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Geometrical product specifications (GPS) — Surface texture: Profile method — Flowchart for *PSm*, *RSm*, *WSm* and *Pc*, *Rc*, *Wc*

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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This document was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

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Introduction

Feature characterization of rough surfaces is of growing interest in terms of a function-oriented description of technical surfaces. A well-known set of feature parameters is the mean width and mean height of profile elements defined in ISO 4287. Unfortunately, the definition given in ISO 4287 is insufficient for an unambiguous implementation in a high-level programming language. Due to the lack of a flowchart, results given by different software packages are not comparable. The main intention of this document is to provide an unambiguous algorithm for feature parameters *PSm*, *RSm*, *WSm* and *Pc*, *Rc*, *Wc* according to ISO 4287.

The flowchart defined in this document was developed by Seewig and Scott[5] and represents an extension of crossing the line segmentation proposed by Scott[4]. The flowchart is based on new knowledge gathered over the past 10 years.

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Geometrical product specifications (GPS) — Surface texture: Profile method — Flowchart for *PSm*, *RSm*, *WSm* and *Pc*, *Rc*, *Wc*

1 Scope

This document provides an unambiguous calculation of parameters *PSm*, *RSm*, *WSm* and *Pc*, *Rc*, *Wc*, as defined in ISO 4287, by means of a flowchart.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

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

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

3.1 General terms

3.1.1
profile
set of ordered pairs (x,z) which describe the intersection of a surface with a specified plane

Note 1 to entry: For every point x on the *X*-axis, there is exactly one ordinate z. The relation between x and z is given by a formula $z=f(x)$.

Note 2 to entry: Usually profiles have value pairs (x,z) above and below the *X*-axis.

Note 3 to entry: In surface metrology three profiles are defined. The primary profile, the roughness profile and the waviness profile. Each profile corresponds to a specific lateral scale.

3.1.2
evaluation length
lm
length in the direction of the *X*-axis used for assessing the profile under evaluation

[SOURCE: ISO 4287:1997, 3.1.10, modified — symbol changed from *ln* and notes to entry removed.]

3.1.3
profile peak
outwardly directed (from material to surrounding medium) portion of the assessed profile connecting two adjacent intersection points of the profile and the *X*-axis

3.1.4
profile peak height
normal distance between the *X*-axis and the highest ordinate of the profile peak

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3.1.5
profile valley
inwardly directed (from surrounding medium to material) portion of the assessed profile connecting two adjacent intersection points of the assessed profile and the *X*-axis

3.1.6
profile valley depth
normal distance between the *X*-axis and the lowest ordinate of the profile valley

3.1.7
profile element
profile peak/valley and the adjacent profile valley/peak within the evaluation length

Note 1 to entry: Profile elements are calculated from the beginning to the end of the evaluation length and vice versa.

3.1.8
profile element height
sum of the profile peak height and the profile valley depth of a profile element

3.1.9
profile element spacing
distance on the *X*-axis between the beginning of two adjacent profile elements

Note 1 to entry: The positive or negative portion of the assessed profile at the beginning or end of the evaluation length is considered as an imperfect profile element and is used for the determination of the profile element spacing.

3.1.10
profile peak height discrimination
minimum height of profile peaks of the assessed profile which is taken into account

Note 1 to entry: The minimum height of profile peaks is 10 % of *Pp* for primary profile parameters, 10 % of *Rp* for roughness profile parameters and 10 % of *Wp* for waviness profile parameters.

3.1.11
profile valley depth discrimination
minimum depth of profile valleys of the assessed profile which is taken into account

Note 1 to entry: The minimum depth of profile valleys is 10 % of *Pv* for primary profile parameters, 10 % of *Rv* for roughness profile parameters and 10 % of *Wv* for waviness profile parameters.

3.1.12
sgm
sign of a real number z depending on the numbers u and $l \in \mathbb{R}_0^+$

$$\operatorname{sgm}(z,l,u)=\begin{cases}1 & \text{if} \quad z \geq u \\ -1 & \text{if} \quad z \leq -l \\ 0 & \text{otherwise}\end{cases}$$

3.1.13
root
intersection of the assessed profile with the *X*-axis by linear interpolation

$$\operatorname{root}(x_a, z_a, x_b, z_b)=\begin{cases}\dfrac{(x_a+x_b)}{2} & \text{if} \quad z_b = z_a \\ \min\left(\max\left(\dfrac{(x_a \cdot z_b - x_b \cdot z_a)}{(z_b - z_a)}, x_a\right), x_b\right) & \text{otherwise}\end{cases}$$

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with $x_a, z_a \in \mathbb{R}$ and $x_b, z_b \in \mathbb{R}$ as the coordinates of the profile whose linear connection intersects the *X*-axis

Note 1 to entry: If the intersection point lies outside the interval $[x_a, x_b]$, then the associated interval limit is used instead of the intersection point.

