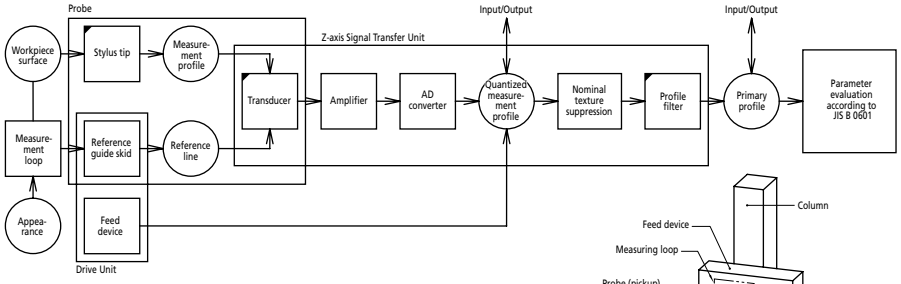
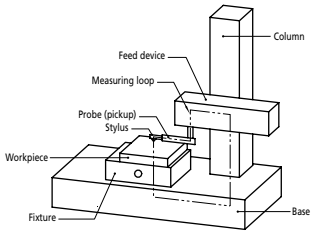
Surftest (Surface Roughness Testers)

JIS B 0601: 2001 Geometric Product Specifications (GPS) –Surface Texture: Profile method–
JIS B 0632: 2001 Geometric Product Specifications (GPS) –Surface Texture: Profile method–
JIS B 0633: 2001 Geometric Product Specifications (GPS) –Surface Texture: Profile method–
JIS B 0651: 2001 Geometric Product Specifications (GPS) –Surface Texture: Profile method–

Nominal Characteristics of Contact (Stylus) Instruments

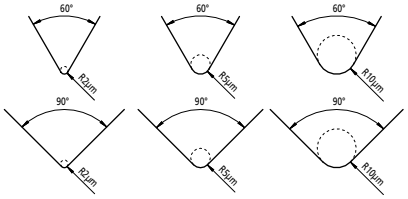
JIS B 0651: 2001 (ISO 3274: 1996)





Stylus Shape

A typical shape for a stylus end is conical with a spherical tip.
Tip radius: r_{tip} = 2 µm, 5 µm or 10 µm
Taper angle of cone: 60°, 90°
In typical surface roughness testers, the taper angle of the stylus end is 60° unless otherwise specified.



Static Measuring Force

Measuring force at the mean position of a stylus: 0.75mN
Ratio of measuring force variations: 0N/m
Standard characteristic value: Static measuring force at the mean position of a stylus

Nominal radius of curvature of stylus tip: µm	Static measuring force at the mean position of stylus: mN	Toleranced ratio of static measuring force variations: mN/µm
2	0.75	0.035
5	0.75 (4.0) Note 1	0.2
10		

Note 1: The maximum value of static measuring force at the average position of a stylus is to be 4.0mN for a special structured probe including a replaceable stylus.

Relationship between Cutoff Value and Stylus Tip Radius

The following table lists the relationship between the roughness profile cutoff value λc, stylus tip radius r_{tip}, and cutoff ratio λc/λs.

λc mm	λs µm	λc/λs	Maximum r_{tip} µm	Maximum sampling length mm
0.08	2.5	30	2	0.5
0.25	2.5	100	2	0.5
0.8	2.5	300	2 Note 1	0.5
2.5	8	300	5 Note 2	1.5
8	25	300	10 Note 2	5

Note 1: For a surface with Ra>0.5µm or Rz>3µm, a significant error will not usually occur in a measurement even if r_{tip}= 5µm.
Note 2: If a cutoff value ls is 2.5µm or 8µm, attenuation of the signal due to the mechanical filtering effect of a stylus with the recommended tip radius appears outside the roughness profile pass band. Therefore, a small error in stylus tip radius or shape does not affect parameter values calculated from measurements. If a specific cutoff ratio is required, the ratio must be defined.

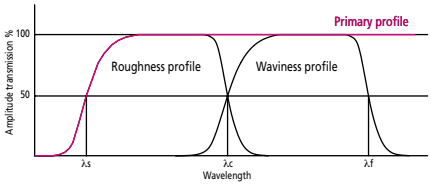
Metrological Characterization of Phase Correct Filters

JIS B 0632: 2001 (ISO 11562: 1996)

A profile filter is a phase-correct filter without phase delay (cause of profile distortion dependent on wavelength).
The weight function of a phase-correct filter shows a normal (Gaussian) distribution in which the amplitude transmission is 50% at the cutoff wavelength.

