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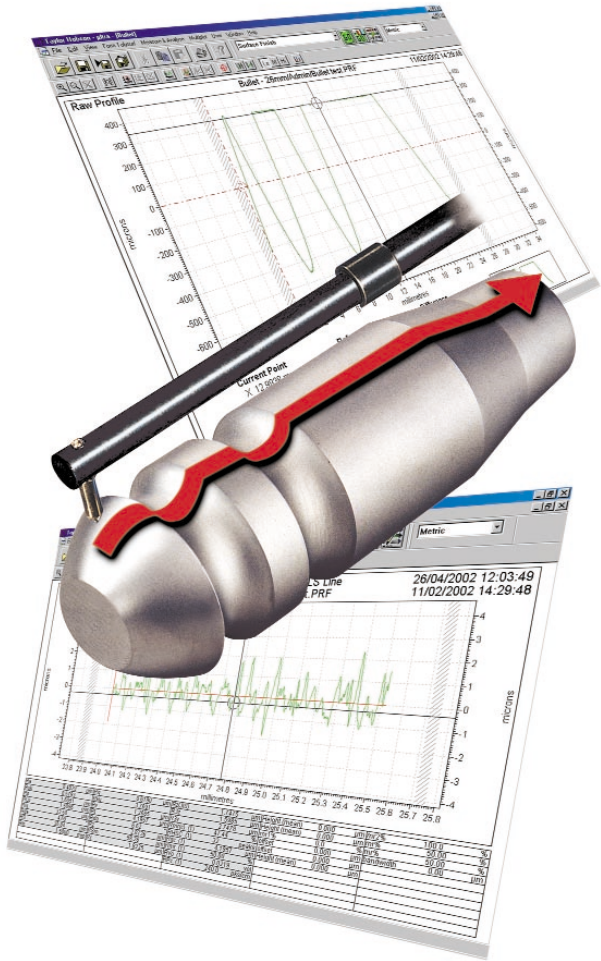
Taylor Hobson PRECISION

A guide to Surface Texture Parameters



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Every component's surface has some form of texture which varies according to its structure and the way it has been manufactured. These surfaces can be broken down into three main categories: Surface Roughness, Waviness and Form. In order to predict a component's behaviour during use or to control the manufacturing process, it is necessary to quantify these surface characteristics. This is done by using surface texture parameters.

Surface texture parameters can be separated into three basic types: **Amplitude, Spacing and Hybrid.**

Amplitude Parameters - Are measures of the vertical characteristics of the surface deviations

Spacing Parameters - Are measures of the horizontal characteristics of the surface deviations

Hybrid Parameters - Are combinations of spacing and amplitude parameters

Mean Line - The mean line is a least squares line of nominal form fitted through the primary profile where the areas of the profile above and below this line are equal and kept to a minimum separation. Profile filters as detailed in ISO 11562 define the mean lines for the roughness and waviness profiles.

Cut-off - A cut-off is a filter that uses either electronic or mathematical means to remove or reduce unwanted data in order to look at wavelengths in the region of interest.

Bandwidth - Bandwidth is the ratio of the upper Cut-off (Lc) to the lower Cut-off (Ls)

Sample Length - The profile is divided into sample lengths l, which are long enough to include a statistically reliable amount of data.
For roughness and waviness analysis, the sample length is equal to the selected cut-off (Lc) wavelength. The sample length is also known as the cut-off length.

Evaluation Length - The length in the direction of the X axis used for assessing the profile under evaluation. The evaluation length may contain one or more sample lengths. For the primary profiles the evaluation length is equal to the sample length.

UKAS TESTING 2624

UKAS CALIBRATION 0026

UL REGISTERED FIRM UKAS QUALITY MANAGEMENT 062

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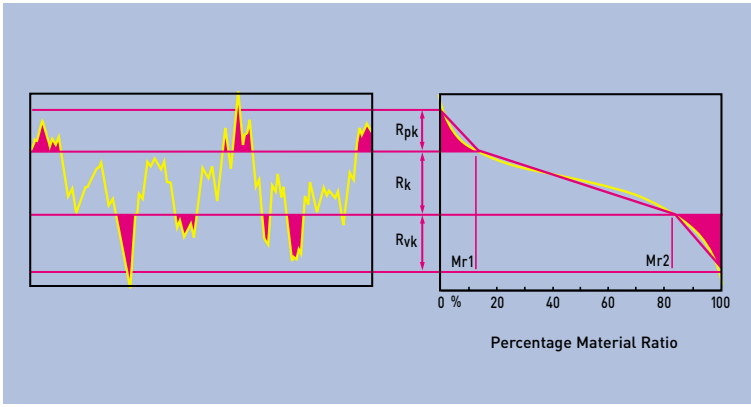


Rpk, Rk, Rvk, Mr1, Mr2

These parameters were specifically designed for the control of the potential wear in cylinder bores in the automotive manufacturing industry. It attempts to describe in numeric terms the form of the material ratio curve.

