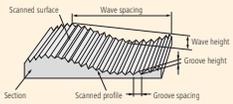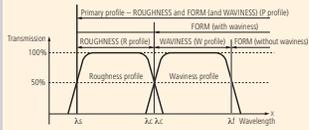## Surface quality

Surface quality: Includes roughness, waviness and form (scanned surface).
Roughness: Surface structure with short intervals.
Waviness: Surface structure with longer intervals.
Form: Surface structure including even longer intervals.
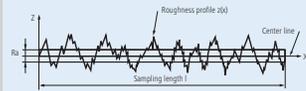

Transmission bands

Roughness: Range between λs and λc.
Waviness: Range between λc and λf.

Profiles

Scanned profile: The unaligned line of the center point of a stylus tip as it was scanned.
Primary profile (P): The aligned total profile delivered with λs. The primary profile comprises the waviness and roughness profile. Center line Compensating line as a reference for the surface parameters.
Roughness profile (R): Profile in which the long-wave portions of the profile are damped with the profile filter λc (primary profile without waviness).
Waviness profile (W): Profile that is generated through the application of the λc and λf filters on the primary profile and in which the shortwave and long-wave form deviations are damped.

Traversing length

Sampling length (lr): The length of the sampling length is numerically the same as the upper cutoff (lr = λc , lw = λf).
Evaluation length (ln): It is part of the evaluation length. The evaluation length (ln) is the sum of the sampling lengths (l). It contains at least one sampling length, usually five.
Traversing length (lt): The overall length traveled by the stylus system during the measuring process. It comprises the evaluation length ln, and pre-travel and post-travel (oscillating and stilling length of the filter).

Profile filter

Profile filter: Filters that separate the long-wave and shortwave components in the profile. Profile filters are characterized by the numeric value of their cutoff.
Cutoff: Wavelengths of the sine-shaped profiles whose amplitude is transferred with 50% (Gaussian filter). The cutoff of a profile filter determines which wavelengths belong to waviness (long wave) and which ones to roughness (shortwave).
Gaussian filter DIN EN ISO11562: A digital, phase-correct filter in which the cutoff is the sine wave that is transferred 50% into the roughness profile.
λs, λc, λf: Filters to limit the transmission of short wavelengths.
Transmission band: λc to λs ratio. See table to the right.
λs filter: Filter that defines the transition from roughness to components with even shorter wavelengths in the profile
λc filter: Filter that defines the transition from roughness to waviness
λf filter: Filter that defines the transition from waviness to even longer wavelengths in the profile

Measurement

(1) Clean the workpiece and place it in a stabile position.
(2) The measuring system must be calibrated and the right stylus arm must be mounted.
(3) Position the workpiece so that the surface is perpendicular to the axis of the stylus and the groove direction of the surface structure is arranged perpendicularly to the measuring direction.
(4) If the roughness parameters of the profile filter λc and the evaluation length are not specified for the measurement, the settings should be selected based on the table to the right.
(5) Set the required profile filters (λc and λs for roughness). (This is usually the Gaussian filter).
(6) Select the required surface parameters.
(7) Measure.
(8) Compare the measuring result with the permissible numeric values entered in the technical documentation.

Selection of sampling length and cutoff ln in accordance with ISO 4288 (04/98)

Peridic profiles	Aperiodic profiles		Cutoff	Sampling length (lr)
All R parameters and RSm for all profiles	Rz, Rmax, Rt, Rv, Rp, Rc	Ra, Rq, Rsk, Rku, RΔq		Evaluation length (ln)
RSm (mm)	Rz[1] Rmax (μm)	Ra (μm)	λc (mm)	lr/ln (mm)
>0.013 to 0.04	>(0.025) to 0.1	>(0.006) to 0.02	0.08	0.08/0.4
>0.04 to 0.13	>0.1 to 0.5	>0.02 to 0.1	0.25	0.25/1.25
>0.13 to 0.4	>0.5 to 10	>0.1 to 2	0.8	0.8/4.0
>0.4 to 1.3	>10 to 50	>2 to 10	2.5	2.5/12.5
>1.3 to 4	>50 to 200	>10 to 80	8.0	8.0/40

1) Rz is based on measuring Rz, Rv, Rp, Rc and Rt

Phase-correct Gaussian filter and roughness transmission bands for contact (stylus) instruments in accordance wit DIN EN ISO 3274 (1998)

λc (mm)	λs (μm)	Transmission band ~ λc : λs	Maximum stylus radius (μm)	Maximum measuring point spacing
0.08	2.5	30	2	0.5
0.25	2.5	100	2	0.5
0.8	2.5	300	2	0.5
2,5	8	300	5	1.5
8	25	300	10	5

Gauss filter: Shortwave cutoff λs
Long-wave cutoff λc

Rmr(c) material ratio of the profile (DIN EN ISO 4287)

Rmr(c) is the ratio from the sum of material lengths of the profile elements Ml(c) in the given section height c and the evaluation length ln (usually given in percent).

$$Rmr(c) = \frac{1}{ln} \, (Ml_1 + Ml_2 + ... \, Ml_n) \cdot 100 = \frac{1}{ln} \cdot Ml_c \cdot 100 \, [\%]$$

Selection of the section level C:
(1) % method: C is 0% at the highest profile peak and 100% at the lowest point of the deepest profile valley.
(2) mm method: C is the depth in mm of the highest profile peak or a reference list C.