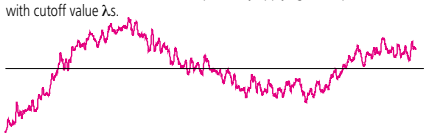
Surface Profiles

JIS B 0601: 2001 (ISO 4287: 1997)



Primary Profile

Profile obtained from the measured profile by applying a low-pass filter with cutoff value λs.

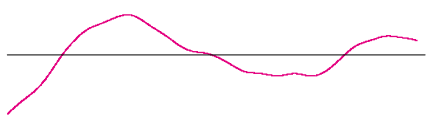


Roughness Profile

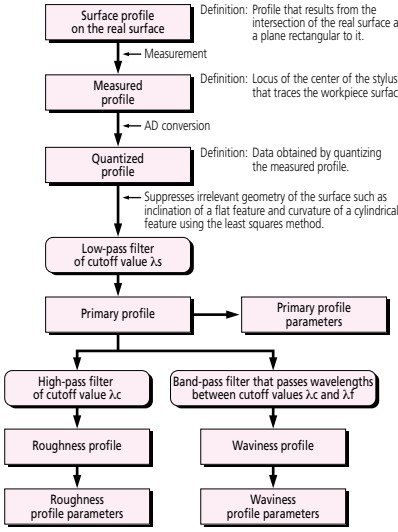
Profile obtained from the primary profile by suppressing the longer wavelength components using a high-pass filter of cutoff value λc.

Waviness Profile

Profile obtained by applying a band-pass filter to the primary profile to remove the longer wavelengths above λf and the shorter wavelengths below λc.



Data Processing Flow



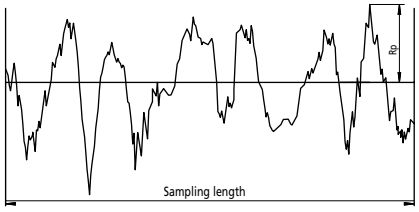
Definition of Parameters

JIS B 0601 : 2001 (ISO 4287 : 1997)

Amplitude Parameters (peak and valley)

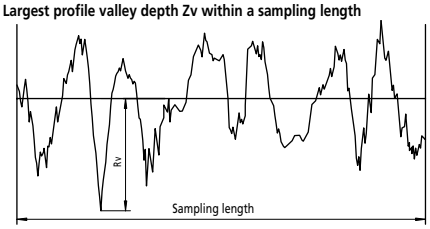
Maximum peak height of the primary profile Pp
Maximum peak height of the roughness profile Rp
Maximum peak height of the waviness profile Wp

Largest profile peak height Zp within a sampling length



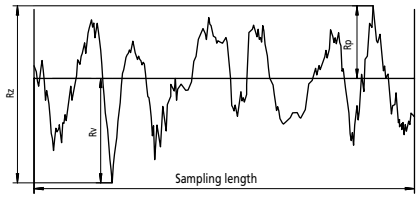
Maximum valley depth of the primary profile Pv
Maximum valley depth of the roughness profile Rv
Maximum valley depth of the waviness profile Wv

Largest profile valley depth Zv within a sampling length



Maximum height of the primary profile Pz
Maximum height of the roughness profile Rz
Maximum height of the waviness profile Wz

Sum of height of the largest profile peak height Zp and the largest profile valley depth Zv within a sampling length

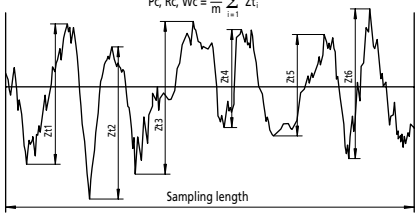


In Old JIS and ISO 4287-1: 1984, Rz was used to indicate the "ten point height of irregularities". Care must be taken because differences between results obtained according to the existing and old standards are not always negligibly small. (Be sure to check whether the drawing instructions conform to existing or old standards.)

Mean height of the primary profile elements Pc
Mean height of the roughness profile elements Rc
Mean height of the waviness profile elements Wc

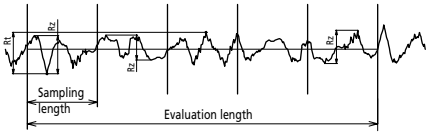
Mean value of the profile element heights Zt within a sampling length

$$Pc, Rc, Wc = \frac{1}{m}\sum_{i=1}^{m} Zt_i$$



Total height of the primary profile Pt
Total height of the roughness profile Rt
Total height of the waviness profile Wt

Sum of the height of the largest profile peak height Zp and the largest profile valley depth Zv within the evaluation length



Terms, definitions, and surface texture parameters
Metrological characterization of phase-correct filters
Rules and procedures for the assessment of surface texture
Nominal characteristics of contact (stylus) instruments

Amplitude Parameters (average of ordinates)

Arithmetical mean deviation of the primary profile Pa
Arithmetical mean deviation of the roughness profile Ra
Arithmetical mean deviation of the waviness profile Wa

Arithmetic mean of the absolute ordinate values Z(x) within a sampling length

$$Pa, Ra, Wa = \frac{1}{l}\int_0^l |Z(x)|dx$$

with l as lp, lr, or lw according to the case.

