

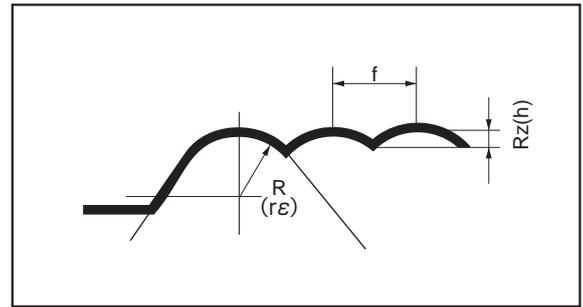
Surface Roughness (JIS B 0601-2001)

Theoretical (Geometrical) Surface Roughness

Theoretical Surface Roughness at Turning indicates the minimum roughness value from the cutting conditions and it is shown by the formula as follows:

$$Rz(h) = \frac{f^2}{8R(r\epsilon)} \times 10^3$$

$Rz(h)$: Theoretical Surface Roughness (μm)
 f : Feed Rate [mm/rev]
 $R(r\epsilon)$: Corner Radius of Insert [mm]



How to Obtain Surface Roughness Values

Type	Symbol	How to Obtain	Explanation
Max. Height Roughness	Rz	Ry is obtained from the distance in micron meter between the highest peak and the lowest valley in the range of sampled reference length (l) to the direction of mean line of the roughness curve. $Rz = Rp + Rv$	
Ten Points Mean Roughness	RzJIS	Rz is obtained from the total in micron meter of the mean value of the each distance between the mean line and 5 peaks (Yp) from the highest one, and the mean value of the each distance between the mean line and the 5 valleys (Yv) from the lowest one, of the roughness curve in the range of sampled reference length " l ". $Rz_{JIS} = \frac{(Yp1+Yp2+Yp3+Yp4+Yp5) + (Yv1+Yv2+Yv3+Yv4+Yv5)}{5}$	 <i>Yp1, Yp2, Yp3, Yp4, Yp5:</i> Distance from the mean line to highest 5 peaks in the range of sampled reference length " l " <i>Yv1, Yv2, Yv3, Yv4, Yv5:</i> Distance from the mean line to the lowest 5 valleys in the range of sampled reference length " l "
Arithmetical Mean Roughness	Ra	Ra is obtained from the following formula in micron meter when the roughness curve is expressed by $y=f(x)$, taking X-axis to the mean line direction and Y-axis to the vertical magnification of the roughness curve in the range of sampled reference length " l ". $Ra = \frac{1}{l} \int_0^l f(x) dx$	

Relationship with Triangle Symbol

Arithmetical Mean Roughness Ra(μm)	Max. Height Roughness Rz(μm)	Ten Points Mean Roughness RzJIS(μm)	Note: (Relationship with Triangle)
0.025	0.1	0.1	▽▽▽
0.05	0.2	0.2	
0.1	0.4	0.4	
0.2	0.8	0.8	
0.4	1.6	1.6	▽▽
0.8	3.2	3.2	
1.6	6.3	6.3	
3.2	12.5	12.5	▽
6.3	25	25	
12.5	50	50	▽
25	100	100	

Note: Finishing symbol (Triangle▽ and wave~) was abolished from JIS standard from 1994 Revision.

How to Indicate

Example

- ① When Ra is $1.6\mu\text{m}$ → $1.6\mu\text{m}Ra$
- ② When Rz is $6.3\mu\text{m}$ → $6.3\mu\text{m}Rz$
- ③ When RzJIS is $6.3\mu\text{m}$ → $6.3\mu\text{m}Rz_{JIS}$

Indication in JIS Standard

Example of Ra Indication	Example of Ry, (Rz) Indication
① When indicating the upper limit only (when upper limit is $6.3\mu\text{m}Ra$) 	① When indicating upper limit only Indicate surface roughness following the parameter symbol.
② When indicating both lower and upper limit (when upper limit is $6.3\mu\text{m}Ra$, lower limit is $1.6\mu\text{m}Ra$) 	② When indicating both lower and upper limit Indicate surface roughness as (upper limit ~ lower limit) following the parameter symbol.

Note: The indications of Ra and Rz are different.

Surface Roughness Symbol Caution

The above information is based on JIS B 0601-2001. However, some symbols were revised as shown in the right table in accordance with ISO Standard from JIS B 0601-2001 version. Ten Points Mean Roughness (Rz) was eliminated from 2001 version but it still remains as RzJIS reference, since it was popular in Japan.

