SLOVENSKI STANDARD
SIST EN ISO 24157:2008

01-september-2008

Oļ esna optika in instrumenti - Postopek prikaza aberacije ļ loveġkega oļ esa (ISO 24157:2008)

Ophthalmic optics and instruments - Reporting aberrations of the human eye (ISO 24157:2008)

Augenoptik und ophthalmische Instrumente - Verfahren zur Darstellung von Abbildungsfehlern des menschlichen Auges (ISO 24157:2008)

Optique et instruments ophtalmiques - Méthodes de présentation des aberrations de l'oeil humain (ISO 24157:2008)

Ta slovenski standard je istoveten z: **EN ISO 24157:2008**

ICS:

11.040.70	Oftalmološka oprema	Ophthalmic equipment

SIST EN ISO 24157:2008 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 24157

July 2008

ICS 11.040.70

English Version

Ophthalmic optics and instruments - Reporting aberrations of the human eye (ISO 24157:2008)

Optique et instruments ophtalmiques - Méthodes de présentation des aberrations de l'oeil humain (ISO 24157:2008)

Augenoptik und ophthalmische Instrumente - Verfahren zur Darstellung von Abbildungsfehlern des menschlichen Auges (ISO 24157:2008)

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Ref. No. EN ISO 24157:2008: E

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Foreword

This document (EN ISO 24157:2008) has been prepared by Technical Committee ISO/TC 172 "Optics and optical instruments" in collaboration with Technical Committee CEN/TC 170 “Ophthalmic optics” the secretariat of which is held by DIN.

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INTERNATIONAL STANDARD

ISO 24157

First edition
2008-07-01

Ophthalmic optics and instruments — Reporting aberrations of the human eye

Optique et instruments ophtalmiques — Méthodes de présentation des aberrations de l'œil humain

Reference number
ISO 24157:2008(E)

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Published in Switzerland

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Foreword

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ISO 24157 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 7, *Ophthalmic optics and instruments*.

Ophthalmic optics and instruments — Reporting aberrations of the human eye

1 Scope

This International Standard specifies standardized methods for reporting aberrations of the human eye.

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 8429, *Optics and optical instruments — Ophthalmology — Graduated dial scale*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply. Symbols used are summarized in Table 1.

3.1
line of sight
line from the point of interest in object space to the centre of the entrance pupil of the eye and continuing from the centre of the exit pupil to the retinal point of fixation (generally the foveola)

3.2
Zernike polynomial function
one of a complete set of functions defined and orthogonal over the unit circle, the product of three terms, a normalization term, a radial term and a meridional term, parameterized by a dimensionless radial parameter, ρ, and a dimensionless meridional parameter, θ, designated by a non-negative radial integer index, n, and a signed meridional index, m, and given by the equation

$$Z_n^m = N_n^m R_n^{|m|}(\rho) M(m\theta) \tag{1}$$

where

N_n^m is the normalization term;

$R_n^{|m|}$ is the radial term;

$M(m\theta)$ is the meridional term;

the parameter ρ is a real number continuous over its range of 0 to 1,0;

the parameter θ is a real number continuous over its range of 0 to 2π.

NOTE For a given value of radial index n, the meridional index m may only take the values $-n$, $-n+2$, …, $n-2$ and n.

3.2.1
radial term
Zernike polynomial function term with indices n and m given by the equation

$$R_n^{|m|}(\rho) = \sum_{s=0}^{0,5(n-|m|)} \frac{(-1)^s (n-s)!}{s!\left[0,5(n+|m|)-s\right]!\left[0,5(n-|m|)-s\right]!} \rho^{n-2s} \quad (2)$$

where s is an integer summation index incremented by one unit

3.2.2
radial parameter
ρ
dimensionless number taking values between 0 and 1, its value at any radial distance, r, from the aperture centre being given by the expression

$$\rho = \frac{r}{a} \quad (3)$$

where a is the value of the aperture radius

3.2.3
meridional term
Zernike polynomial function term with index m given by the equations

$$M(m\theta) = \cos(m\theta) \quad \text{if } m \geqslant 0 \quad (4)$$

$$M(m\theta) = \sin(|m|\theta) \quad \text{if } m < 0 \quad (5)$$

NOTE The meridional term is also known as the *azimuthal* term.

3.2.4
meridional parameter
θ
angular value taking values between 0 and 2π (0° and 360°), expressed in the coordinate system defined in Clause 4

NOTE This is also called the *azimuthal* angle.

3.2.5
normalization term
Zernike polynomial function term with indices n and m, equal to 1,0 for “un-normalized” functions (3.2.7) and for “normalized” functions (3.2.6) by the equation

$$N_n^m = \sqrt{(2-\delta_{0,m})(n+1)} \quad (6)$$

where $\delta_{0,m} = 1$ if $m = 0$, $\delta_{0,m} = 0$ if $m \neq 0$.

3.2.6
normalized Zernike polynomial function
Zernike polynomial function whose normalization term takes the form given in 3.2.5 for “normalized” functions defined as orthogonal in the sense that it satisfies the following equation

$$\int_0^1 \rho d\rho \int_0^{2\pi} Z_n^m Z_{n'}^{m'} d\theta = \pi \delta_{n,n'} \delta_{m,m'} \quad (7)$$

where

$\delta_{n,n'} = 1$ if $n = n'$, $\delta_{n,n'} = 0$ if $n \neq n'$;

$\delta_{m,m'} = 1$ if $m = m'$, $\delta_{m,m'} = 0$ if $m \neq m'$.

3.2.7
un-normalized Zernike polynomial function
Zernike polynomial function whose normalization term is equal to 1,0 and defined as orthogonal in the sense that it satisfies the equation

$$\left(2-\delta_{0,m}\right)\left(n+1\right)\int_0^1 \rho d\rho \int_0^{2\pi} Z_n^m Z_{n'}^{m'} d\theta = \pi\delta_{n,n'}\delta_{m,m'} \tag{8}$$

where

$\delta_{n,n'} = 1$ if $n = n'$, $\delta_{n,n'} = 0$ if $n \neq n'$;

$\delta_{m,m'} = 1$ if $m = m'$, $\delta_{m,m'} = 0$ if $m \neq m'$;

$\delta_{0,m} = 1$ if $m = 0$, $\delta_{0,m} = 0$ if $m \neq 0$.

3.2.8
order
value of the radial index n of a Zernike polynomial function

3.3
Zernike coefficient

member of a set of real numbers, c_n^m, which is multiplied by its associated Zernike function to yield a term that is subsequently used in a sum of terms to give a value equal to the best estimate of the surface, $S(\rho,\theta)$, that has been fitted with Zernike terms, such a sum being represented by

$$S\left(\rho,\theta\right) = \sum_{\text{all } n \text{ and } m} c_n^m Z_n^m \tag{9}$$

NOTE 1 Each set of Zernike coefficients has associated with it the aperture diameter that was used to generate the set from surface elevation data. The set is incomplete without this aperture information.

NOTE 2 Annex A gives information on a method to find Zernike coefficients from wavefront slope (gradient) data.

3.3.1
normalized Zernike coefficient
Zernike coefficient generated using normalized Zernike functions and so designed to be used with them to reconstruct a surface

NOTE Normalized Zernike coefficients have dimensional units of length.

3.3.2
un-normalized Zernike coefficient
Zernike coefficient generated using un-normalized Zernike functions and so designed to be used with them to reconstruct a surface

NOTE Un-normalized Zernike coefficients have dimensional units of length.