Surface Roughness Standards

For Metal Face Seal & Elastomeric O-Rings

Content:

- Defining Surface Finish
- Understanding the Surface Roughness Parameters
- Significance of roughness in Metal – Rubber Contact
- Approach to control the surface roughness values.

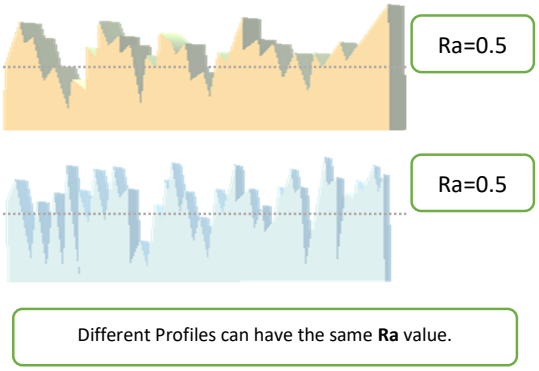
Defining Surface Finish:

Particularly about the Metal Face Seals the surface finish attribute directly controls the sealing performance. The Metal Surface however clean appears, bears a unique pattern of peaks and valleys that is called as Surface Finish or Surface Roughness, often measured in thousandth part of a meter. An optimized surface profile consists of valleys aimed for the lubrication and avoiding the high concentration of peaks in the given area. This texture of peaks and valleys creates a pocketing arrangement on the surface thereby an adequate lubrication oil film is retained that in terns reduces the friction and wear, Whereas highly concentrated peaks on a surface profile can causes excessive and early wear during the relative frictional movement of the surfaces. Hence defining and controlling surface finish attribute is one of the most critical and significant aspects, while dealing with dealing surfaces, in order to assure the life and the reliability of the seal.

Conventionally the arithmetic average of the roughness value measured in a given profile (in thousandth part of a meter) is termed to be a Standard in predicting the goodness of the surface, and is termed in Ra. **However the Ra value alone is not sufficient to properly define the surface finish.** The illustrations below will explain significance of other parameters apart from Ra, to collectively define the Surface roughness attribute, and hence for the complete understanding of surface roughness all these surface measurement parameters must be considered. Since the **Ra** is only an average value, it could be same for different topographies even those contain concentration of Peaks or Valleys or the distribution of peaks and valleys in a random intervals. What is significant for the desirable surface topography is the availability or non-availability of volume for retention of lubrication film or an area for intended frictional behavior.

Significant Surface Roughness Measurements

- Ra = Arithmetical mean roughness value
- Rt = Total height of roughness profile
- Rz = Mean roughness depth
- Rp = Maximum Profile Peak Height
- Rsk = The degree of skew
- tp (Rmr) = Profile Bearing Ratio



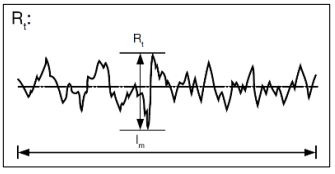
Definitions:

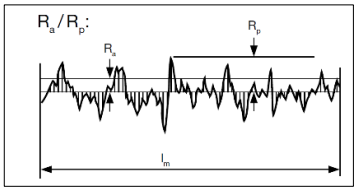
Ra is Arithmetical mean of all absolute roughness values in the given length of the trace.

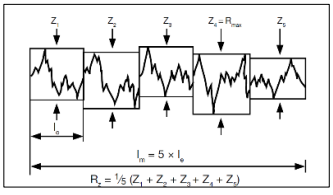
Rt is the vertical distance between the highest and the lowest points in a roughness profile over the length of the trace.

Rz is the average roughness value of 5 consecutive trace lengths, and so is more preferred over Ra.

Rp is the Depth roughness, defined as the vertical distance between the highest point and the centerline of the profile.







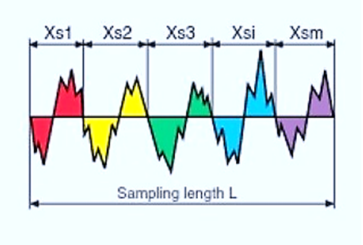
Understanding the Surface Parameters

1. Spacing Parameters:

{RSm, PSm,WSm} Mean width of the profile

Mean width of the profile elements width Xs within a sampling length.

