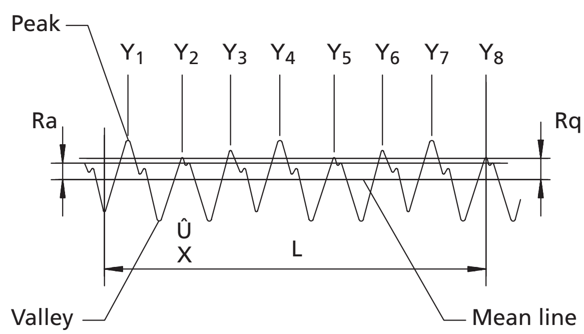
Surface Finish (Measurement Methods)

R_a - Arithmetic Average Roughness

Roughness averages are the most commonly used parameters because they provide a simple value for accept/reject decisions. Arithmetic average roughness, or R_a, is the arithmetic average height of roughness-component irregularities (peak heights and valleys) from the mean line, measured within the sampling length, L. See figure 29.

The measurements are taken as the fine point of the stylus on a profilometer which traverses the sampling length on the surface being measured.



$$Ra = \frac{1}{L}\int_0^L |y(x)|dx$$

$$Rq = \sqrt[n]{\frac{1}{L}\int_0^L Y^z(x)dx}$$

Y = individual measured peak height

Figure 29 Surface Finish - R_a Versus R_q

R_q - Geometric Average Roughness

R_q is the current term for what was formerly called root-mean-square or RMS. R_q is more sensitive to occasional highs and lows, making it a valuable complement to R_a. R_q is the geometric average height of roughness-component irregularities from the mean line measured within the sampling length, L. Compare to R_a in Table V.

The main difference in the two scales is that R_q amplifies occasional high or low readings, while R_a simply averages them. For a given surface, therefore, the Rq value will be higher than the Ra value (by approximately 11%). That is, a surface finish that measures R_q 0.5 µm is equivalent to approximately R_a 0.45 µm.

Table V Surface Finish Conversion Table

R_a, AA, CLA		R_q or RMS	German-Swiss Norm[1]
English (min.)	Metric (mm)	English (min.)	
0.9	0.02	**1.0**	
1.0	0.03	1.1	**N1**
1.8	0.05	**2.0**	
2.0	0.05	2.2	**N2**
3.6	0.09	**4.0**	
4.0	0.10	4.4	**N3**
5.4	0.14	**6.0**	
7.2	0.18	**8.0**	
8.0	0.20	8.9	**N4**
10.8	0.28	**12.0**	
14.4	0.37	**16.0**	
16.0	0.41	17.8	**N5**
28.8	0.73	**32.0**	
32.0	0.81	35.5	**N6**
56.8	1.44	**63.0**	
63.0	1.60	69.9	**N7**

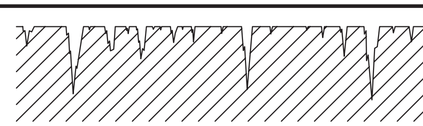
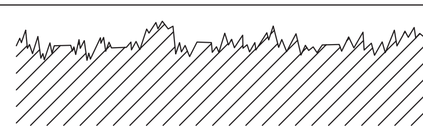
R_a : Arithmeric average roughness
AA : Arithmeric average
CLA : Center Line Average
R_q : Geometric average roughness
RMS : Root-mean-square

1) The German-Swiss Norm is a series of roughness-grade numbers used to avoid confusion with numerical values of other types.

Improved Measurement Methods

The R_a measurement does not give a true picture of the real surface profile. The finish process plays a very important role in the outcome. In particular, the open profile "Peak Structure" can seriously affect seal performance, as its jagged structure can cut and nick the seal surface. On the other hand the closed profile form "valley structure", gives improved seal performance, because the valleys retain fluid and lubricate the running seal surface. Please see Table VI.

Table VI R_a Comparison

Surface Profile	R_a
	0.2
	0.2

Even with identical R_a values, the resulting seal performance will be very different.

An improved surface measurement method is described in the new ISO 13565-1 / -2 / -3, including the peak, valley and material ratios as described below.

