Evaluation of Roughness Measurements (DIN EN ISO 4288:1999)

Roughness measuring values - especially the vertical parameters (amplitude parameters Rz, Ra, Rt) and Ra have a spread between 20% and ±2%. A single measuring value can therefore not provide a complete statement concerning the observance of the permissible parameter tolerances. DIN EN ISO 4288 Appendix A specifies the following procedure:

Max-rule:
All roughness parameters with the addition “max” as maximum value of the average value from the five single measured lengths. Measurement at least three points on the surface where the highest values are to be expected, the limit value must not be exceeded at any point.

16% rule:
All roughness parameters without the addition “max” as mean value from the five single measured lengths. 16% of the measuring values may exceed the limit value, step by step procedure:
1. If the first measuring value is smaller than 70% of the limit value the latter is considered to be observed.
2. Otherwise two further measurements at other points on the surface. If all these measuring values are smaller than the limit value, the latter is considered to be observed.
3. Otherwise nine further measurements at other points on the surface. If more than two measuring values exceed the limit value, the latter is considered to be observed.

Drawing symbols (DIN EN ISO 10302:2002)

Basic symbol
a Single-surface finish requirement
b Further surface requirement

Material removal through mechanical machining required
C Machining process (e.g. turned, ground, chrome-plated)

Material removal not permissible
d Symbol for the direction of the surface grooves
x Machining allowance (mm)

Identical texture for all surfaces
x Letter for ease of benchmarking if space is limited

Entry at symbol top
Symbol for the direction of the surface groove (position 4, bottom)

Note:
All information regarding our products, and in particular the illustrations, drawings, dimensional and performance data contained in this pamphlet as well as other technical data are to be regarded as approximated average values. The manufacturer reserves the right to make changes of design, manufacturing procedures, as well as other technical data which are necessary to improve the quality of the products. Any claims regarding the illustrations, drawings or related data are not permissible. Only qualified, trained sales staff are authorized to sell the products. All data will be provided as far as possible. Only qualified, trained sales staff are authorized to sell the products. All data will be provided as far as possible.

Mitutoyo America Corporation
Newbury Park, California
One Newbury Park, Suite 500, Box 4200
1-888-MITUTOYO (1-888-648-8869)
www.mitutoyo.com

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Practical tips for laboratory and workshop

SURFACE ROUGHNESS MEASUREMENT

Examples

Table 4.2.9

Max-rule:

- Profile
- Rule transmission characteristic
- Profile, 16% value, surface roughness depth 5 µm (upper limit value)

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Max-rule:

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Examples

Table 4.2.9

Max-rule:

- Profile
- Rule transmission characteristic
- Profile, 16% value, surface roughness depth 5 µm (upper limit value)
The roughness profile results from high-pass filtering the primary profile with the cutoff wavelength $\lambda_c$. In doing so, the short-wave parts are cut-off. The parameters are identified by $W$ and evaluated over the measured length $l_m$ which is usually composed of five single measured lengths $l_i$. The single measured length corresponds to the cutoff wavelength $\lambda_c$ of the filter profile.

The primary profile is the profile after low-pass filtering the measuring values using the measured. If necessary, tolerances must be determined for this according to DIN EN ISO 8785.

The measured surface profile is the profile after tracing the actual surface profile using a probe. In doing so, the measured values are filtered through the effect of the stylus tip radius and - where applicable - through the sliding skid of the probe system. Imperfections of the surface, like cracks, scratches and dents do not count as roughness and should not be measured. If necessary, tolerances must be determined for this according to DIN EN ISO 8785.

The actual surface profile results from the intersection of the actual part surface with a plane perpendicular to this surface. The plane should roughly be vertical to the machining grooves.

Fig. 1: Primary profile after $\lambda_c$, low-pass filtering and $W$, high-pass filtering with center curve representation according to DIN ISO 4287

Non-periodic profiles

<table>
<thead>
<tr>
<th>Roughness parameters (DIN EN ISO 4287:1998)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Ra$ – Arithmetic mean surface roughness: Arithmetical mean of the sum of all profile values $R_{\text{Am}}$ – Material proportion of the profile: Quotient from the sum of all maximal lengths of the profile elements: at the specified section height $l_m$ in µm and the measured length $l_m$ (expressed in per cent)</td>
</tr>
<tr>
<td>RSm – Average groove width: Mean value of the width of the profile elements $X_s$ (formerly $X_{s1}$) for the evaluation, horizontal and vertical counting are determined differently</td>
</tr>
<tr>
<td>Rt – Total height of the roughness profile: Sum from the height $Z_p$ of the highest profile peak and the depth $Z_t$ of the lowest profile valley within the measured length $l_m$</td>
</tr>
<tr>
<td>Rz – Maximum height of the roughness profile: Sum from the height of the highest profile peak and the depth of the lowest profile valley within a sampling length $l_w$</td>
</tr>
<tr>
<td>Rzmax – Maximum surface roughness: Largest of the five $R_z$ values from the five sampling lengths $l_w$ over the total measured length $l_m$</td>
</tr>
<tr>
<td>$l_{r}$ – Total length</td>
</tr>
<tr>
<td>$l_{t}$ – Maximum stylus tip radius</td>
</tr>
<tr>
<td>$l_{m}$ – Total measured length</td>
</tr>
<tr>
<td>$l_{w}$ – Sampling length</td>
</tr>
</tbody>
</table>