3.2 Surface profile parameters

3.2.1
mean height of the profile elements *Pc*, *Rc*, *Wc*

mean value of the profile element heights Zt_i within the evaluation length

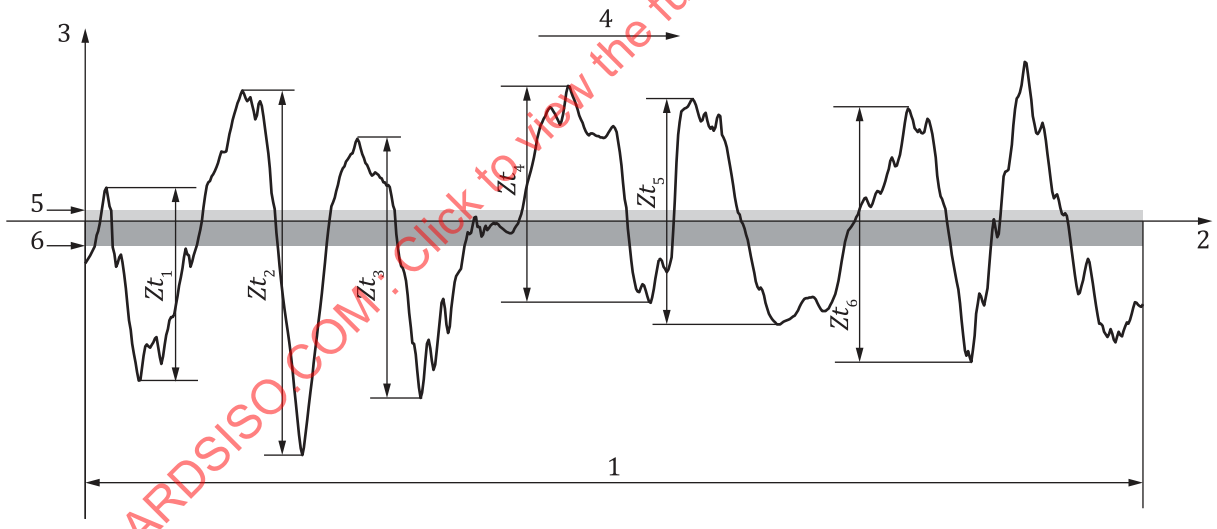
$$Rc = \frac{1}{m} \sum_{i=1}^{m} Zt_i$$

where m is the total number of profile elements calculated from the beginning to the end of the evaluation length and vice versa.

Note 1 to entry: See Figure 1 and Figure 2.

Note 2 to entry: In ISO 4287, the mean height of the profile elements is defined over the sampling length.

Note 3 to entry: Formulae for parameter definitions are exemplarily given for roughness profile parameters. Primary profile parameters and waviness profile parameters are defined in a similar manner, replacing the parameters related to the roughness profile with those related to the primary profile or waviness profile.



Key

1 evaluation length
2 *X*-axis
3 profile height
4 direction of evaluation
5 profile peak height discrimination
6 profile valley depth discrimination

Figure 1 — Heights Zt_i of profile elements which are calculated from the beginning to the end of the evaluation length

