be planar, convergent or divergent. See 7.5 and 7.6.

3.2
peak-to-valley difference between two wavefronts
PV difference between two wavefronts

maximum distance minus the minimum distance between the wavefronts

NOTE It is possible that the wavefronts cross, in which case the minimum distance between the wavefronts is a negative number; the sign must be taken into account in computing the PV difference.

3.3
total wavefront deformation function

theoretical surface defined by the difference between the wavefront transmitted and/or reflected once through the optical system under test and the nominal theoretical wavefront, measured normal to the nominal theoretical wavefront

See Figure 1a).

3.4
approximating spherical wavefront

theoretical spherical wavefront tangent to the exit pupil of the system under test for which the root-mean-square difference to the wavefront transmitted and/or reflected once through the optical system under test is a minimum

See Figure 1b).

NOTE 1 For the purpose of this definition, “spherical wavefronts” include the “planar wavefront”. (The planar wavefront is considered to be a particular case of the spherical wavefront.)

NOTE 2 See Clause 5 in the case of non-circular test areas.

3.5
wavefront sagitta error

peak-to-valley difference between the approximating spherical wavefront and the reference sphere

NOTE 1 The wavefront sagitta error represents the extent to which the radius of curvature of the approximating wavefront departs from that of the nominal theoretical wavefront.

NOTE 2 If no restrictions are specified on the location of the image of the optical system under test, the reference sphere is identical to the approximating spherical wavefront, and the wavefront sagitta error is defined to be zero.

3.6
wavefront irregularity function

theoretical surface defined by the difference between the total wavefront deformation function and the approximating spherical wavefront

See Figure 1c).

3.7
wavefront irregularity

peak-to-valley difference between the wavefront irregularity function and the plane which best approximates it

NOTE The wavefront irregularity represents the departure of the wavefront from sphericity.

3.8**approximating aspheric wavefront**

rotationally symmetric aspheric wavefront for which the root-mean-square difference to the wavefront irregularity function is a minimum

See Figure 1d).

NOTE See Clause 5 in the case of non-circular test areas.