The filter used in Rk is a specific filter described in DIN 4776 (ISO 13 565 Part 1 1998)

Rpk is the Reduced Peak Height – the top portion of the surface which will quickly be worn away when the engine begins to run.

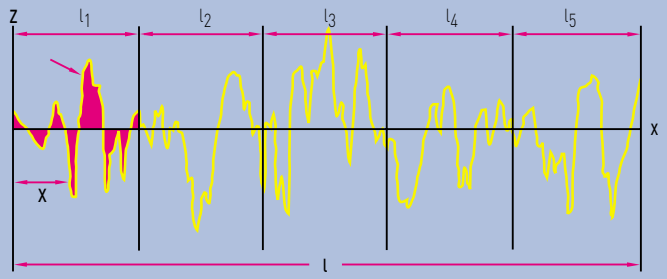
Rk is the Core Roughness Depth – the long term running surface which will influence the performance and life of the cylinder. (The depth of the Roughness Core Profile).

Rvk is the Trough Depth - the oil retaining capability of the deep troughs which have been machined into the surface.

Mr1 is the Material ratio corresponding to the upper limit of the roughness core.

Mr2 is the Material ratio corresponding to the lower limit of the roughness core.

AMPLITUDE PARAMETERS



Ra, Rq, Wa, Wq, Pa, Pq

l_1 - l_5 are consecutive and equal sampling lengths (l the sampling length corresponds to filter cut-off length λ_c).

The assessment length l is defined as the length of profile used for the measurement of surface roughness parameters (usually containing several sampling lengths; five consecutive sampling lengths are taken as standard).

Ra is the universally recognised, and most used, international parameter of roughness. It is the arithmetic mean of the absolute departures of the roughness profile from the mean line.

$$Ra = \frac{1}{l}\int_0^l \left|z(x)\right| dx$$

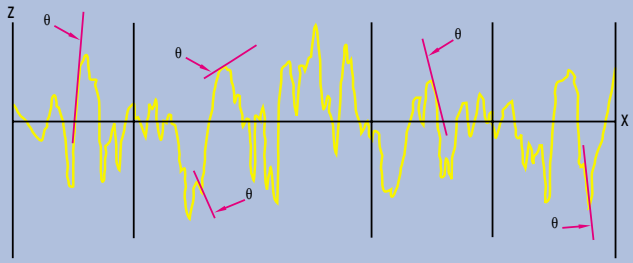
Rq is the rms parameter corresponding to R_a

$$Rq = \sqrt{\frac{1}{l}\int_0^l z^2(x)\,dx}$$

Wa, Wq, Pa and **Pq** are the corresponding parameters from the waviness and primary profiles, respectively.

Note: **Rq** is sometimes referred to as RMS.

HYBRID PARAMETERS



RΔq, WΔq, PΔq, Rλq, Wλq, Pλq

RΔq is the rms slope of the profile within the sampling length.

$$R\Delta q = \sqrt{\frac{1}{l}\int_0^l \left[\theta(x) - \bar{\theta}\right]^2 dx}$$

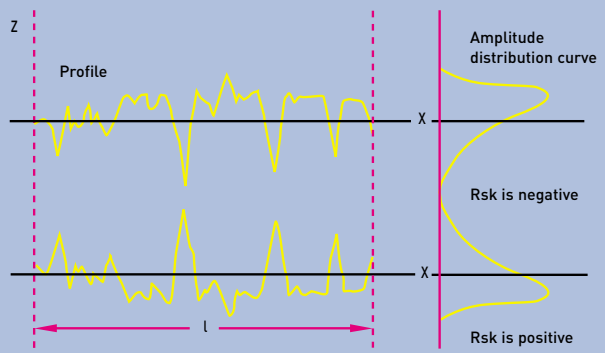
$$\bar{\theta} = \frac{1}{l}\int_0^l \theta(x)\,dx$$

