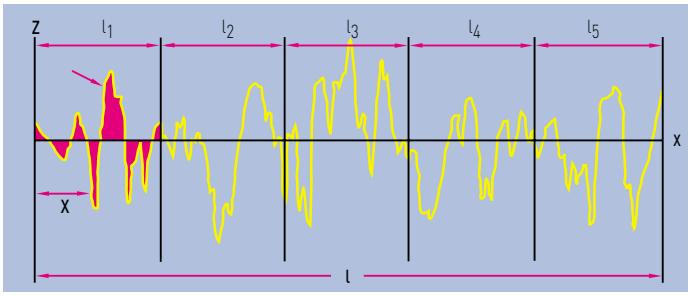
The Measurement of Surface Finish

Every surface has some form of texture which will vary according to the way it has been manufactured. Surface characteristics can be quantified by the use of parameters, the most popular of which are described here. Visit www.taylor-hobson.com for further explanation and a list of additional resources.

Amplitude Parameters



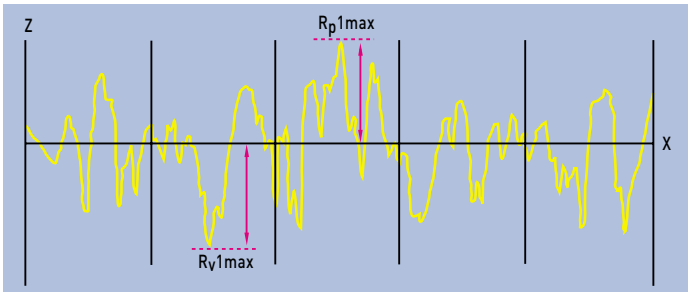
Ra, Rq, Wa, Wq, Pa, Pq

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

Rq (sometimes referred to as RMS) is the rms parameter corresponding to Ra.

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

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



Rv, Rp, Rt, Wv, Wp, Wt, Pv, Pp, Pt

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

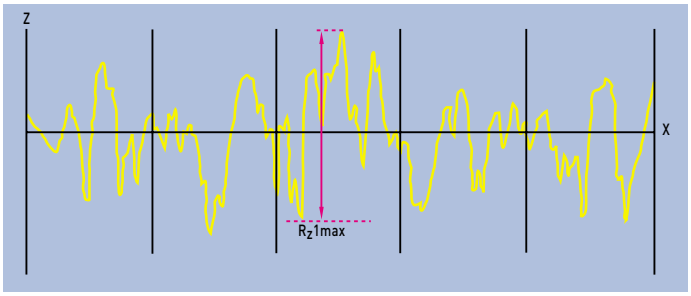
Rp is the maximum height of the profile above the mean line within the sampling length.

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

Rp1max is the largest of the individual peak to mean from each sample length.

Rv1max is the largest of the individual mean to valleys from each sample length.

Wv, Wp, Wt, Pv, Pp, and **Pt** are the corresponding parameters from the waviness and primary profiles, respectively.

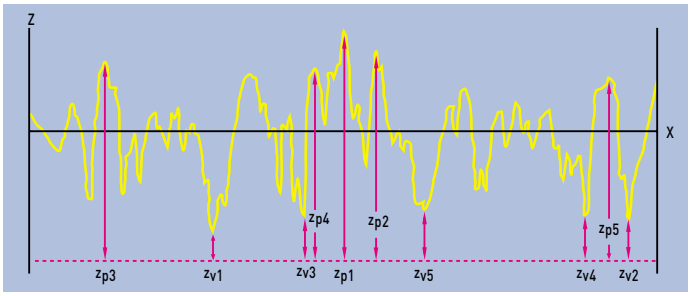


Rz, Wz, Pz

Rz = Rp + Rv and is the maximum peak to valley height of the profile within a sampling length.

Rz1max is the largest of the individual peak to valleys from each sample length.

Wz, Pz are the corresponding parameters from the waviness and primary profiles respectively.



Rz (JIS), Pz (JIS)

Rz (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.

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

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

Cut-off, Evaluation and Sample lengths

A cut-off is a filter that uses electronic or mathematical means to remove or reduce unwanted data in order to look at wavelengths in the region of interest. Sample lengths are equal to the filter cut-off length λc (see table at right) and are long enough to include a statistically reliable amount of data.

The evaluation length (l) is defined as the length of profile used for the measurement of surface roughness parameters. It usually contains several sample lengths with five consecutive sample lengths taken as standard.

