INTERNATIONAL STANDARD

ISO 16610-61

First edition
2015-07-01

Geometrical product specification (GPS) — Filtration —

Part 61: Linear areal filters — Gaussian filters

Spécification géométrique des produits (GPS) — Filtrage —

Partie 61: Filtres surfaciques linéaires : Filtres Gaussiens

Reference number
ISO 16610-61:2015(E)

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Contents

Page

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 on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

ISO 16610 consists of the following parts, under the general title *Geometrical product specifications (GPS) — Filtration*:

— *Part 1: Overview and basic concepts*

— *Part 20: Linear profile filters: Basic concepts*

— *Part 21: Linear profile filters: Gaussian filters*

— *Part 22: Linear profile filters: Spline filters*

— *Part 28: Profile filters: End effects*

— *Part 29: Linear profile filters: Spline wavelets*

— *Part 30: Robust profile filters: Basic concepts*

— *Part 31: Robust profile filters: Gaussian regression filters*

— *Part 32: Robust profile filters: Spline filters*

— *Part 40: Morphological profile filters: Basic concepts*

— *Part 41: Morphological profile filters: Disk and horizontal line-segment filters*

— *Part 49: Morphological profile filters: Scale space techniques*

— *Part 60: Linear areal filters: Basic concepts*

— *Part 61: Linear areal filters: Gaussian filters*

— *Part 71: Robust areal filters: Gaussian regression filters*

— *Part 85: Morphological areal filters: Segmentation*

The following parts are planned:

— *Part 26: Linear profile filters: Filtration on nominally orthogonal grid planar data sets*

— *Part 27: Linear profile filters: Filtration on nominally orthogonal grid cylindrical data sets*

— *Part 45: Morphological profile filters: Segmentation*

— *Part 62: Linear areal filters: Spline filters*

— *Part 69: Linear areal filters: Spline wavelets*

— *Part 70: Robust areal filters: Basic concepts*

— *Part 72: Robust areal filters: Spline filters*

— *Part 80: Morphological areal filters: Basic concepts*

— *Part 81: Morphological areal filters: Sphere and horizontal planar segment filters*

— *Part 89: Morphological areal filters: Scale space techniques*

Introduction

This part of ISO 16610 is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO/TR 14638). It influences chain links 3 and 5 in the GPS matrix structure..

The ISO/GPS Masterplan given in ISO/TR 14638 gives an overview of the ISO/GPS system of which this part of ISO 16610 is a part. The fundamental rules of ISO/GPS given in ISO 8015 apply to this part of ISO 16610 and the default decision rules given in ISO 14253-1 apply to specifications made in accordance with this part of ISO 16610, unless otherwise indicated.

For more detailed information about the relation of this part of ISO 16610 to the GPS matrix model, see Annex D.

This part of ISO 16610 specifies the metrological characteristics of linear areal Gaussian filters for the rotationally symmetric filtration of nominal planar surfaces and the filtration of nominal cylindrical surfaces. It specifies, in particular, how to separate long and short wave components of a surface.

Geometrical product specification (GPS) — Filtration —

Part 61:
Linear areal filters — Gaussian filters

1 Scope

This part of ISO 16610 specifies linear areal Gaussian filters for the rotationally symmetric filtration of nominal planar surfaces and the filtration of nominal cylindrical surfaces. It specifies, in particular, how to separate long and short wave components of a surface.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 16610-1, *Geometrical product specification (GPS) — Filtration — Part 1: Overview and basic terminology*

ISO 16610-20, *Geometrical product specification (GPS) — Filtration — Part 20: Linear profile filters: basic concepts*

ISO 16610-21:2011, *Geometrical product specifications (GPS) — Filtration — Part 21: Linear profile filters: Gaussian filters*

ISO 16610-60, *Geometrical product specification (GPS) — Filtration — Part 60: Linear areal filters: Basic concepts*

ISO/IEC Guide 99:2007, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16610-1, ISO 16610-20, ISO 16610-21, ISO 16610-60, ISO/IEC Guide 98-3:2008, ISO/IEC Guide 99, and the following apply.

3.1
linear areal filter
areal filter which separates surfaces into long wave and short wave components and is also a linear function

[SOURCE: ISO 16610-60, 3.1]

3.1.1
linear planar filter
linear areal filter (3.1) that separate surfaces into long wave and short wave components, which applies to nominal planar surfaces

[SOURCE: ISO 16610-60, 3.1.1]

3.1.2
linear cylindrical filter
linear areal filter (3.1) that separate surfaces into long wave and short wave components, which applies to nominal cylindrical surfaces

[SOURCE: ISO 16610-60, 3.1.2]

3.2
cut-off wavelength (nesting index)
wavelength of a sinusoidal surface of which 50% of the amplitude is transmitted by the *linear areal filter* (3.1)

Note 1 to entry: Linear areal filters are identified by the filter type and the cut-off wavelength.