RSm, PSm,WSm = $= \frac{1}{m}\sum_{i=1}^{m} Xsi$

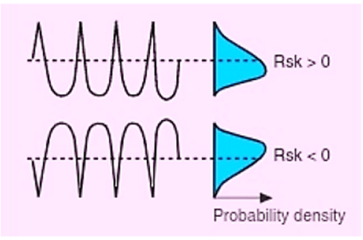


2. Height Characteristic Average Parameters:

a. {Rsk,Psk,Wsk} Skewness

Skewness is the Quotient of mean cube value of the ordinates value Z(x) and cube Pq,Rq,Wq respectively within a sampling length.

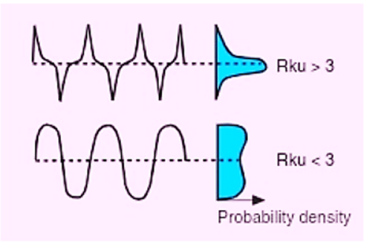
$$\text{Rsk} = \frac{1}{Rq^3}\left[\frac{1}{\text{lr}}\int_0^{\text{lr}} \text{Z}^3(\text{x})\text{dx}\right]$$



b. {Rku,Pku,Wku} Kurtosis of Profile

Quotient of mean quartic value of the Ordinate value Z(x) and the 4th power of Pq, Rq, Wq respectively within a sampling length.

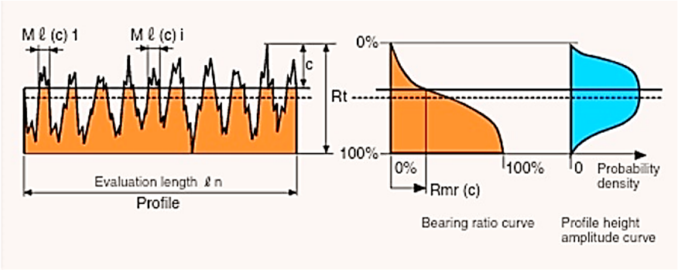
$$Rku = \frac{1}{Rq^4}\left[\frac{1}{lR}\int_0^{lr} Z^4(x)dx\right]$$



Parameters from Bearing Ratio curve and Profile height amplitude curve

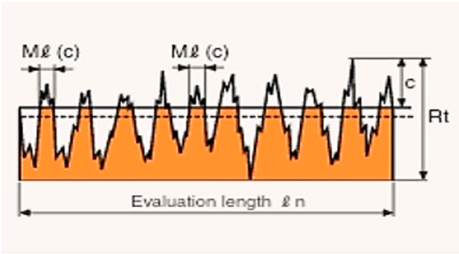
a. **Material Ratio Curve of the profile** (Abbott Firestone Curve) - is a curve representing the material ratio of the profile as a function of level 'c'

b. **Profile Height Amplitude Curve** is sample probability density function of ordinate Z(x) within an evaluation length.



c. {Rmr(c), Pmr(c), Wmr (c)} **Material Ratio of Profile** (Rmr(c) =ex-tp) is the Ratio of the material length of the profile elements Ml(c) at a given level 'c' to the evaluation length.

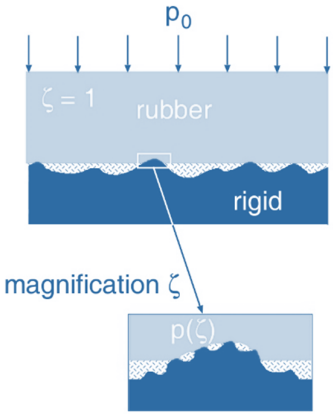
$$Rmr(c) = \frac{100}{ln}\sum_{i=1}^{m} Ml(c), \%$$



Approach to control the surface roughness values:

1. Metal Face Seal & Elastomeric O-ring Contact Friction Considerations

MFS & O ring contact (sealing effectiveness) is attributed to the Surface Finish of metal seal, the Hardness of the O-Ring and the compression force acting upon the joint on account of the assembly conditions. SAP Parts sealing designs are hence configured to address these specifications to an extent Elastomer Hardness Shore A (55~70), Compression (25~45)% and bear the roughness values for mating parts that is for the seal housing cavity as listed below.



Parameter	MFS - Seal Housing Cavity (Ramp Angle)
Ra	3.75 ~ 6.25 λ 2.5 mm
Rz	20 ~ 40 Max.
Rp	20 Max.
Rsm	250 Min.
Rsk	-0.5 to -1
Rku	≤ 2.5
Tp (25%)	25 ~ 70 @depth of P=0.25 Rz reference line Co=5%Tp

2. Metal Part Machining Controls
   a. CNC Turning operation : Tool travelling Feed range :-(F) 0.33 - 0.38 mm/min. *(only at roughness required portion)*
   b. Recommended Depth of the cut: 0.2mm
   c. Recommended Insert radius: 0.4 mm