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

Selecting the proper cut-off length

RECOMMENDED CUT-OFF ISO 4288-1997				
PERIODIC PROFILES	NON-PERIODIC PROFILES		CUT-OFFS	SAMPLING LENGTH / EVALUATION LENGTH
Spacing Sm (mm)	R_z (µm)	R_a (µm)	λc (µm)	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

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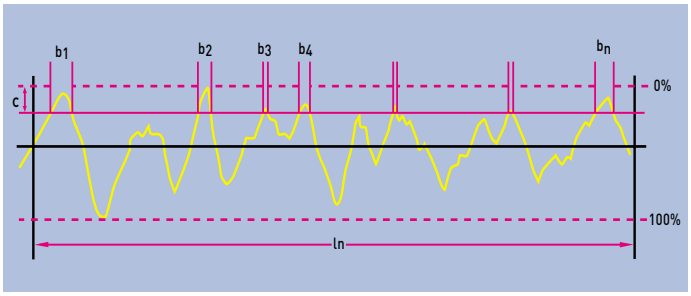
Hybrid Parameters

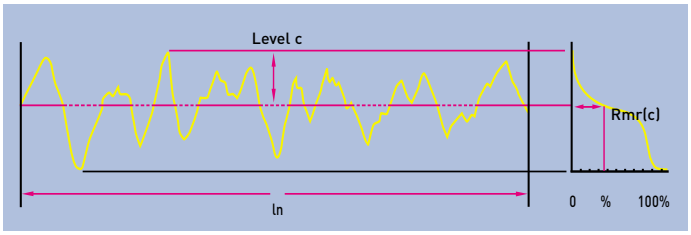


Material Ratio Rmr (c), Rmr

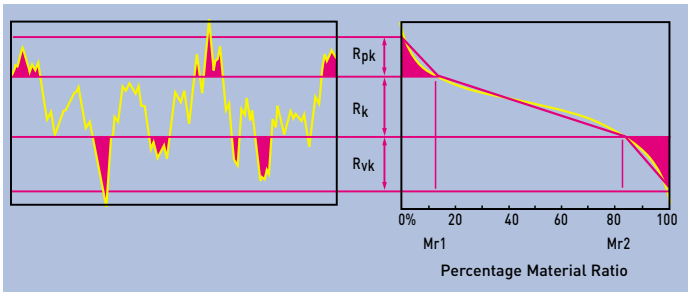
Material ratio Rmr (c) is the length of bearing surface (expressed as a percentage of the evaluation length ln) at a depth c below the highest peak.

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

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



The Material Ratio curve (or Abbot Firestone curve) above shows how the ratio varies with level.



Rpk, Rk, Rvk, Mr1, Mr2

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

The filter used in Rk is 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.

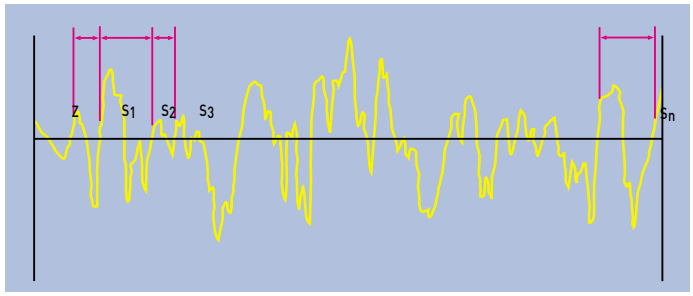
Rk is the Core Roughness Depth – the long term running surface which will influence the performance and life of the cylinder. (The depth of the Roughness Core Profile).

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 at the upper limit of the roughness core.

Mr2 is the Material ratio at the lower limit of the roughness core.

Spacing Parameters



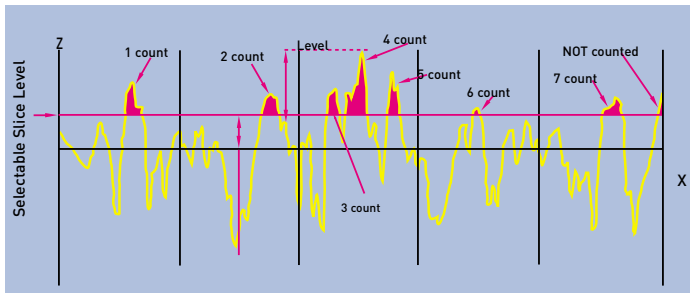
RSm, WSm, PSm

RSm 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:

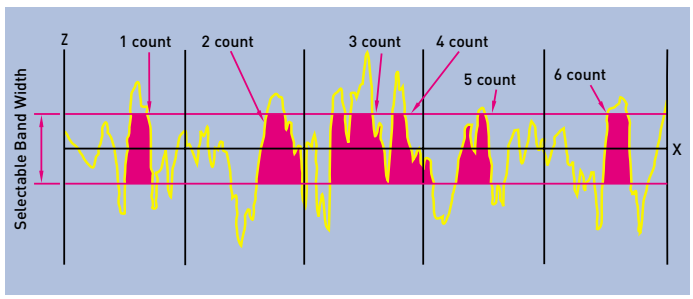
$$R_{sm} = \frac{1}{n} \sum_{i=1}^{i=n} Si = \frac{S_1+S_2+S_3+\ldots+S_n}{n}$$

WSm and **PSm** 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 the evaluation length) projecting above the mean line, or above 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.



RPc, WPc, PPc (Peak Count)

RPc is the number of local peaks which project through a selectable band centered about the mean line. The count is determined only over the assessment length, although the results are given in peaks per cm (or peaks per inch). A multiplication factor is used to dertermine peak count when the assessment length is less than 1cm (or 1in) therefore the greatest possible assessment length should be measured.

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

WPc and **PPc** are the corresponding parameters from the waviness and primary profiles, respectively.

Note, parameters and procedures are as determined in ISO 4287-1997, ISO 4288-1996, ISO 11 562 and other international standards and followed where appropriate by Taylor Hobson equipment.