Fig. 2: Roughness profile after $\lambda_c$, high-pass filtering with center line representation according to DIN ISO 4287

The waviness profile results from low-pass filtering the primary profile with the cut-off wavelength $\lambda_c$ and high-pass filtering with the cutoff wavelength $\lambda_w$. The parameters are identified by $W$ and evaluated over the measured length $l_m$ which is composed of several sampling lengths $l_w$. The single measured length $l_i$ corresponds to the cutoff wavelength $\lambda_c$ of the high-pass filter. However, their number is not standardized and must therefore always be indicated on the drawing. It should range between five and ten. Profile filters $C$ (Fig. 3) and $C_1$ are applied successively. The waviness profile always results from application of both filters (Fig. 4).

Fig. 3: Representation after $\lambda_c$, low-pass filtering

Fig. 4: Waviness profile after $\lambda_c$, high-pass filtering and $\lambda_w$, high-pass filtering with center line representation according to DIN ISO 4287

Fig. 5: Transmission characteristics of the filters for the different profiles, Gaussian filter according to DIN EN ISO 11562:1998

Fig. 6: Arithmetic average roughness value $Ra$

<table>
<thead>
<tr>
<th>Preferred parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum surface roughness $Ra$ for surfaces where individual deviations heavily affect the function of the surface, e.g. sealing surfaces.</td>
</tr>
<tr>
<td>Material portion of the profile $Rm(t)$ for guide surfaces and sealing surfaces moving against each other</td>
</tr>
<tr>
<td>Surface roughness depth $R_t$, as a rule, is used for all other surfaces</td>
</tr>
<tr>
<td>The arithmetic average roughness value $Ra$ hardly reacts to peaks or valleys due to the mean value formation from all profile values so that its significance is rather low</td>
</tr>
</tbody>
</table>

Fig. 8: Total height of the roughness profile $R_t$, surface roughness depth $R_t$ and maximum surface roughness $R_t\text{max}$

The average profile width is the mean value of the width of the profile elements.

$\text{Mean value of the width of the profile elements}$

$\text{Mean value of the five sampling lengths} R_z$ from the five sampling lengths $l_w$ over the total measured length $l_m$

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Fig. 9: The material ratio curve of the profile plots (the material portion $Rm(t)$ of the profile as a function of the section height $l_m$ perpendicular to the main groove)

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<tr>
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</table>

Fig. 10: The material ratio curve of the profile plots (the material portion $Rm(t)$ of the profile as a function of the section height $l_m$ perpendicular to the main groove)
The roughness profile results from high-pass filtering the primary profile with the cutoff wavelength $\lambda_c$. In doing so, the long-wave profile parts are cut-off. The parameters are identified by $W$ and evaluated over the measured length $l_m$ which is usually composed of several measured single lengths $l_m$. The measured profile as a function of the section height $i$ is composed of several single measured lengths $l_m$. The single measured length $l_m$ corresponds to the cutoff wavelength $\lambda_c$ of the high-pass filter. However, their number is not standardized and must therefore always be indicated on the drawing. It should range between five and ten. Profile filters (Fig. 4) and $\lambda_c$ are applied successively. The waviness profile always results from application of both filters (Fig. 4).

In doing so, the short-wave profile parts are cutoff. The parameters are identified by $W$ and evaluated over the measured length $l_m$ which is composed of several measured single lengths $l_m$. The single measured length $l_m$ corresponds to the cutoff wavelength $\lambda_c$ of the high-pass filter. However, their number is not standardized and must therefore always be indicated on the drawing. It should range between five and ten. Profile filters (Fig. 4) and $\lambda_c$ are applied successively. The waviness profile always results from application of both filters (Fig. 4).

