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

Part 16:
Diffractive surfaces

Optique et photonique — Indications sur les dessins pour éléments et systèmes optiques —

Partie 16: Surfaces diffractives

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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).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

A list of all parts in the ISO 10110 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

A diffractive surface contains diffractive structures (see Annex A), which are very small structures on or in the surface which use the wave properties of the light and work with diffraction and interference. The diffractive optical function is realized by relief structures on or in the surface or by variations of the index of refraction in the coating material. Diffractive surfaces may be also situated inside of optical assemblies.

Due to the large variety of diffractive optical elements for many purposes, this document is divided in several sub clauses. Common diffractive properties and specifications will be described in the beginning of this document. Specific properties and specifications of several basic types are described in the Annex to this document.

The three most applied types of diffractive structures are linear diffractive structures, concentric circular structures and more complex computer generated diffractive structures.

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

Part 16:
Diffractive surfaces

1 Scope

This document provides general methods of describing surfaces adding a diffractive optical function on optical surfaces, such as planes, spheres, aspheres or general optical surfaces, in the ISO 10110 series, which standardizes drawing indications for optical elements and systems. The subject of this document is the presentation, description and dimensioning of diffractive surfaces in technical drawings.

This document does not apply to diffractive surfaces with random surface texture, for example stochastic antireflective structures. Also not addressed by this document are all types of 3-dimensionally extended diffractive structures: Bragg gratings, volume holograms (HOE) and acousto-optic modulators.

This document does not address the methods to test and qualify the specifications.

This document does not address tools and methods for manufacturing diffractive surfaces.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 1: General*

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

ISO 10110-14, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 14: Wavefront deformation tolerance*

ISO 15902, *Optics and photonics — Diffractive optics — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15902 and the following apply.

IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
diffractive structure
structure on or in the optical surface which uses the wave properties of light and works with diffraction and interference

Note 1 to entry: This document does not include random surface textures or coatings which may also have a diffractive optical function.

3.2
diffractive surface
surface of an optical element, which contains *diffractive structures* (3.1)

3.3
diffractive region
single closed diffractive structured part of a *diffractive surface* (3.2)

3.4
diffractive test region
used part of a *diffractive region* (3.3), where the desired specifications are valid

3.5
base surface
finished surface of the substrate before realizing *diffractive structures* (3.1)

Note 1 to entry: The base surface is an intermediate surface state in the technological sequence, which may not exist in some manufacturing processes.

3.6
face view
view perpendicular to the diffractive surface

3.7
diffraction grating
regular periodic diffractive structure, which is unambiguously mathematically describable

3.8
linear grating
diffraction grating (3.7) with translation invariant profile in one dimension (which consists of parallel straight equal lines or grooves)

3.9
circular grating
diffraction grating (3.7) with rotationally invariant profile (which consists of concentric circular lines or grooves)

3.10
computer-generated hologram
CGH
diffractive optical element which is computer designed and fabricated under computer control

Note 1 to entry: Only 2-dimensional CGHs are addressed by this document.

Note 2 to entry: Since CGH is a definition of a surface structure through a production technology, the resulting diffractive structure can be a linear or circular grating. However, it can also be used to fabricate more complex structures. In most cases when referring to a CGH, more complex diffractive structures are meant.

[SOURCE: ISO 15902:2019, 3.2.8]

3.11
transmission grating
diffraction grating (3.7), where incident light and diffracted light are situated on different sides

3.12
reflection grating
diffraction grating (3.7), where incident light and diffracted light are situated on the same side

3.13
amplitude grating
diffraction grating (3.7), which consists of lines of non-transparent material on or in the surface, which form periodic light gaps

3.14
phase grating
diffraction grating (3.7), which works with periodic different retardation of the lightwaves

Note 1 to entry: Phase gratings are subclassified into surface relief gratings and index gratings.

3.15
surface relief grating
diffraction grating (3.7), which consists of periodic groves in the surface (periodically changing thickness)

3.16
index grating
diffraction grating (3.7), which consists of a thin smooth coating on the surface with periodically changing refractive index

3.17
diffractive optical element
DOE
optical element for which the phenomenon of the diffraction of optical radiation is the operating principle, usually characterized in terms of its periodic spatial structure

Note 1 to entry: All DOEs containing 2-dimensional diffractive structures are addressed by this document.