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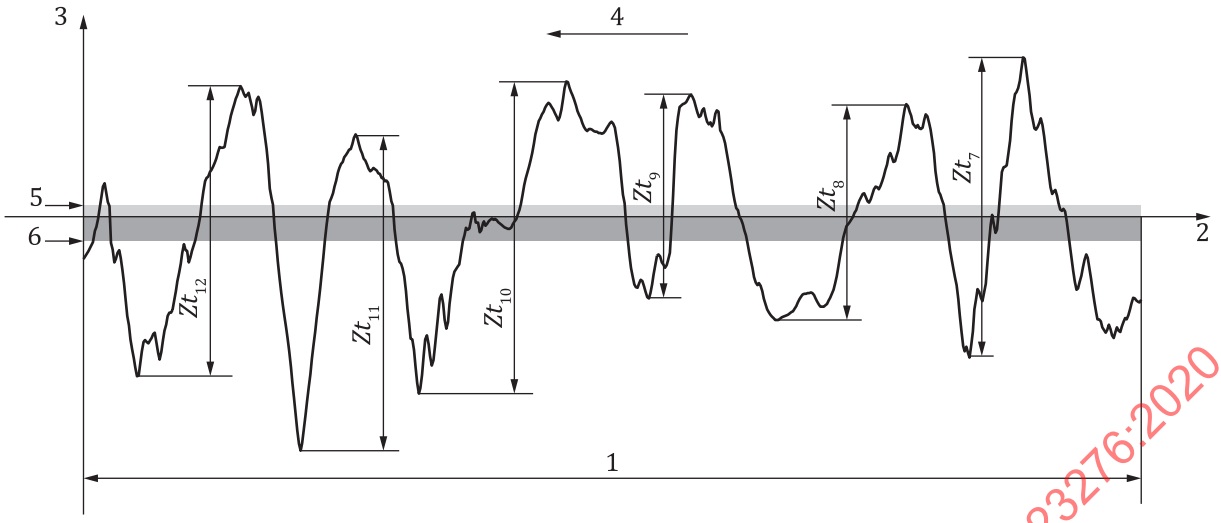

Key

1 evaluation length
2 *X*-axis
3 profile height
4 direction of evaluation
5 profile peak height discrimination
6 profile valley depth discrimination

Figure 2 — Heights Zt_i of profile elements which are calculated from the end to the beginning of the evaluation length

3.2.2
mean spacing of the profile elements *PSm*, *RSm*, *WSm*
mean value of the profile element spacings Xs_i within the evaluation length

$$RSm = \frac{1}{m}\sum_{i=1}^{m} Xs_i$$

where m is the total number of profile elements calculated from the beginning to the end of the evaluation length and vice versa.

Note 1 to entry: See Figure 3 and Figure 4.

Note 2 to entry: In ISO 4287, the parameter is defined as the mean width of the profile elements.

Note 3 to entry: In ISO 4287, the mean width of the profile elements is defined over the sampling length.

Note 4 to entry: Formulae for parameter definitions are exemplarily given for roughness profile parameters. Primary profile parameters and waviness profile parameters are defined in a similar manner, replacing the parameters related to the roughness profile with those related to the primary profile or waviness profile.

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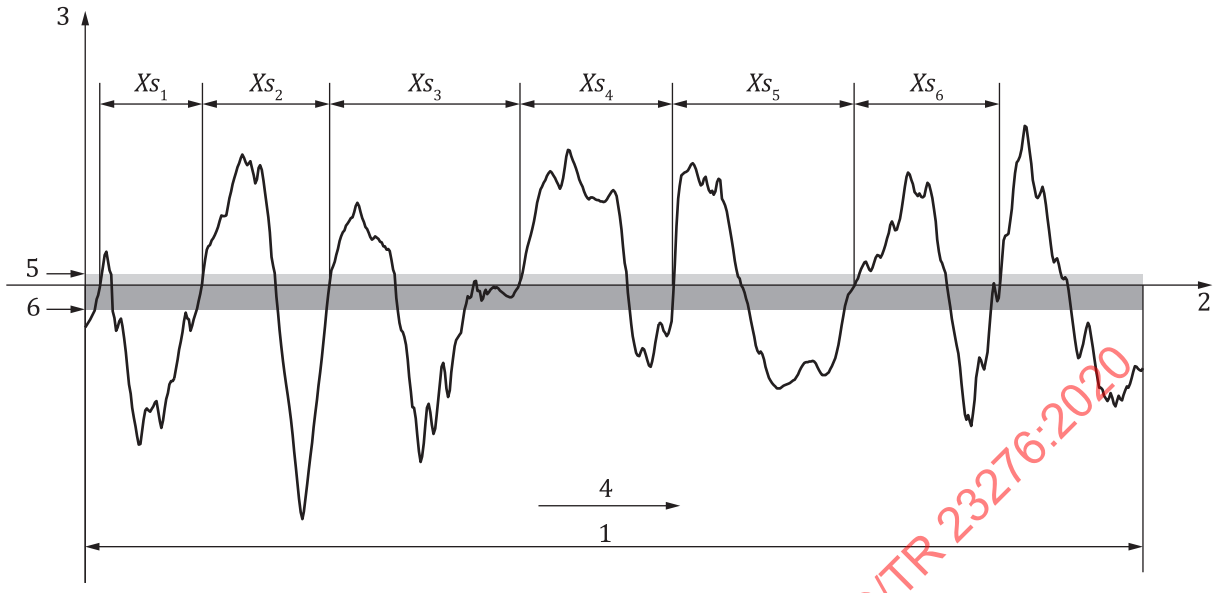