Root mean square deviation of the primary profile Pq
Root mean square deviation of the roughness profile Rq
Root mean square deviation of the waviness profile Wq

Root mean square value of the ordinate values Z(x) within a sampling length

$$Pq, Rq, Wq = \sqrt{\frac{1}{l}\int_0^l Z^2(x)dx}$$

with l as lp, lr, or lw according to the case.

Skewness of the primary profile Psk
Skewness of the roughness profile Rsk
Skewness of the waviness profile Wsk

Quotient of the mean cube value of the ordinate values Z(x) and the cube of Pq, Rq, or Wq respectively, within a sampling length

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

The above equation defines Rsk. Psk and Wsk are defined in a similar manner. Psk, Rsk, and Wsk are measures of the asymmetry of the probability density function of the ordinate values.

Kurtosis of the primary profile Pku
Kurtosis of the roughness profile Rku
Kurtosis of the waviness profile Wku

Quotient of the mean quartic value of the ordinate values Z(x) and the fourth power of Pq, Rq, or Wq respectively, within a sampling length

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

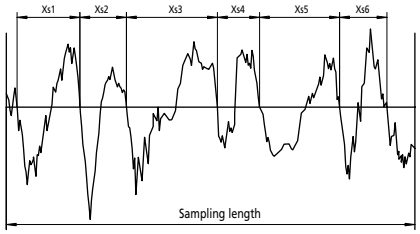
The above equation defines Rku. Pku and Wku are defined in a similar manner. Pku, Rku, and Wku are measures of the sharpness of the probability density function of the ordinate values.

Spacing Parameters

Mean width of the primary profile elements PSm
Mean width of the roughness profile elements RSm
Mean width of the waviness profile elements WSm

Mean value of the profile element widths Xs within a sampling length

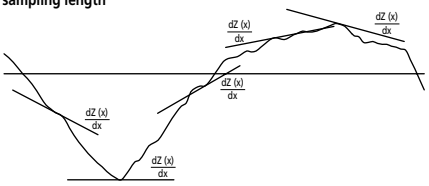
$$PSm, RSm, WSm = \frac{1}{m}\sum_{i=1}^{m} X_{si}$$



Hybrid Parameters

Root mean square slope of the primary profile PΔq
Root mean square slope of the roughness profile RΔq
Root mean square slope of the waviness profile WΔq

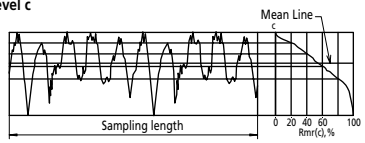
Root mean square value of the ordinate slopes dZ/dX within a sampling length



Curves, Probability Density Function, and Related Parameters

Material ratio curve of the profile (Abbott-Firestone curve)

Curve representing the material ratio of the profile as a function of section level c



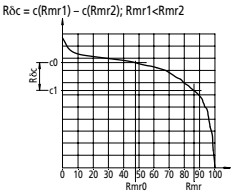
Material ratio of the primary profile Pmr(c)
Material ratio of the roughness profile Rmr(c)
Material ratio of the waviness profile Wmr(c)

Ratio of the material length of the profile elements Ml(c) at a given level c to the evaluation length

$$Pmr(c), Rmr(c), Wmr(c) = \frac{Ml(c)}{ln}$$

Section height difference of the primary profile Pdc
Section height difference of the roughness profile Rdc
Section height difference of the waviness profile Wdc

Vertical distance between two section levels of a given material ratio



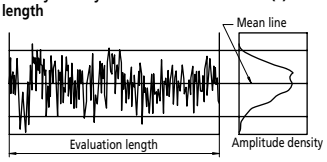
Relative material ratio of the primary profile Pmr
Relative material ratio of the roughness profile Rmr
Relative material ratio of the waviness profile Wmr

Material ratio determined at a profile section level Rδc (or Pδc or Wδc), related to the reference section level c0

Pmr, Rmr, Wmr = Pmr(c1), Rmr(c1), Wmr(c1)
where c1 = c0 – Rδc(or Pδc or Wδc)
c0 = c(Pm0, Rmr0, Wmr0)

Probability density function
(profile height amplitude distribution curve)

Sample probability density function of the ordinate Z(x) within the evaluation length