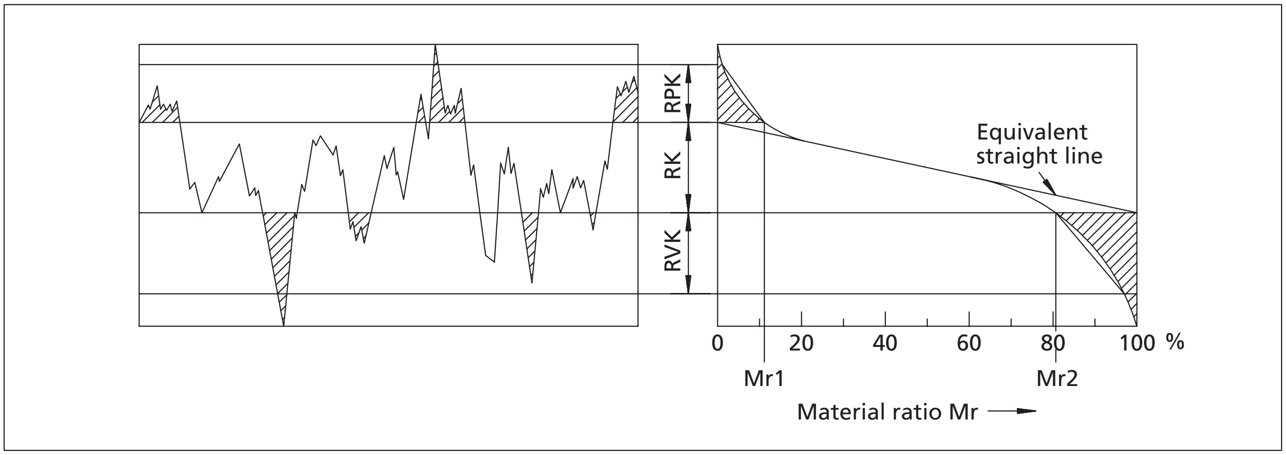


Figure 30 Abbot Curve

R_k (Core Roughness)
The core roughness depth is the depth of the roughness core profile.

M_r (Material Ratio)

M_{r1} in %
The material portion M_{r1} is determined by the intersecting line which separates the protruding peaks from the roughness core profile.

M_{r2} in %
The material portion M_{r2} is determined by the intersecting line which separates the valleys from the roughness core profile.

R_{pk} (Reduced peak height)
The reduced peak height R_{pk} is the average height of the protruding peaks above the roughness core profile.

R_{vk} (Reduced valley depth)
The reduced valley depth R_{vk} is the average depth of the profile valleys projecting through the roughness core profile.

The harder the material the more important it is to reduce the peak height R_{pk}. If mating surface is ceramic, the R_{pk} value must be down to 0.05 μmm because the hard peaks will cut into the seal surface.

Other surface parameters are skewnesss and kurtosis, which give a more detailed picture of the surface. For explanation see Figure 31 below.

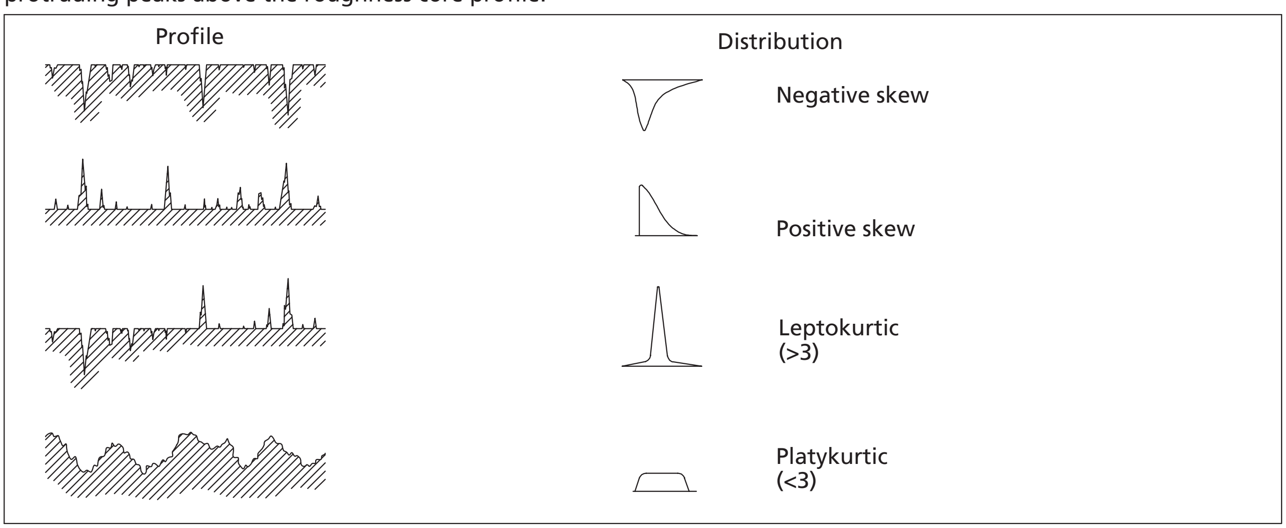


Figure 31 Surface Measurement Visualized