[SOURCE: ISO 16610-60, 3.7]

Note 2 to entry: The cut-off value for the Gaussian filter is an example of a nesting index.

3.3
undulations per revolution
UPR
number of sinusoidal undulations contained in the roundness profile

3.3.1
undulation cut-off (nesting index)
cut-off wavelength (3.2) of the filter applied to the extracted circumferential line

Note 1 to entry: These are usually defined in terms of undulations per revolution (UPR).

4 Characteristics of linear planar Gaussian filters

4.1 General

Linear planar Gaussian filters confirming to this part of ISO 16610 shall conform to 4.2 to 4.4.

4.2 Weighting function of linear planar filters

The weighting function of an areal filter (see Figure 1) has the formula of a rotationally symmetric Gaussian function with a cut-off wavelength, λ_c, given by Formula (1):

$$s(x,y)=\frac{1}{\alpha^2\lambda_c{}^2}\exp\left[-\frac{\pi}{\alpha^2}\left(\frac{x^2+y^2}{\lambda_c{}^2}\right)\right] \quad (1)$$

where

x is the distance from the centre (maximum) of the weighting function in X direction;

y is the distance from the centre (maximum) of the weighting function in Y direction;

λ_c is the cut-off wavelength;

α is the constant, to provide 50% transmission characteristic at the cut-off λ_c.

For a practical application, the weighting function of a filter (see Figure 1) is expressed within $-L_c\lambda_c \le \sqrt{x^2+y^2} \le L_c\lambda_c$ where L_c is the truncation indices of the Gaussian filter.

NOTE See ISO 16610-21, Annex A for recommended values of L_c.

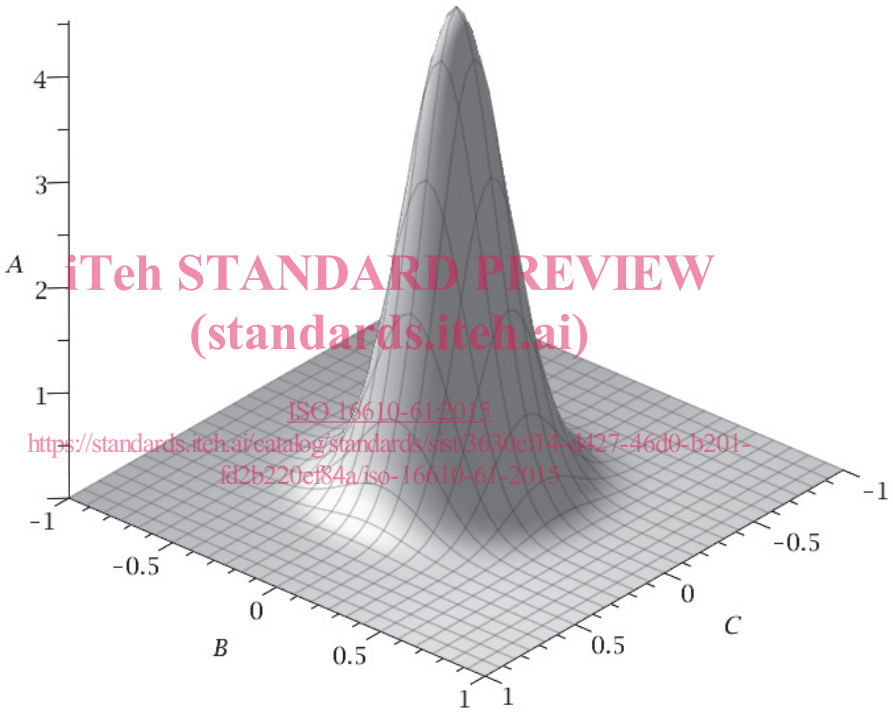
If smaller index values of L_c are used, then the uncertainty contributed by systematic error can become unacceptable,[3] as given in Formula (2):

$$s(x,y)=\begin{cases}\dfrac{1}{\alpha^2\lambda_c{}^2}\exp\left[-\dfrac{\pi}{\alpha^2}\left(\dfrac{x^2+y^2}{\lambda_c{}^2}\right)\right], & -L_c\lambda_c\le\sqrt{x^2+y^2}\le L_c\lambda_c\\ 0 & \text{otherwise}\end{cases} \tag{2}$$

where α is given by Formula (3):

$$\alpha=\sqrt{\frac{\ln 2}{\pi}}\approx\frac{318}{677}\approx 0,4697\approx\frac{31}{66} \tag{3}$$

The graph of the weighting function is shown in Figure 1.