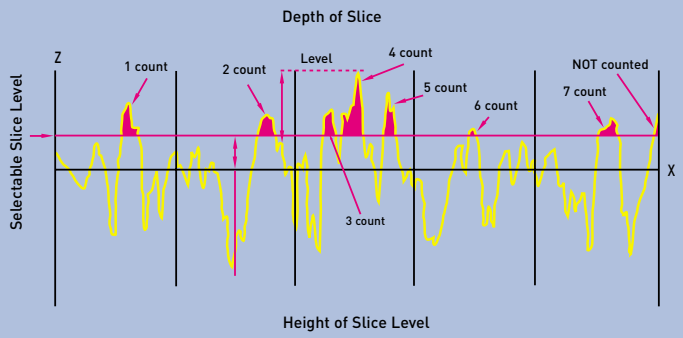
Where θ is the slope of the profile at any given point

Rλq is the rms wavelength which is a measure of the spacings between local peaks and valleys, taking into account their relative amplitudes and individual spatial frequencies. Being a hybrid parameter, determined from both amplitude and spacing information, it is, for some applications, more useful than a parameter based solely on amplitude or spacing.

$$R\lambda q = \frac{2\pi Rq}{R\Delta q}$$

WΔq, Wλq, PΔq and **Pλq** are the corresponding parameters from the waviness and primary profiles, respectively.





R_{sk}, R_{ku}, W_{sk}, W_{ku}, P_{sk}, P_{ku}

R_{sk} – Skewness – is the measure of the symmetry of the profile about the mean line. It will distinguish between asymmetrical profiles of the same R_a or R_q.

$$R_{sk} = \frac{1}{R_q^3}\left[\frac{1}{l}\int_0^l z^3(x)\,dx\right]$$

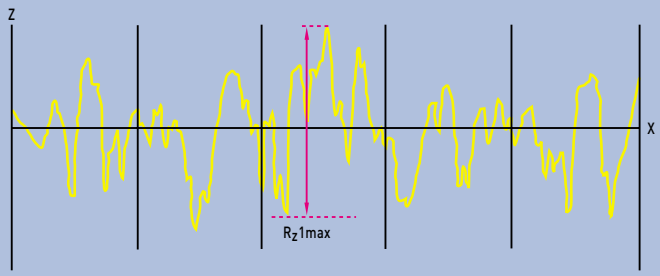
R_{ku} – Kurtosis – is a measure of the sharpness of the surface profile.

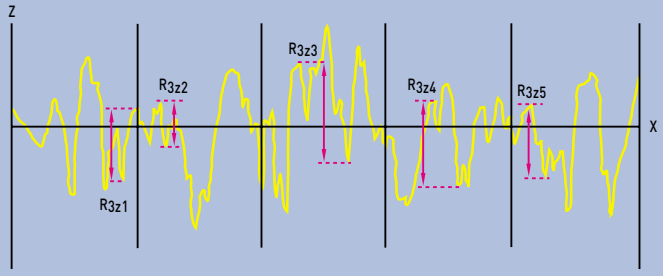
$$R_{ku} = \frac{1}{R_q^4}\left[\frac{1}{l}\int_0^l z^4(x)\,dx\right]$$

W_{sk}, W_{ku}, P_{sk} and **P_{ku}** are the corresponding parameters from the waviness and primary profiles, respectively.

RHSC

RHSC The high spot count is the number of complete profile peaks (within evaluation length) projecting above the mean line, or a line parallel with the mean line. This line can be set at a selected depth below the highest peak or a selected distance above or below the mean line.





R_z, W_z, P_z

***$R_z = R_p + R_v$** and is the maximum peak to valley height of the profile within a sampling length.

R_z1max is the largest of the individual peak to valleys from each sample length.

W_z, P_z are the corresponding parameters from the waviness and primary profiles respectively.

*See note 1 on page 3

R_{3z}, R_{3y} (R3z1max)

R_{3z} is the vertical mean from the third highest peak to the third lowest valley in a sample length over the assessment length. DB N31007 (1983).