Note 2 to entry: DOE is the generic term for all optical elements described by this document.

[SOURCE: ISO 15902:2019, 3.2.1]

3.18
reference axis
theoretical axis of the *base surface* (3.5), given by the optical designer which does not depend on symmetries of the *base surface* (3.5) and which usually represents the centre of the optical path for the main function

Note 1 to entry: In the case of a rotationally invariant base surface the reference axis is the optical axis.

3.19
local reference axis
theoretical axis of the diffractive structure, given by the optical designer which does not depend on symmetries of the diffractive structure

Note 1 to entry: The intersection point of the local reference axis with the base surface is the origin of the coordinate system of the diffractive structure.

3.20
global coordinate system
coordinate system of the part

Note 1 to entry: Often, the coordinate system of the part is also the coordinate system of the base surface.

Note 2 to entry: The global coordinate system notation is described in ISO 10110. It may be preferred to define the global coordinate system origin to be the coordinate system origin of the base surface; e.g. the point of intersection of the reference axis and the base surface.

3.21
local coordinate system
coordinate system of the *diffractive surface* (3.2)

Note 1 to entry: The origin of the local coordinate system is the intersection point of the local reference axis with the base surface, where the diffractive structure is located.

4 Coordinate systems

4.1 General

The diffractive structure is referenced with the coordinate systems used in the process chain, e.g. to define centring tolerances according to ISO 10110-6. A diffractive structure can have 2 essential coordinate systems as shown in Figure 1:

— The local coordinate system with the origin of the mathematical description of the diffractive structure;

— The global coordinate system of the optical component (e.g. the optical axis).

Specifications shall be available for the clear orientation of the local coordinate system of the diffractive structure according to its position and orientation relative to the global coordinate system. A diffractive structure has 2 or 3 degrees of freedom for referencing onto the base surface. Two lateral coordinates specify the position of the origin of the diffractive structure with respect to the origin of the base surface. A third lateral coordinate is not necessary, because diffractive structures are always located onto the surface of the base surface. If the diffractive structure is rotationally variant, the azimuthal orientation of the local coordinate system onto the base surface shall be specified by an angle or a preferred direction. This angle, if necessary, is the third degree of freedom.

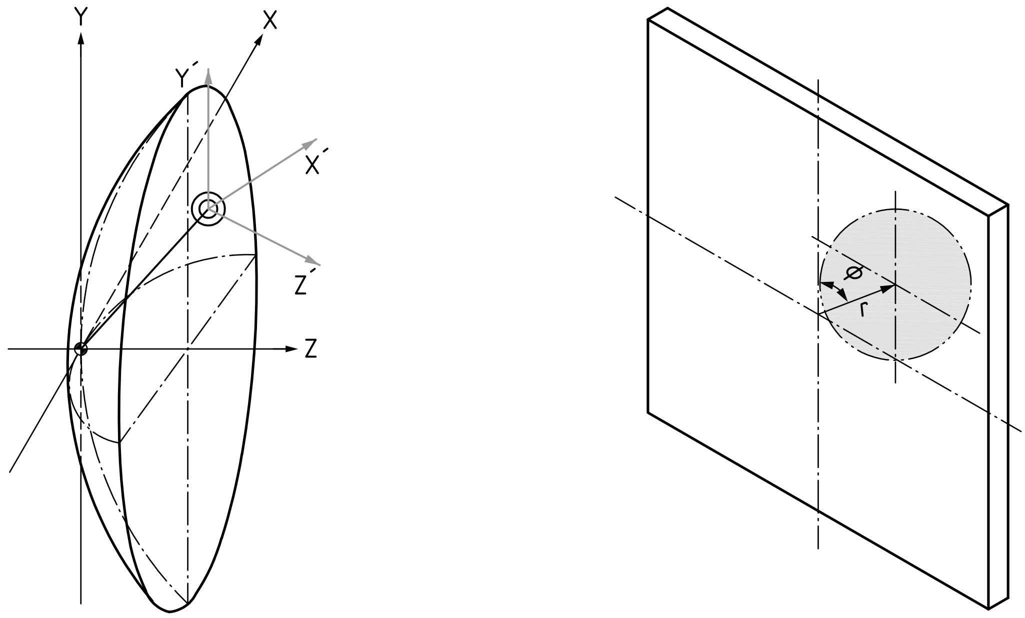
Reference marks in the form of crosses, circles, or lines and combinations of the specified structures can also be specified in this way.