RSm average groove width (DIN EN ISO 4287, ASME B46.1)

RSm is the arithmetic mean value of the widths of the profile elements of the roughness profile within the sampling length l.

$$RSm = \frac{1}{n} \sum_{i=1}^{i=n} XSi$$

Parameters on the P profile
Profile depth Pt (DIN EN ISO 4287)

The profile depth Pt is the vertical distance from the lowest to the highest profile point in the primary profile (P profile) within the evaluation length.

Ra Mean roughness (DIN EN ISO 4287, ASME B46.1)

Ra is the arithmetic mean average of all ordinate values within the sampling length l.
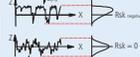Ra corresponds to the terms AA (arithmetic average) and CLA (center line average).

$$Ra = \frac{1}{l} \int_0^l |z(x)| dx$$

Rq root mean square (DIN EN ISO 4287, ASME B46.1)

Rq is the root mean square of all ordinate values within the sampling length l.
Rq corresponds to the term RMS (root mean square).

$$Rq = \sqrt{\frac{1}{l} \int_0^l z^2(x) dx}$$

Rp, Rv, Profile valley depth, Profile peak height (DIN EN ISO 4287)

Rp The distance from the center line to the highest profile peak within the sampling length.
Rv The distance from the center line to the deepest profile valley within the sampling length.
Rt The vertical distance from the deepest to the highest profile point within the evaluation length.

Abbott-curve (BAC Bearing Area Curve) (DIN EN ISO 4287) Material ratio curve

The curve represents the relationship between the material ratio and the section level.

RΔq average profile slope (DIN EN ISO 4287, ASME B46.1)

RΔq is the root mean square average of the local profile slopes of the roughness profile.

$$R\Delta q = \sqrt{\frac{1}{l} \int_0^l \left(\frac{dz}{dx}\right)^2 dx}$$

S spacing of the local profile peaks (ISO 468, JIS B0601)

S is the arithmetic average of the profile peaks.

$$S = \frac{1}{n} \sum_{i=1}^{n} Si$$

Rsk skewness DIN EN ISO 4287

Rsk is a measure of the asymmetry of the amplitude density curve. Negative values indicate a surface with good bearing properties positive values indicate profiles with a high percentage of peaks.

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

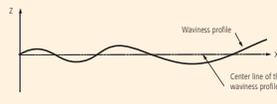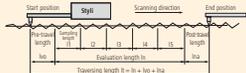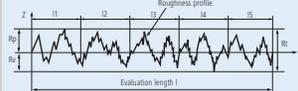## Rku kurtosis DIN EN ISO 4287

Rku is a measure of the peakedness of the amplitude density curve. Low values indicate profiles with flattened peaks and valleys.

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

Rmax maximum roughness depth (ASME B46.1; VDA 2006 (07/2002))

Rmax is the largest single roughness depth within the sampling length. A single roughness depth Rzi is the largest vertical distance from the lowest to the highest profile point within the sampling length.

Rz mean roughness depth; roughness depth Rt (DIN EN ISO 4287 ASME B46.1)

Rz corresponds to the arithmetic average of the single roughness depths of all sampling lengths.

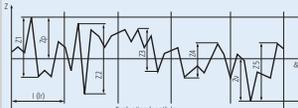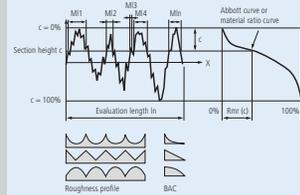$$Rz = \frac{1}{n}(Rz1 + Rz2 + ... + Rzn)$$

R3z Base roughness depth (DBN 31007)

R3Z is the mean average of the third highest profile peak and the third deepest profile valley of a sampling length.

$$R3z = \frac{1}{5}(R3z1 + R3z2 + ... R3z5)$$

Rt overall height of the profile (roughness depth) (DIN EN ISO 4287)

Rt is the sum of the height of the highest profile peak Zp and the depth of the deepest profile valley Zv within the evaluation length ln.

Rk, Rpk, Rvk, Mr1, Mr2 (DIN EN ISO 13565-1 und -2)
Material ratio curve parameter

These parameters, which are collectively described as Rk parameters, must be calculated from the Abbott curve. They enable descriptions of heavy-duty functional surfaces suitable for the function, e.g. seal faces and lubricated sliding surfaces.
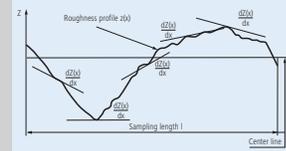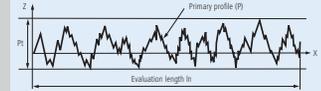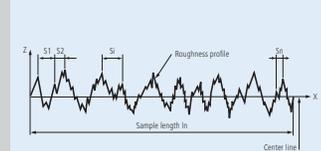
Rk – core roughness depth
Rpk – reduced peak height
Rvk – reduced valley depth
Mr1, Mr2 – material ratios

RPc peak count on the roughness profile (ASME B46.1)

RPc is the number of profile elements per cm on the roughness profile which consecutively intersect the specified upper and lower section levels. The intersection lines are placed above and below the center line.

RHSC high spot count on the roughness profile

HSC is the number of profile peaks per cm that exceed the specified section level. Pc and HSC must be described as RPc and RHSC to emphasize that the peak counts are determined on the roughness profile.

W parameter on the waviness profile
Wt waviness height (DIN EN ISO 4287)

The waviness height Wt is the vertical distance from the lowest to the highest profile peak in the waviness profile (W profile).

Surface parameters

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We make it visible.

Created in cooperation with Prof. Dr. habil. Eberhard Heldt, Chemnitz