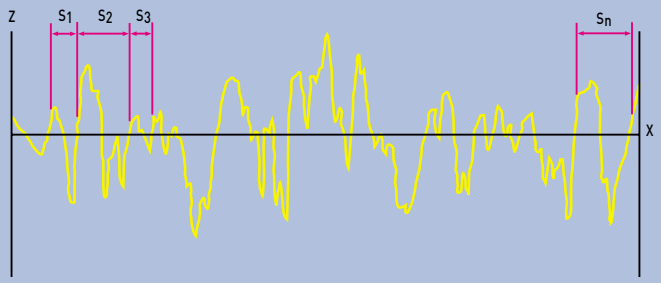
Where N = number of cut-offs, then

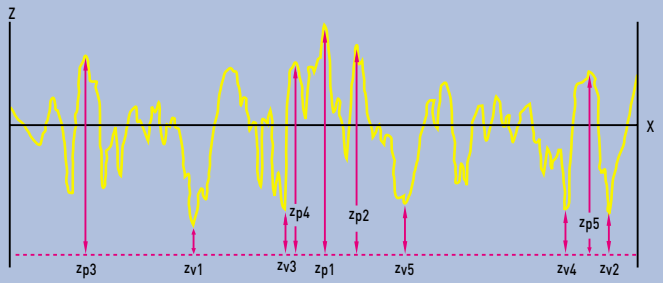
$$R_{3z} = \frac{1}{N} \sum_{i=1}^{i=N} R3zi = \frac{R3z1+R3z2+ \ldots +R3zN}{N}$$

R_{3y} (R3z1max) is the largest of the **R3zi, i=1...N** values.

The above parameters are non-ISO Standards but are application specific.

SPACING PARAMETERS





R_{Sm}, W_{Sm}, P_{Sm}

R_{Sm} is the mean spacing between profile peaks at the mean line, measured within the sampling length. (A profile peak is the highest point of the profile between an upwards and downwards crossing of the mean line).

Where n = number of peak spacings, then

$$R_{sm} = \frac{1}{n} \sum_{i=1}^{i=n} Si = \frac{S_1+S_2+S_3+ \ldots +S_n}{n}$$

W_{Sm} and **P_{Sm}** are the corresponding parameters from the waviness and primary profiles, respectively.

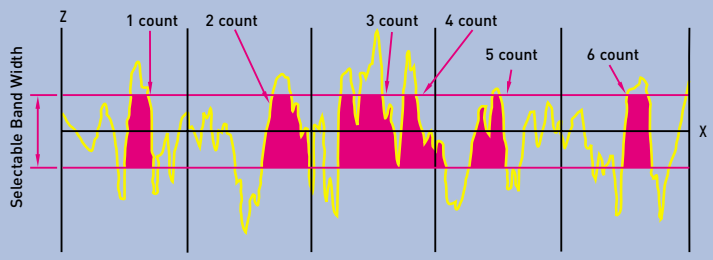
R_z (JIS), P_z (JIS)

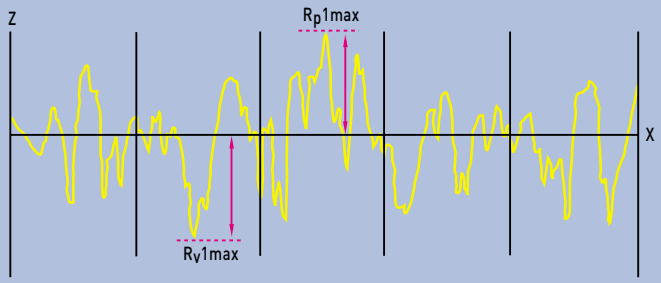
R_z (JIS) also known as the ISO 10 point height parameter in ISO 4287/1-1984, is measured on the roughness and primary profiles only and is numerically the average height difference between the five highest peaks and the five lowest valleys within the sampling length.

$$Rz\ (JIS) = \frac{(zp1+zp2+zp3+zp4+zp5)-(zv1+zv2+zv3+zv4+zv5)}{5}$$

$$= \frac{1}{5} \left(\sum_{i=1}^{i=5} zpi - \sum_{i=1}^{i=5} zvi \right)$$

P_z (JIS) is the corresponding parameter from the primary profile.





RP_c

RP_c is the peak count and is the number of local peaks which project through a selectable band centred about the mean line. The count is determined only over the assessment length, though the results are given in peaks per cm (or per inch). The peak count obtained from assessment lengths of less than 1 cm (or 1 inch) is obtained by using a multiplication factor. The parameter, should, therefore be measured over the greatest assessment length possible.

$$RP_c = \frac{\text{Nº. of counts}}{\text{Assessment length (cm)}} = \text{Peaks/cm}$$