Type	Symbol of JIS B 0601-1994	Symbol of JIS B 0601-2001
Max. Height Roughness	Ry	Rz
Ten Points Mean Roughness	Rz	(RzJIS)
Arithmetical Mean Roughness	Ra	Ra

1. Varieties of Surface Roughness Indicators

Definitions and presentations of 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 are given as parameters indicating the surface roughness of an industrial product. Surface roughness is the arithmetical average of values at randomly extracted spots on the surface of an object.

[Centerline average roughness(Ra75)is defined in the supplements to JIS B 0031 and JIS B 0601.]

Typical calculations of surface roughness

<p>Arithmetic Average Roughness Ra</p> <p>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. Ra is represented by the equation shown at right, in microns(μm).</p>	
<p>Maximum Height Ry</p> <p>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 the trough line is measured in the direction in which the magnitude axis extends, in microns(μm).</p> <p>Reference A portion without an abnormally high peak or abnormally low trough, which may be regarded as a flaw, is cut out over the reference length.</p>	
<p>Ten-spot Average Roughness Rz</p> <p>A portion stretching over a reference length in the direction in which the average line extends is cut out from the roughness curve. The average of the levels(Yp)of the highest peak to the fifth highest peak as measured from the average line and the average of the levels(Yv)of the lowest trough to the fifth lowest trough similarly measured in the said portion are added together. Rz is this sum, in microns(μm).</p>	

Reference Relation between Arithmetic Average Roughness(Ra)and Conventional Parameters

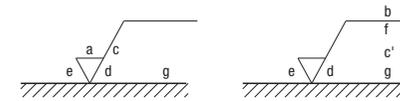
Arithmetic Average Roughness Ra			Maximum Height Ry	Ten-spot Average Roughness Rz	Reference Length of Ry(Rz) l(mm)	Conventional Finish Symbol
Standard Series	Cut-off Value c(mm)	Graphical Representation of Surface Texture	Standard Series	Standard Series		
0.012 a	0.08		0.05 s	0.05 z	0.08	
0.025 a			0.1 s	0.1 z		
0.05 a			0.2 s	0.2 z		
0.1 a			0.4 s	0.4 z		
0.2 a			0.8 s	0.8 z		
0.4 a	0.25		1.6 s	1.6 z	0.25	
0.8 a			3.2 s	3.2 z		
1.6 a			6.3 s	6.3 z		
3.2 a	0.8		12.5 s	12.5 z	0.8	
6.3 a			25 s	25 z		
12.5 a	2.5		50 s	50 z	2.5	
25 a			100 s	100 z		
50 a			200 s	200 z		
100 a	8		400 s	400 z	8	
	-				-	

*Interrelations among the three types shown here are not precise, and are presented for convenience only.
*Ra: The evaluation values of Ry and Rz are the cut-off value and the reference length each multiplied by five, respectively.

1. Positions of Auxiliary Symbols for Surface Symbol

A surface roughness value, cut-off value or reference length, machining method, grain direction, surface undulation, etc. are indicated around the surface symbol as shown in Fig. 1 below.

Fig. 1 Positions of Auxiliary Symbols



- a : Ra Value
- b : Machining Method
- c : Cut-Off Value, Evaluation Length
- c' : Reference Length, Evaluation Length
- d : Grain Direction
- f : Parameter other than Ra(tp:Parameter/Cut-Off Level)
- g : Surface Undulation(JIS B 0610)

Reference These symbols except a and f are provided when they are needed.

Reference Under ISO 1302, a finish range should be indicated as e in Fig. 1.

Code	Meaning	Illustration
=	The trace left by a cutting instrument is parallel to the projection plane in the drawing. Ex. Shaped Surface	
⊥	The trace left by a cutting instrument is perpendicular to the projection plane in the drawing. Ex. Shaped Surface(Side View) Circular Cut, Cylindrical Cut	
X	The pattern left by a cutting instrument diagonally crosses the projection plane in the drawing. Ex. Honed Surface	
M	The pattern left by a cutting instrument crosses in various directions or has no grain direction. Ex. Lapped Surface, Superfinished Surface and Surface Finished with a Front Mill or End Mill	
C	The pattern left by a cutting instrument is virtually concentric around the center of the plane in the drawing. Ex. Faced Surface	
R	The pattern left by a cutting instrument is virtually radial around the center of the plane in the drawing.	

Examples of Graphical Representation of Surface Texture

Surface Symbol

Removal of Material by Machining is required

Removal of Material is Prohibited

Upper Limit of Ra

Grain Direction

Upper and Lower Limits of Ra

Machining Method

