Varieties of Surface Roughness

The definitions and notation are prescribed for the parameters which indicate the surface roughness of an industrial product, including the arithmetic average roughness (Ra), maximum height (Ry), 10-spot average roughness (Rz), average concave-to-convex distance (Sm), average distance between local peaks (S), and load length rate (tp). Surface roughness is the arithmetic average of values at randomly selected spots on the surface of an object.

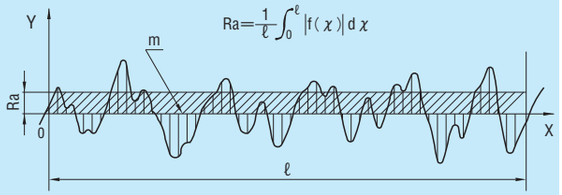
[Center-line average roughness (Ra_{75}) is defined in the supplements to JIS B 0031 and JIS B 0601.]

Typical calculations of surface roughness

Arithmetical average roughness (Ra)

A portion stretching over a reference length in the direction in which the average line extends is cut out from the roughness curve. This portion is presented in a new graph with the X axis extending in the same direction as the average line and the Y axis representing the magnitude. When the roughness curve is represented by $y=f(x)$, Ra is the value in microns (μm) found from the formula shown at right.

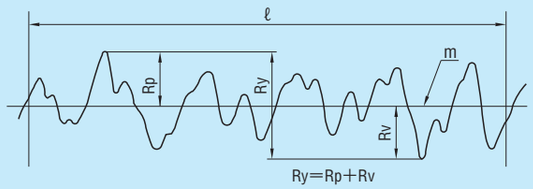
$$Ra=\frac{1}{\ell}\int_0^{\ell}|f(x)|\,dx$$



Maximum height (Ry)

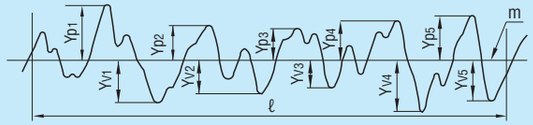
A portion stretching over a reference length in the direction in which the average line extends is cut out from the roughness curve. The gap between the peak line and valley line in this portion is measured in the direction of the magnitude axis, and this value is indicated in microns (μm).

Note: When finding Ry, the reference length is selected from a portion which contains no abnormally high peaks or abnormally low valleys (locations which are likely flaws).



Ten-spot average roughness (Rz)

A portion stretching over a reference length in the direction in which the average line extends is cut out from the roughness curve. Within this portion, the average absolute value of the height (Yp) of the five highest peaks as measured from the average line and the average absolute value of the height (Yv) of the five lowest valleys are added together. Rz is this sum, in microns (μm).



$$Rz=\frac{|Yp_1+Yp_2+Yp_3+Yp_4+Yp_5|+|Yv_1+Yv_2+Yv_3+Yv_4+Yv_5|}{5}$$

$Yp_1, Yp_2, Yp_3, Yp_4, Yp_5$: Heights of the of top five peaks within the sampled portion of reference length ℓ

$Yv_1, Yv_2, Yv_3, Yv_4, Yv_5$: Heights of the five lowest valleys within the sampled portion of reference length ℓ

Reference: Relationship Between Arithmetic Average Roughness (Ra) and Previous Notation