Key

1 evaluation length
2 *X*-axis
3 profile height
4 direction of evaluation
5 profile peak height discrimination
6 profile valley depth discrimination

Figure 3 — Spacings Xs_i of the profile elements which are calculated from the beginning to the end of the evaluation length

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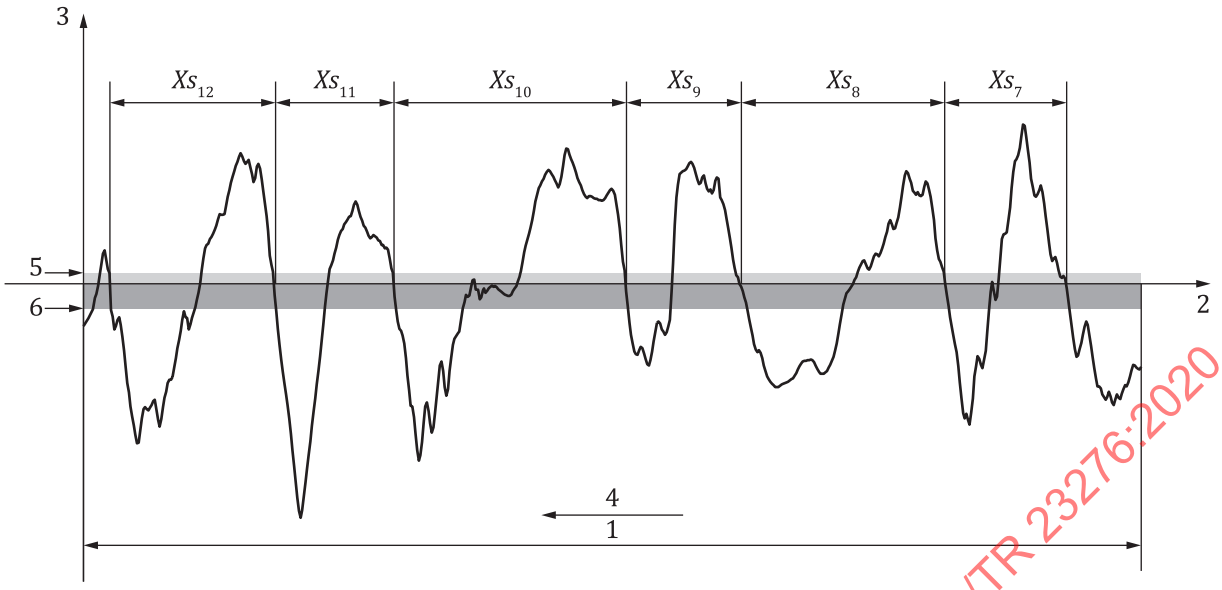

Key

1 evaluation length
2 *X*-axis
3 profile height
4 direction of evaluation
5 profile peak height discrimination
6 profile valley depth discrimination

Figure 4 — Spacings Xs_i of the profile elements which are calculated from the end to the beginning of the evaluation length

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4 Flowchart for parameters *PSm*, *RSm*, *WSm* and *Pc*, *Rc*, *Wc*

4.1 General

To calculate the mean spacing of the profile elements *PSm*, *RSm*, *WSm* and the mean height of the profile elements *Pc*, *Rc*, *Wc* the flowchart is separated into four parts.

— Part one: detection of profile peaks and profile valleys with arbitrary height or depth within the evaluation length.

— Part two: calculation of significant profile peaks and profile valleys applying the profile peak height discrimination and profile valley depth discrimination.

— Part three: merging of adjacent significant profile peaks or adjacent significant profile valleys.

— Part four: calculation of the profile parameters *PSm*, *RSm*, *WSm* and *Pc*, *Rc*, *Wc*.

NOTE The flowchart is specified for a generic type of profile, designated by the letter *X*, with parameters *XSm* and *Xc*. Primary profile parameters, roughness profile parameters and waviness profile parameters are defined in a similar manner, replacing the parameters related to the *X* profile with those related to the primary profile, roughness profile or waviness profile.