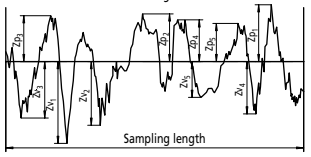


JIS Specific Parameters

Ten-point height of irregularities, Rz_{JIS}

Sum of the absolute mean height of the five highest profile peaks and the absolute mean depth of five deepest profile valleys, measured from the mean line within the sampling length of a roughness profile. This profile is obtained from the primary profile using a phase-correct band-pass filter with cutoff values of lc and ls.

$$Rz_{JIS} = \frac{|Zp_1+Zp_2+Zp_3+Zp_4+Zp_5| + |Zv_1+Zv_2+Zv_3+Zv_4+Zv_5|}{5}$$



Symbol	Used profile
RzJIS82	Surface profile as measured
RzJIS94	Roughness profile derived from the primary profile using a phase-correct high-pass filter

Arithmetic mean deviation of the profile Ra_{75}

Arithmetic mean of the absolute values of the profile deviations from the mean line within the sampling length of the roughness profile (75%). This profile is obtained from a measurement profile using an analog high-pass filter with an attenuation factor of 12db/oct and a cutoff value of λc.

$$Ra_{75} = \frac{1}{ln}\int_0^{ln} |Z(x)|dx$$

Sampling Length for Surface Roughness Parameters

JIS B 0633: 2001 (ISO 4288: 1996)

Table 1: Sampling lengths for aperiodic profile roughness parameters (Ra, Rq, Rsk, Rku, RΔq), material ratio curve, probability density function, and related parameters

Ra μm	Sampling length lr mm	Evaluation length ln mm
(0.006) <Ra≤0.02	0.08	0.08
0.02 <Ra≤0.1	0.25	0.25
0.1) <Ra≤2	0.8	0.8
2 <Ra≤10	2.5	2.5
10 <Ra≤80	8	8

Table 2: Sampling lengths for aperiodic profile roughness parameters (Rz, Rv, Rp, Rc, Rt)

Rz Rz1max μm	Sampling length lr mm	Evaluation length ln mm
(0.025) <Rz, Rz1max≤0.1	0.08	0.08
0.1 <Rz, Rz1max≤0.5	0.25	0.25
0.5) <Rz, Rz1max≤10	0.8	0.8
10 <Rz, Rz1max≤50	2.5	2.5
50 <Rz, Rz1max≤200	8	8

1) Rz is used for measurement of Rz, Rv, Rp, Rc, and Rt.
2) Rzlmax only used for measurement of Rzlmax, Rvlmax, Rplmax, and Rclmax.

Table 3: Sampling lengths for measurement of periodic roughness profile roughness parameters and periodic or aperiodic profile parameter Rsm

Rsm μm	Sampling length lr mm	Evaluation length ln mm
0.013 <Rsm≤0.04	0.08	0.08
0.04 <Rsm≤0.13	0.25	0.25
0.13) <Rsm≤0.4	0.8	0.8
0.4 <Rsm≤1.3	2.5	2.5
1.3 <Rsm≤4	8	8

Procedure for determining a sampling length if it is not specified

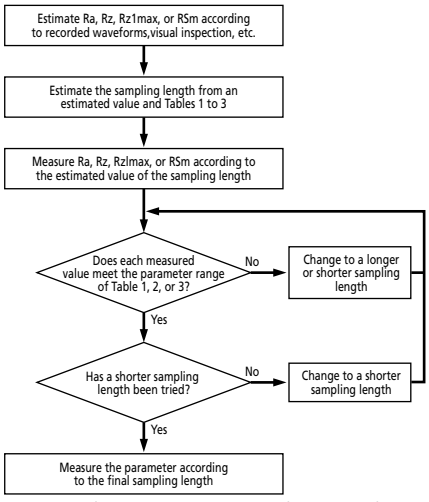


Fig.1 Procedure for determining the sampling length of an aperiodic profile if it is not specified

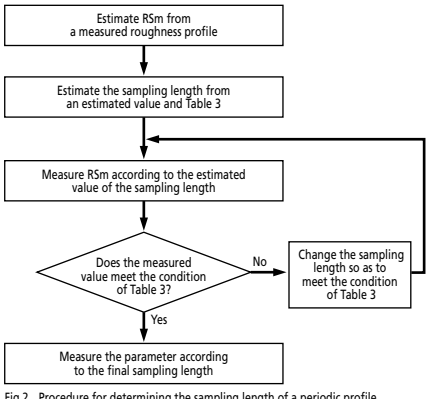


Fig.2 Procedure for determining the sampling length of a periodic profile if it is not specified