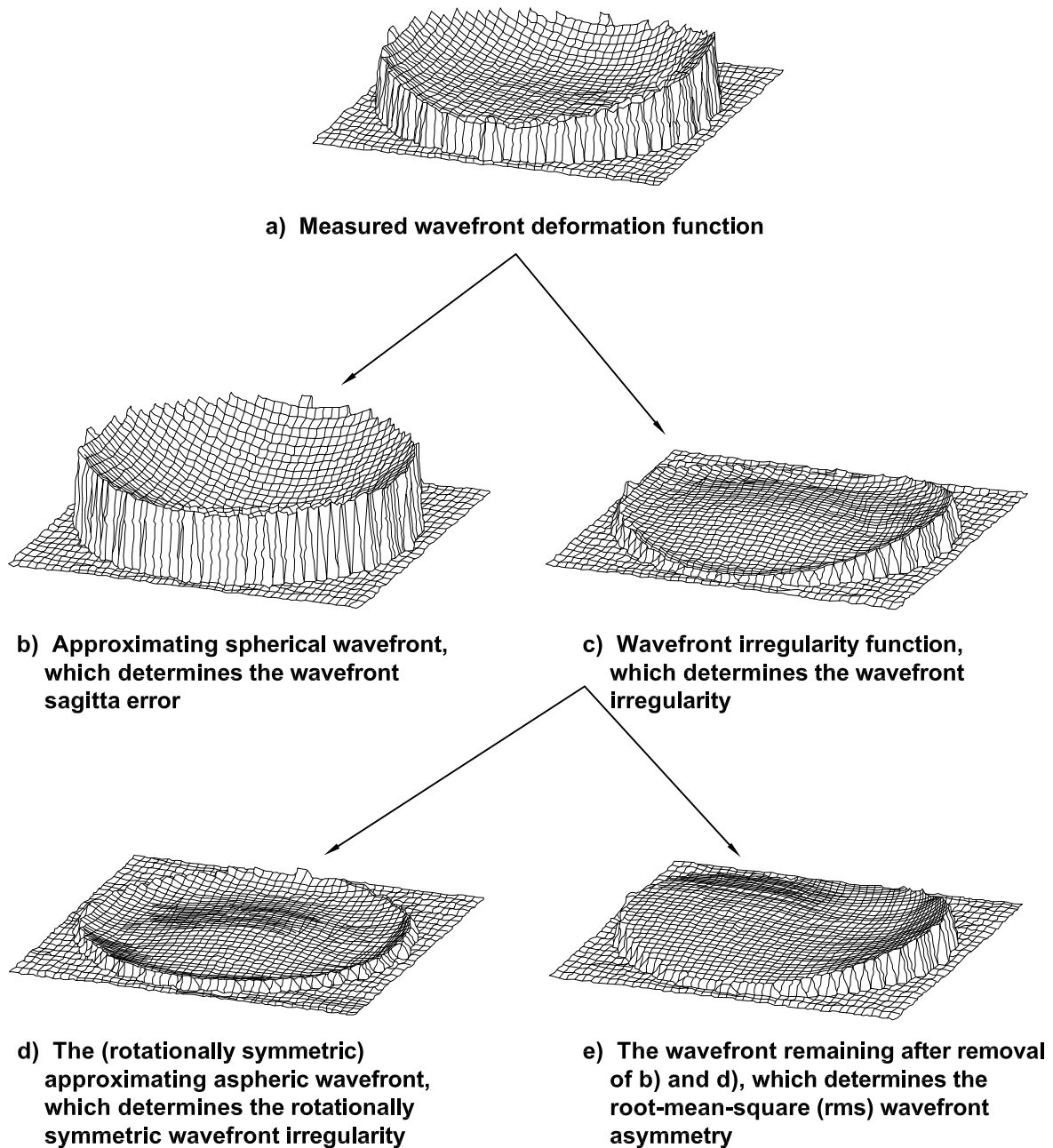


Figure 1 — Example of a measured wavefront and its decomposition into wavefront deformation types

3.9

rotationally symmetric wavefront irregularity

peak-to-valley difference between the approximating aspheric wavefront and the plane which best approximates it

NOTE The rotationally symmetric wavefront irregularity is the rotationally symmetric irregularity of the wavefront irregularity function. Its value cannot exceed that of the wavefront irregularity function.

3.10

total rms wavefront deformation

RMSt

root-mean-square difference between the wavefront transmitted once through, and/or reflected once from, the optical system under test and the nominal theoretical wavefront, which includes any specified target aberrations

3.11

rms wavefront irregularity

RMSi

root-mean-square value of the wavefront irregularity function defined in 3.6

3.12

rms wavefront asymmetry

RMSa

root-mean-square value of the difference between the wavefront irregularity function and the approximating aspheric wavefront

See Figure 1e).

3.13

single-pass

testing arrangement in which the light beam passes once through, or in the case of reflective optics, is reflected once by, the element under test

NOTE 1 For corner-cubes, roof prisms, “cat’s eyes”, and other types of retroreflectors, a single retroreflection from the element constitutes a “single-pass” configuration, even though the light actually passes through much of the element twice.

NOTE 2 Although the wavefront deformation as defined in 3.1 refers to a “single-pass” measurement, many types of optical systems are commonly tested in a “double-pass” configuration, in which the light passes through or reflects from the element twice. In many cases, when an element is tested in a double-pass configuration, the observed deformation of the wavefront is approximately twice the wavefront deformation as defined in 3.1. Regardless of how the system is actually to be tested or used, the tolerance for wavefront deformation always refers to the “wavefront deformation” as defined in 3.1, that is, as if used in a single-pass configuration.

NOTE 3 When an element of poor optical quality is tested in a double-pass configuration, it is possible that the rays of the test beam are disturbed sufficiently (for example, made divergent or convergent) so that they do not pass through the same positions of the test element on the second transmission. In this case, the wavefront deformation is not equal to one-half the observed deformation, and a precise determination of the (single-pass) wavefront deformation is difficult.

NOTE 4 In some cases, the double-pass wavefront deformation is not even approximately equal to twice the single-pass wavefront deformation. For instance, an optical system containing a wedged prism will convert a test beam of circular cross-section into one having an elliptical cross-section. When converting between single-pass and double-pass results, it is necessary to take such effects into account.

3.14

target aberrations

aspheric deformations of the wavefront which have been specified for inclusion in the nominal theoretical wavefront

3.15

nominal theoretical wavefront

theoretical wavefront equal to the reference sphere plus any target aberrations which may be specified

NOTE This is the “Desired shape” of the wavefront mentioned in Clause 1.