JENOPTIK

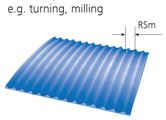
MORE LIGHT

Precise roughness measurement. Surface texture parameters in practice.

Selection of the cut-off (profile filter) according to ISO 4288:1998 and ISO 3274:1998

The cut-off is selected depending on the workpiece surface either according to the valley spacing, or the expected roughness values. At the same time the total evaluation length and the corresponding traverse length are defined according to standards. Deviations are necessary if the workpiece does not allow the required traverse length. See drawing entries.

Periodic profiles
e.g. turning, milling

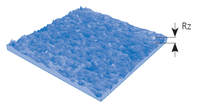


Measurement conditions

lr	sampling length
ln	evaluation length
lt	traverse length
λc	cut-off
λs	shortwave profile filter
r_{tip}	stylus tip radius
ΔX	digitization distance [1]

[1] The digitization distance is also standardized. This is set automatically by most roughness measuring instruments.

Aperiodic profiles
e.g. grinding, eroding



RSm (mm)		λc = lr (mm)	ln (mm)	lt (mm)	r_{tip} (µm)	λs (µm)	Ra (µm)		Rz (µm)	
> 0.013	…0.04	0.08	0.4	0.48	2	2.5	> (0.006)	…0.02	> (0.025)	…0.1
> 0.04	…0.13	0.25	1.25	1.5	2	2.5	> 0.02	…0.1	> 0.1	…0.5
> 0.13	…0.4	0.8	4	4.8	2 or 5 *	2.5	> 0.1	…2	> 0.5	…10
> 0.4	…1,3	2.5	12.5	15	5	8	> 2	…10	> 10	…50
> 1.3	…4	8	40	48	10	25	> 10	…80	> 50	…200

Application example
In a periodic profile the mean width of the profile elements RSm is used. With an RSm between 0.4 and 1.3 mm the following measuring conditions result: λc = 2.5 mm / ln = 12.5 mm / lt = 15 mm / r_{tip} = 5 µm / λs = 8 µm.

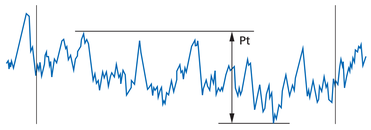
* At Rz ≤ 2 µm the stylus tip radius is 2 µm, at Rz > 2 µm it is 5 µm. The distance between two measuring points is ≤ 0.5 µm.

Shortened standard evaluation length
If the actual possible traverse length on the workpiece surface is not enough for lt, the number of sampling lengths is reduced accordingly and specified in the drawing.

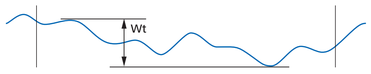
If the actually available traverse length is less than a sampling length, the total height of profile Pt of the primary profile is evaluated instead of Rt or Rz.

Division of a surface

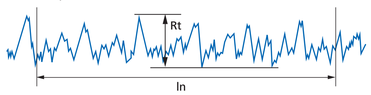
Unfiltered P-profile

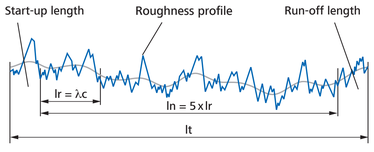


Filtered W-profile



Filtered R-profile





Surface profiles – total height of the profile
Surface profile is measured two-dimensionally using the tracing system.

The unfiltered primary profile (P-profile) is the actual measured surface profile. Filtering it in accordance with ISO 11562/ISO 16610-21 produces the waviness profile (W-profile) and the roughness profile (R-profile). The variable for determining the limit between waviness and roughness is the cut-off λc.

Following ISO 4287, all parameter definitions are valid for both the roughness profile as well as for the primary and waviness profiles. The profile type is identified by the capital letters P, R or W.

The total height Pt, Wt or Rt of the respective profile type is the maximum height between the highest peak and the deepest valley of the evaluation length profile.

Evaluation lengths – cut-off
The traverse length (lt) is the total length of the probe movement during the scanning process. It must be greater than the evaluation length ln in order to be able to form the roughness profile with the profile filter.

With the exception of Rt, Rmr(c) and RPc, the roughness parameters are defined within an evaluation length ln, which is determined using an average of five sampling lengths lr.

The sampling length lr corresponds to the cut-off λc.

Evaluation of measurement results

According to ISO 4288 the surface measurement should be made where the highest values are to be expected (visual determination).

Maximum value rule
The surface is considered good when the measured values of a parameter do not exceed the fixed maximum value. In this case, the parameter is identified by the suffix „max", e.g. Rz1max.

16 % rule
If the suffix „max" is not specified, the 16 % rule applies, which states that the surface is considered "good" if not more than 16 % of the measured parameter values exceed the fixed maximum value. You will find further information about this rule in the standard ISO 4288:1997.

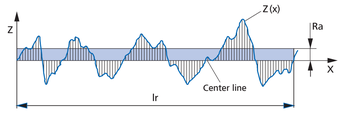
Special rule VDA
The 16 % rule is not used. VDA 2006 assumes that the dispersion of the parameters is taken into account in the definition of the limit values. The maximum value rule applies generally even without the „max" index in the designation. The use of the λs filter is prohibited.