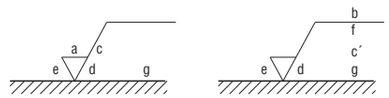
Arithmetical average roughness Ra			Max. height Ry	Ten-spot average roughness Rz	Ry·Rz reference length ℓ (mm)	Conventional finishing symbol
Standard sequence	Cut-off value λc (mm)	Drawing indication of surface texture	Standard sequence			
0.012 a	0.08	0.012 ~ 0.2	0.05 s	0.05 z	0.08	▽▽▽▽
0.025 a	0.25		0.1 s	0.1 z		
0.05 a			0.2 s	0.2 z	0.25	
0.1 a			0.4 s	0.4 z		
0.2 a			0.8 s	0.8 z		
0.4 a	0.8	0.4 ~ 1.6	1.6 s	1.6 z	0.8	▽▽▽
0.8 a			3.2 s	3.2 z		
1.6 a			6.3 s	6.3 z		
3.2 a	2.5	3.2 ~ 6.3	12.5 s	12.5 z	2.5	▽▽
6.3 a			25 s	25 z		
12.5 a	8	12.5 ~ 25	50 s	50 z	8	▽
25 a			100 s	100 z		
50 a	—	50 ~ 100	200 s	200 z	—	~
100 a			400 s	400 z		

※The relationships among the three varieties shown here are not precise, and are presented for convenience only.
※Ra: The evaluation lengths of Ry and Rz are the cut-off values and the reference length each multiplied by five.

Position of Auxiliary Symbols for Surface Symbols

An auxiliary symbol indicating a surface roughness value, cut-off value or reference length, machining method, grain direction, surface undulation, etc. is placed around the surface symbol as shown in Fig. 1.

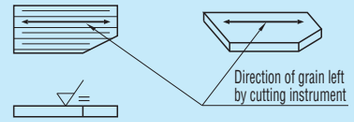
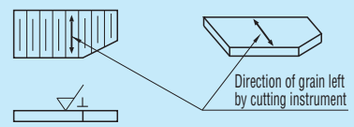
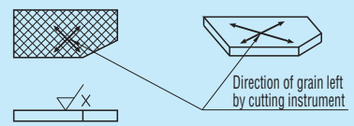
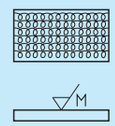
Fig. 1 Positions of Auxiliary Symbols



a: Ra value
b: Machining method
c: Cutoff value・Evaluation length
c´: Reference length・Evaluation length
d: Grain direction
f: Parameter other than Ra (when tp, this is parameter / cutoff level)
g: Surface undulation (according to JIS B 0610)

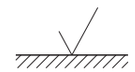
Remark : Symbols other than a and f shall be entered when needed.

Reference : In ISO 1302, a finish allowance is entered at the location of e in Figure 1.

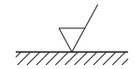
Symbol	Meaning	Diagram
=	Direction of grains left by the cutting instrument are parallel to the projection plane of the drawing where the symbol is entered. Example: Shaped surface	
⊥	Direction of grains left by the cutting instrument are perpendicular to the projection plane of the drawing where the symbol is entered. Examples: Shaped surface (side view), circular cut, cylindrical cut	
X	Direction of grains left by the cutting instrument intersect in 2 directions at angles to the projection plane of the drawing where the symbol is entered. Example: Honed surface	
M	Direction of grains left by the cutting instrument intersect in multiple directions or have no direction. Examples: Lapped surface, superfinished surface, and surface finished by front milling or end milling with cross feed	
C	Grains left by the cutting instrument are virtually concentric around the center of the projection plane of the drawing where the symbol is entered. Example: Facing surface	
R	Grains left by the cutting instrument are virtually radial with respect to the center of the projection plane of the drawing where the symbol is entered.	

■Examples of surface symbols

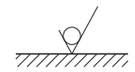
Surface symbol



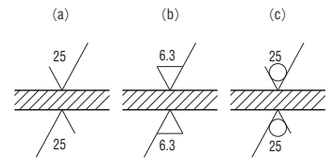
Symbol indicating a surface that requires a removal process



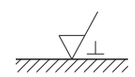
Symbol indicating a surface where removal processes are prohibited



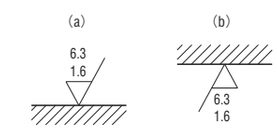
Examples of indicating the Ra upper limit



Example of indicating grain direction



Examples of indicating Ra upper limit and lower limit



Examples of indicating the machining method