



# Quaker Knowledge Network

## Surface Finish

### Skill Builder

#### Overview

We have all heard the expression, “as smooth as glass,” but how many of us know what that really means? Every surface has a texture no matter how smooth it looks to the naked eye. In metalworking, some customers are very concerned about this texture in what they refer to as the “surface finish” of the part. Some metal components or parts must have extremely smooth surfaces to function properly. Most bearing surfaces are subjected to grinding to control the surface finish while honing and reaming are two machining methods employed to provide a smooth finish. Surface finish requirements vary depending upon the customer and the part.

#### Measurements

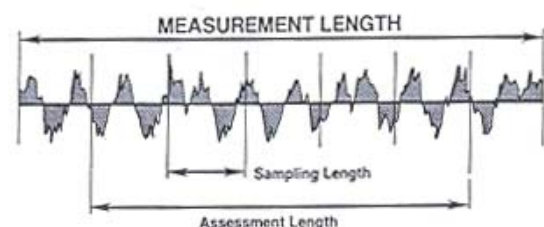
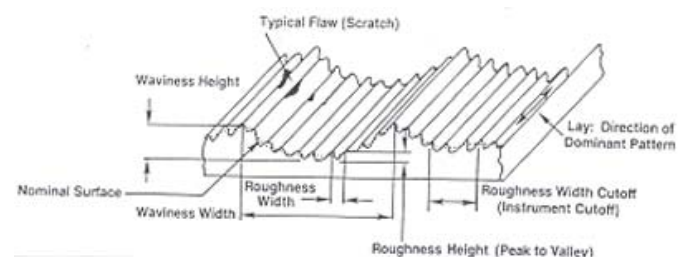
The surface finish or smoothness of the machined or ground part is typically measured in micro-inches ( $\mu$  in) or microns. The Greek letter mu ( $\mu$ ) is used as an abbreviation for “micro” and it looks like a fancy lower case U. Both optical and physical instruments can be employed to measure a surface. The most common method is the physical method using a profilometer. This device measures the peaks and valleys of a surface in the exact same fashion as the stylus of a record player. With a record player, a diamond tip rides up & down the grooves of the record and translates the vibrations into music. The stylus of the profilometer operates in a similar fashion. The device that controls the measurement can be adjusted to determine how much of the surface is “assessed.”

There are applications where the surface finish can reach as low as 1.0 micro-inch or finer! Remember the lower the number or value the smoother the finish. (By the way, glass is typically about 4 micro-inches. This means there are metalworking operations that produce finishes smoother than glass!)

The most common measurement is Ra, which is average roughness. Another value is Rrms, which is root mean square roughness. Rrms are sometimes expressed as Rq. Both of these measurements employ basic arithmetic calculations to produce a value. Ra uses an arithmetic average, which is simply adding all of the values and dividing by the number of values. The root mean square method is the square root of the average value of the square of the quantity. Ra is used more often than Rrms. A wide range of calculations can be used depending upon the parameters that are most important to the customer.

#### Describing the Surface

To the naked eye, a surface may appear to be very smooth. But imagine that you are a tiny insect. At this new level, the world around you takes on a different perspective. A tiny scratch is now a significant hill to traverse. This is the perspective we need to remember when we think of the surface. Specific terminology is used to describe the surface as viewed by the measuring device. Figures A & B illustrate the terms that are described below in alphabetical order.





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#### Describing the Surface Cont.

Assessment length - distance traveled by the profilometer for the average profile. This should cover at least five cut-off lengths.

Cut-off - the same as sampling length (see sampling length below).

Flaws - nicks, scratches and other naturally occurring surface marks that can be ruled out of the surface measurements.

Lay - orientation of the pattern, which is generated by the machining or grinding method and is also referred to as the surface lay.

Measurement length - maximum length available of which the assessment length is a subset.

Nominal surface - what you would expect to see and would be similar to a technical drawing. All values are compared to the nominal surface.

Peaks and valleys - actual high and low points that the stylus rides on while measuring roughness.

Sampling length - pre-selected distance that the profilometer will assess. This is also called the cut-off length.

Skewness - the parameter that defines the distribution of the peaks and valleys relative to the mean.

Waviness - the measure of the larger irregularities formed on the surface normally measured at intervals larger than that of roughness.

#### Process

The various metalworking operations produce different surface finishes. A list of typical metal removal processes is shown on page three. The ranges shown are typical of the processes. However, better or worse values can be achieved under special circumstances. The indicators in the table clearly show why some applications are used over others.

#### Lubrication

Lubrication by the metal removal fluid has a tremendous impact on the surface finish. Therefore, concentration control plays a key role in producing finer finishes. Using the correct speeds and feeds is important too. Higher lubrication products contain either boundary lubrication and/or extreme pressure lubrication.

#### Summary

This Skill Builder gives you the basic knowledge about how surface finish is measured and described.

Note: Illustrations and Table from "[Metalworking Fluids](#)," Jerry Byers, Marcel Dekker, Inc. 1994, p. 52-58.

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PROCESS	ROUGHNESS HEIGHT (IN MICROINCHES)											
	<<<<< rougher								smoother >>>>>			
	2000-1000	1000-500	500-250	250-125	125-63	63-32	32-16	16-8	8-4	4-2	2-1	1.0-0.5
Drilling												
Chemical Milling												
Milling												
Broaching												
Reaming												
Boring, Turning												
Roller Burnishing												
Grinding												
Honing												
Polishing												
Lapping												
Super Finishing												
	50.8-25.4	25.4-12.7	12.7-6.35	6.35-3.18	3.18-1.60	1.60-0.81	0.81-0.40	0.40-0.20	0.20-0.10	0.10-0.05	0.05-0.025	0.025-0.013
	<<<<< rougher				ROUGHNESS HEIGHT (IN MICROMETERS)				smoother >>>>>			
		=	AVERAGE APPLICATION									
		=	LESS FREQUENT APPLICATION									