At Rz ≤ 2 µm the stylus tip radius is 2 µm, at Rz > 2 µm it is 5 µm. The distance between two measuring points is ≤ 0.5 µm.

The cone angle is either 60° or 90°. If not otherwise specified, it is 90°.

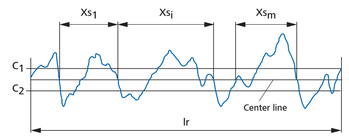
The most important roughness parameters according to ISO 4287, ISO 13565 and EN 10049

Ra according to ISO 4287



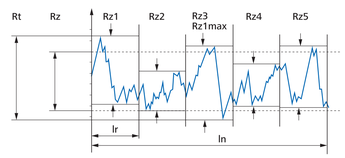
Ra – arithmetical mean deviation
Ra is the arithmetic mean roughness value from the amounts of all profile values. Ra does not differentiate between peaks and valleys and has therefore a relatively weak information character.

RSm according to ISO 4287



RSm – mean width of the profile elements
RSm is the arithmetic mean value of the width of the roughness profile elements within the sampling length and requires the definition of height discriminations (c1, c2) matching the function of the surface. If not specified otherwise, the sum of the height discriminations should add up to 10 % of Rz.

Rz, Rz1max, Rt according to ISO 428

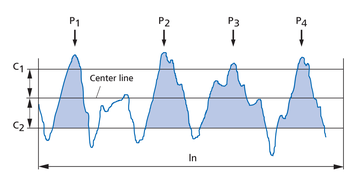


Rz – maximum height of profile
Average value of the five Rz values.

Rz1max – maximum height of profile (ISO 4287:1997)
Greatest Rz value from the five sampling lengths lr.

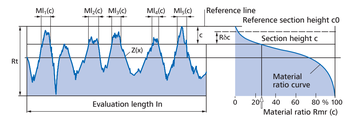
Rt – total height of profile
Rt is the distance between the highest peak and the deepest valley of the profile of the total evaluation length ln.

RPc according to EN 10049/ISO 4287



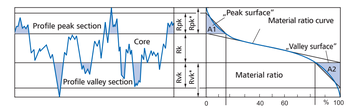
RPc – standardized number of peaks
RPc corresponds to the number of local peaks, which successively exceed an upper section line c1 and a lower section line c2. The number of peaks is related to a length of 10 mm irrespective of the evaluation length selected.

Rmr(c) according to ISO 4287



Rmr(c) – material ratio of the profile
Rmr indicates what ratio the totaled length in the material has assumed relative to the evaluation length (in %). The comparison is made in the specified section height c and the total evaluation length ln. The material ratio curve indicates the material ratio as a function of the section height.

Rk, Rpk, Rvk, Mr1, Mr2 according to ISO 13565-2



Rk – core roughness depth
Depth of the roughness core profile.

Rpk – reduced peak height
Mean height of the peaks protruding from the roughness profile.

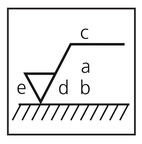
Rpk* – highest profile peak height (not ISO 13565-2)

Rvk – reduced valley depth
Mean depth of the valleys reaching into the material from the core.

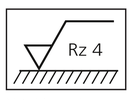
Rvk* – deepest profile valley depth (not ISO 13565-2)

Mr1, Mr2 – material ratio
Smallest (Mr1) and greatest (Mr2) material ratio (in %) at the limits of the roughness core area.

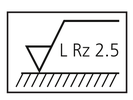
Drawing entries according to ISO 1302:2002



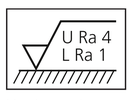
Specifications for requirements
a surface parameter with numeric value in µm
b second requirement (surface parameter in µm)
c production method
d specification of valley direction
e machining allowance in mm



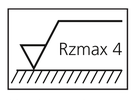
Material removing machining;
Rz = max. 4 µm



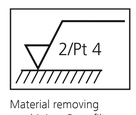
Material removing machining; lower limit value for Rz demanded;
Rz = min. 2.5 µm



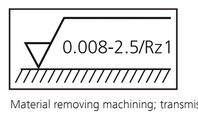
Material removing machining; upper and lower limit value for Ra demanded;
Ra = min. 1 µm and max. 4 µm



Material removing machining;
Rz = max. 4 µm;
the maximum value rule applies

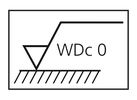


Material removing machining; P-profile, traverse length = 2 mm;
Pt = max. 4 µm

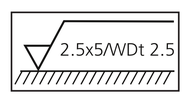


Material removing machining; transmission characteristic does not comply with standard case (cf. table) Rz = max. 1 µm; filter selection λs = 0.008 mm and λc = 2.5 mm

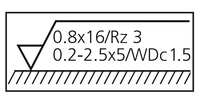
Drawing entries according to VDA 2007 – dominant waviness



Material removing machining; WDc 0 or WDt 0: no dominant waviness allowed



Material removing machining; in the period range up to 2.5 mm, WDt = max. 2.5 µm applies



Material removing machining;
Rz: the evaluation length is 12.5 mm and λc = 0.8 mm, Rz = max. 3 µm;
WDc: in the period range of 0.2 to 2.5 mm, WDc = max. 1.5 µm applies

00031708 · 2020-06 · Copyright © JENOPTIK Industrial Metrology Germany GmbH. All rights reserved. Subject to change without notice.