The following variables are used:

i, j, k	running index
m	number of profile elements

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n	number of profile values
x_k	position on the *X*-axis (in ascending order) with $k=\{1,2,\ldots,n\}$
z_k	profile value for a given x_k with $k=\{1,2,\ldots,n\}$
k_h	index of the profile value indicating a profile peak height or a profile valley depth
t	$\in\{-1,0,1\}$ indicates a valley, a zero element or a peak
n_{PV}	total number of profile peaks and profile valleys
PV_i	profile peak or profile valley with $i=\{1,2,\ldots,n_{PV}\}$
	PV_i has four members:
	$PV.t\in\{-1,0,1\}$ indicates a valley, a zero element or a peak
	$PV.h$ the height of a profile peak or depth of a profile valley
	$PV.i_l$ index of the left boundary $x_{PV.i_l}$ of a profile peak or a profile valley
	$PV.i_r$ index of the right boundary $x_{PV.i_r}$ of a profile peak or a profile valley
x_i, x_j	intersection points with the *X*-axis
H_u	profile peak height discrimination $\in\mathbb{R}_0^+$
H_l	profile valley depth discrimination $\in\mathbb{R}_0^+$
O_P	outwardly directed threshold to suppress numerical noise $\in\mathbb{R}_0^+$
O_V	inwardly directed threshold to suppress numerical noise $\in\mathbb{R}_0^+$

4.2 Part one — Calculation of peaks and valleys within the evaluation length

Part one of the flowchart defines an algorithm in order to detect peaks and valleys with arbitrary height and depth within the evaluation length. The result is a sequence PV of peaks and valleys.

NOTE See Figure 5.

The value O_p is 0,01 % of *Pp* for primary profile parameters, 0,01 % of *Rp* for roughness profile parameters and 0,01 % of *Wp* for waviness profile parameters.

The value O_V is 0,01 % of *Pv* for primary profile parameters, 0,01 % of *Rv* for roughness profile parameters and 0,01 % of *Wv* for waviness profile parameters.

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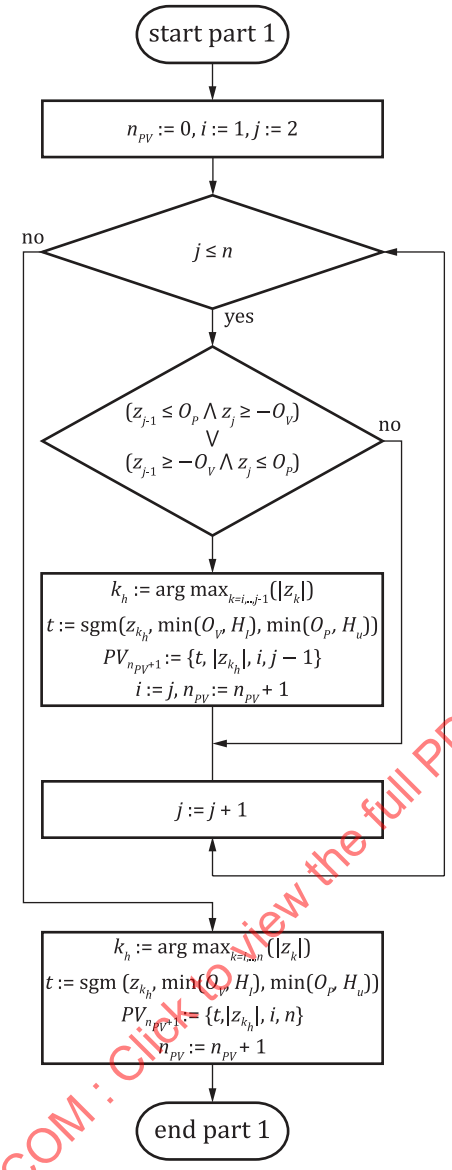

Figure 5 — Flowchart part one

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4.3 Part two — Peak height discrimination and valley depth discrimination

Part two of the flowchart defines an algorithm in order to delete insignificant peaks and valleys applying the profile peak height and profile valley depth discrimination.

NOTE 1 See Figure 6 a).

NOTE 2 The minimum height of profile peaks H_u is 10 % of *Pp* for primary profile parameters, 10 % of *Rp* for roughness profile parameters and 10 % of *Wp* for waviness profile parameters.

NOTE 3 The minimum depth of profile valleys H_l is 10 % of *Pv* for primary profile parameters, 10 % of *Rv* for roughness profile parameters and 10 % of *Wv* for waviness profile parameters.

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