Key

A weight modified to make it a unit number: $\lambda_c{}^2 s(x,y)$

B length modified to make it a unit number: $\dfrac{y}{\lambda_c}$

C length modified to make it a unit number: $\dfrac{x}{\lambda_c}$

Figure 1 — Weighting function of a Gaussian areal filter

4.3 Transmission characteristics of linear planar Gaussian filters

4.3.1 Transmission characteristic of the long wave component

The transmission characteristic is determined from the weighting function by means of the Fourier transformation. The transmission characteristic of the long wave component (mean) is given by Formula (4):

$$\frac{a_1}{a_0} = H\left(\lambda \mid \lambda_c\right) = \exp\left[-\pi\left(\alpha \frac{\lambda_c}{\lambda}\right)^2\right] \tag{4}$$

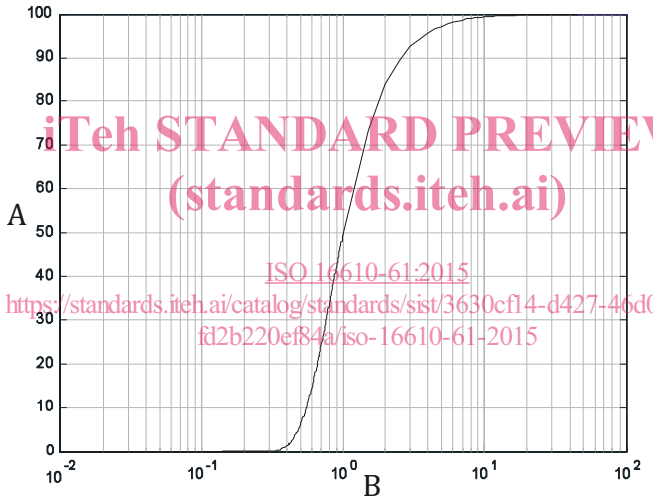
where

a_0 is the amplitude of a sine wave surface before filtering;

a_1 is the amplitude of the long wave component of a sine wave surface;

λ is the wavelength of a sine surface in any direction.

The transmission characteristic of the long wave component with λ_c for a sine wave in any direction with wavelength λ is shown in Figure 2.



Key

A amplitude transmission $\frac{a_1}{a_0}$ in %

B $\frac{\lambda}{\lambda_c}$

Figure 2 — Long wave transmission function of the areal Gaussian filter for planar surfaces with λ_c

4.3.2 Transmission characteristic of the short wave component

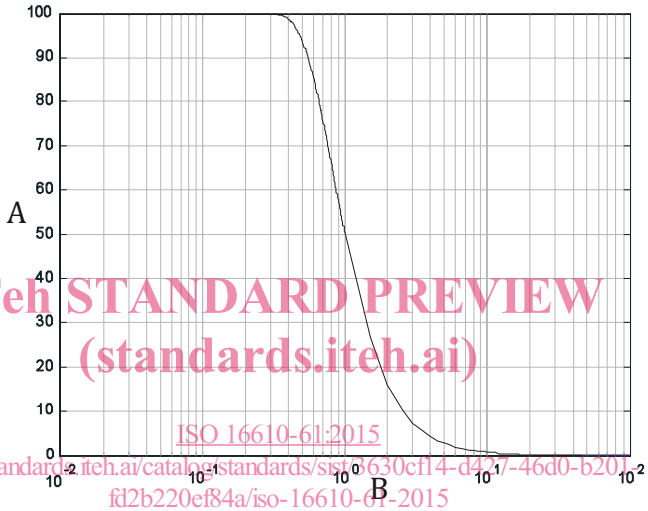
The transmission characteristic is determined from the weighting function by means of the Fourier transformation and is complementary to the transmission characteristic of the long wave profile component. The transmission characteristic of the short wave component is given by Formula (5):

$$\frac{a_2}{a_0} = 1 - \frac{a_1}{a_0} = 1 - H\left(\lambda \mid \lambda_c\right) = 1 - \exp\left[-\pi\left(\alpha \frac{\lambda_c}{\lambda}\right)^2\right] \tag{5}$$

where

a_2 is the amplitude of the short wave component of a sine wave surface.

The transmission characteristic of the short wave component with λ_c for a sine wave in any direction with wavelength λ is shown in Figure 3.



Key

A amplitude transmission $\frac{a_2}{a_0}$ in %

B $\frac{\lambda}{\lambda_c}$

Figure 3 — Short wave transmission function of the areal Gaussian filter for planar surfaces with λ_c