R_v, R_p, R_t, W_v, W_p, W_t, P_v, P_p, P_t

***R_v** is the maximum depth of the profile below the mean line within the sampling length.

***R_p** is the maximum height of the profile above the mean line within the sampling length.

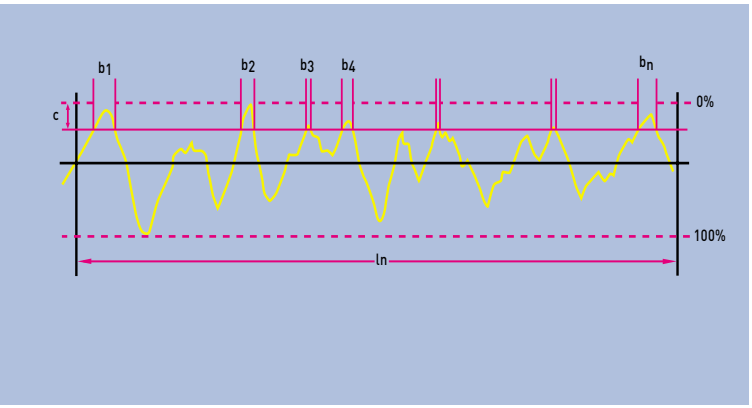
R_t is the maximum peak to valley height of the profile in the assessment length.

R_p1max is the largest of the individual peak to mean from each sample length.

R_v1max is the largest of the individual mean to valleys from each sample length.

W_v, W_p, W_t, P_v, P_p and **P_t** are the corresponding parameters from the waviness and primary profiles, respectively.

*See note 1 on page 3.

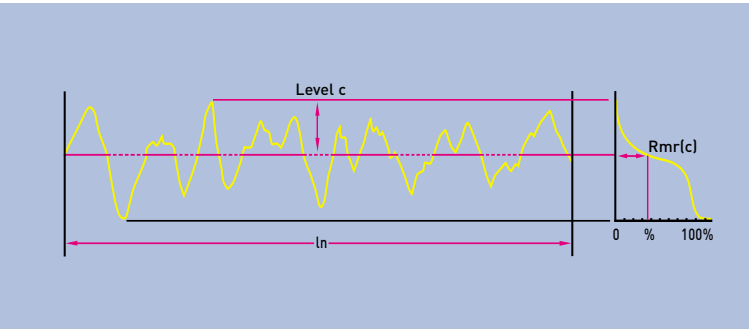


Material Ratio Rmr (c), Rmr

Material ratio Rmr (c) is the length of bearing surface (expressed as a percentage of the evaluation length ln) at a depth c below the highest peak.

$$Rmr\ (c) = \frac{b1+b2+b3+b4\ldots+bn}{ln} \times 100 = \frac{100}{ln} \sum_{i=l}^{i=n} bi$$

Rδc - the height difference between two section levels of given material ratio.



Note 1 - Almost all parameters are defined over one sample length, however in practice more than one sample length is assessed (usually five) and the mean calculated. This provides a better statistical estimate of the parameter's measured value.

All parameters using either Roughness, Waviness or Primary Profiles conform to the following assumptions:

T = Type of profile, either R (Roughness) or W (Waviness) or P (Primary)
n = Parameter suffix, for example: q, t, p, v, etc.
N = Number of measured sampling lengths

When a parameter is displayed as Tn (e.g. Rp), then it is assumed that the value has been measured over 5 sampling lengths. If the number of measured sampling lengths is other than 5 sampling lengths, then the parameter shall display this number thus TnN, e.g. Rp2.

Max Rule - If a parameter also displays max (e.g. Rpmax) then the measured value shall not be greater than the specified tolerance value. If max is not displayed (e.g. Rp) then 16% of the measured values are allowed to exceed the tolerance value.

If not otherwise indicated on a drawing, the following should be used to determine the cut-off λc (ISO 4288)-1997.

See ISO 4288-1996 for more details of the Max and 16% rules.

Taylor Hobson follows ISO 3274-1996, ISO 4287-1997, ISO 4288-1997, ISO 11 562 and other International Standards where appropriate.

RECOMMENDED CUT-OFF ISO 4288-1997				
PERIODIC PROFILES	NON-PERIODIC PROFILES		CUT-OFFS	SAMPLING LENGTH/ EVALUATION LENGTH
Spacing Distance Sm (mm)	R_z (µm)	R_a (µm)	λc (mm)	λc/L (mm)
>0.013 to 0.04	(0.025) to 0.1	(0.006) to 0.02	0.08	0.08/0.4
>0.04 to 0.13	>0.1 to 0.5	>0.02 to 0.1	0.25	0.25/1.25
>0.13 to 0.4	>0.5 to 10	>0.1 to 2	0.8	0.8/4
>0.4 to 1.3	>10 to 50	>2 to 10	2.5	2.5/12.5
>1.3 to 4	>50 to 200	>10 to 80	8	8/40