

Roughness measuring systems from Jenoptik – Surface 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 the standards. Deviations are necessary if the workpiece does not allow the required traverse length. See drawing entries.

Periodic profiles e.g. turning, milling		Measuring conditions						Aperiodic profiles e.g. grinding, eroding	
		l_r	sampling length						
		l_n	evaluation length						
		l_t	traverse length						
		λ_c	cut-off						
		λ_s	shortwave profile filter		1) The digitization distance is also standardized. This is set automatically by most roughness measuring instruments.				
		r_{tp}	stylus tip radius						
		ΔX	digitization distance 1)						
RSm (mm)		$\lambda_c = l_r$ (mm)	l_n (mm)	l_t (mm)	r_{tp} (µm)	λ_s (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 R_{Sm} is used. With an R_{Sm} between 0.4 and 1.3 mm the following measuring conditions result:
 $\lambda_c = 2.5$ mm / $l_n = 12.5$ mm / $l_t = 15$ mm / $r_{tp} = 5$ µm / $\lambda_s = 8$ µm.

Shortened standard evaluation length

If the actual possible traverse length on the workpiece surface is not enough for l_t , 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 P_t of the primary profile is evaluated instead of R_t or R_z .

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

Ra – parameter according to ISO 4287

Ra – arithmetical mean deviation of the assessed profile
 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.

Rz, Rz1max, Rt – parameters according to ISO 4287

Rz/Rz1max – maximum height of profile: Average value of the five Rz values/greatest Rz value from the five sampling lengths l_r .
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 l_n .

RSm – parameter 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 (c_1 , c_2) matching the function of the surface.

RPC – parameter according to EN 10049

RPC – standardized number of peaks
 RPC corresponds to the number of local peaks, which successively exceed an upper section line c_1 and a lower section line c_2 . The number of peaks is related to a length of 10 mm irrespective of the evaluation length selected.

Rmr(c) – parameter according to ISO 4287

Rmr(c) – material ratio of the profile
 Rmr indicates what ratio the totalled 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 l_n . The material ratio curve indicates the material ratio as a function of the section height.

Rk, Rpk, Rvk, Mr1, Mr2 – parameters according to ISO 13565

Parameters of the material ratio curve
Rk – core roughness depth
 Depth of the roughness core profile.
Rpk – reduced peak height
 Mean height of the peaks protruding from the roughness profile.
Rvk – reduced valley depth
 The mean depth of the valleys reaching into the material from the core.
Mr1, Mr2 – material ratio
 Smallest and greatest material ratio (in %) at the limits of the roughness core area.

Division of a surface

Surface profiles – total height of the profile
 The 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 λ_c .
 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 P_t , W_t or R_t 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 (l_t) is the total length of the probe movement during the scanning process. It must be greater than the evaluation length in order to be able to form the roughness profile with the profile filter. With the exception of R_t and $R_{mr}(c)$, the roughness parameters are defined within an evaluation length l_n , which is determined using an average of five sampling lengths l_r .
 The sampling length l_r corresponds to the cut-off λ_c .

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. R_z1max .

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 λ_s filter is prohibited.

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

Drawing entries according to ISO 1302:2002

Symbol	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 $\lambda_s = 0.008$ mm and $\lambda_c = 2.5$ mm

Drawing entries according to VDA 2007 – dominant waviness

	Material removing machining; WDc0 or WDt0: 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; the evaluation length is 12.5 mm and $\lambda_c = 0.8$ mm; Rz = max. 3 µm; in the period range of 0.2 to 2.5 mm, WDc = max. 1.5 µm applies