4.2 Description of global and local coordinate systems

The coordinate system of the optical surface consists of three axes (X, Y, Z) orthogonal to each other and follows the right hand rule (right-handed system). The local coordinate origin of the diffractive structure shall be referenced with respect to the global coordinate system of the diffractive part. The local coordinate system of the diffractive structure has its origin onto the base surface. The local coordinate system has three axes (X’, Y’, Z’) and follows also the right hand rule.

The direction of the local Z’ coordinate is parallel to the normal of the local base surface at [X, Y]. The local Z’ direction indicates the local reference axis of the diffractive structure, Y' and X' lie within the tangential plane of the local base surface at X, Y. Figure 1 shows the coordinate system of the base surface and the local coordinate system of the diffractive structure.

The general coordinate transformation shall be done in accordance with ISO 10110-1. Further restriction is that the coordinate system of the diffractive structure is located on the base surface of the optical part.



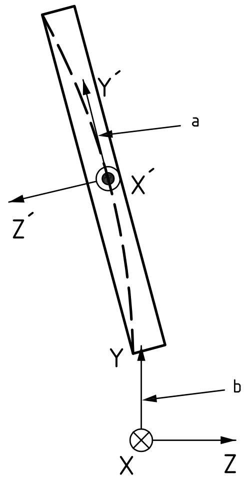
a) Cartesian coordinate system **b) Polar coordinate system**

NOTE The origin of the local coordinate system is always on the base surface, therefore two position coordinates are sufficient to describe the position on the base surface. The reference axis is labelled with Z, the local reference axis is Z’

Figure 1 — Coordinate system of the base surface and the local origin of the diffractive structure

If global reference axis and local reference axis are not identical then a coordinate transformation rule shall be indicated on the drawing or as a supplement to the optical drawing. This transformation rule includes a sketch of the optical part where the local reference axis and the global reference axis can be seen (see Figure 2). Second a calculation table shall be given, which describes the transformation sequence mathematically (see Table 1). And third, one or more tables with explicit data points shall be given. The purpose of these tables is to confirm the correct calculation of the coordinate transformation. The tables shall state clearly to which surface and to which reference axis the table is referring to. The surface types are defined in Clause 3. Examples of such a table can be seen from Table 2 to Table 4. If necessary it is allowed to define multiple reference axes and multiple local reference axes. For all defined axes a coordinate transformation shall be given to indicate the correct positions. If the order of the coordinate transformation from one axis to the next axis is important, the correct order shall be indicated either on the drawing or in the tables.

NOTE A similar type of table is known as “sagitta table” in the optical community and also used in other standards for example ISO 10110-12 on “aspherical surfaces” and ISO 10110-19 on “general surfaces”.



a Local reference axis.

b Reference axis.

Figure 2 — Coordinate systems as 2 dimensional image with right handed coordinate system arrow markers

Table 1 — Example for a coordinate transformation table

Transformation sequence 1 Translation 2 Rotation around Z 3 Rotation around Y 4 Rotation around X	**Coordinate transformation**					
	Translation mm			**Rotation around** degrees (°)		
	X	Y	Z	X	Y	Z
Reference axis to local reference axis #1						
Reference axis to local reference axis #2						
…………						
Reference axis to local reference axis #...						

Table 2 — Table for X’ coordinate

X’ coordinate of the base surface with respect to local reference coordinate system #1 [mm] (parameters from reference coordinate system)								
Y ↓	X →	...	-20	-10	0	10	20	...
...								
-20								
-10								
0								
10								
20								
...								