The actual surface profile results from the intersection of the actual part surface with a plane perpendicular to this surface. The plane should roughly be vertical to the machining grooves. The measured surface profile is the profile after tracing the actual surface profile using a probe. In doing so, the measured values are filtered through the effect of the stylus tip radius $r_s$ and - where applicable - through the sliding slid of the probe system. Imperfections of the surface, like cracks, scratches and dents do not count as roughness and should not be measured. If necessary, tolerances must be determined for this according to DIN EN ISO 8785.

The measurement conditions for roughness measurements (DIN EN ISO 4287:1998) are categorized into non-periodic and periodic profiles. The preferred parameters are $R_z$, $R_r$, $R_m$, and $R_{max}$.

**Preferred parameters**

- Maximum surface roughness $R_{max}$ for surfaces where individual deviations heavily affect the function of the surface, e.g. sealing surfaces.
- Surface roughness depth $R_t$, as a rule, for all other surfaces.

The arithmetic average roughness value $R_a$ hardly reacts to peaks or valleys due to the mean value formation from all profile values so that its significance is rather low.


- $R_a$ - Arithmetic mean surface roughness:
  - Arithmetic mean of the sums of all profile values
- $R_m$ - Material proportion of the profile:
  - Quotient from the sum of all maximum lengths of the profile elements, at the specified section height $i$ (in µm) and the measured length $l_m$ (in µm), expressed in per cent
- $R_g$ - Average groove width:
  - Mean value of the width of the profile elements $x_i$ (formerly $x'_i$) for the evaluation, horizontal and vertical counting determined are:
  - $R_{t1}$ - Total height of the roughness profile:
    - Sum from the height $R_{z1}$ of the highest profile peak and the height $R_{z1}$ of the lowest profile valley within the measured length $l_m$
  - $R_{z1}$ - Maximum height of the roughness profile:
    - Sum from the height of the lowest profile peak and the depth of the lowest profile valley within a sampling length $l_m$
  - $R_{z1}$ - Maximum surface roughness:
    - Largest of the five $R_z$ values from the five sampling lengths $l_m$ over the total measured length $l_m$
  - $R_{t}$ - Surface roughness depth:
    - Mean value of the five $R_z$ values from the five sampling lengths $l_m$ over the total measured length $l_m$


The actual surface profile results from the intersection of the actual part surface with a plane perpendicular to this surface. The plane should roughly be vertical to the machining grooves. The measured surface profile is the profile after tracing the actual surface profile using a probe. In doing so, the measured values are filtered through the effect of the stylus tip radius $r_s$ and - where applicable - through the sliding slid of the probe system. Imperfections of the surface, like cracks, scratches and dents do not count as roughness and should not be measured. If necessary, tolerances must be determined for this according to DIN EN ISO 8785.

The actual surface profile results from the intersection of the actual part surface with a plane perpendicular to this surface. The plane should roughly be vertical to the machining grooves. The measured surface profile is the profile after tracing the actual surface profile using a probe. In doing so, the measured values are filtered through the effect of the stylus tip radius $r_s$ and - where applicable - through the sliding slid of the probe system. Imperfections of the surface, like cracks, scratches and dents do not count as roughness and should not be measured. If necessary, tolerances must be determined for this according to DIN EN ISO 8785.

**Material portion of the profile $R_m$** for guide surfaces and sealing surfaces moving against each other.

**Surface roughness depth $R_t$**, as a rule, for all other surfaces.

The arithmetic average roughness value $R_a$ hardly reacts to peaks or valleys due to the mean value formation from all profile values so that its significance is rather low.

**Measurement conditions for roughness measurements (DIN EN ISO 4288:1998)**

- The surface roughness depth $R_t$ hardly reacts to peaks or valleys due to the mean value formation from all profile values so that its significance is rather low.
- The surface roughness depth $R_t$ hardly reacts to peaks or valleys due to the mean value formation from all profile values so that its significance is rather low.

**Preferred parameters**

- Maximum surface roughness $R_{max}$ for surfaces where individual deviations heavily affect the function of the surface, e.g. sealing surfaces.
- Surface roughness depth $R_t$, as a rule, for all other surfaces.
The roughness profile results from high-pass filtering the primary profile with the cutoff wavelength $\lambda_c$. In doing so, the long-wave profile parts are cut-off. The parameters are identified by $P$ and evaluated over the measured length $I$ which is usually composed of five single measured lengths $I_i$. The single measured length corresponds to the cutoff wavelength $\lambda_c$ of the filter profile.

The waviness profile results from low-pass filtering the primary profile with the cutoff wavelength $\lambda_c$ and high-pass filtering with the cutoff wavelength $\lambda_w$. The parameters are identified by $W$ and evaluated over the measured length $I_w$ which is composed of several sampling lengths $I_w$. The single measured length $I_i$ corresponds to the cutoff wavelength $\lambda_i$ of the high-pass filter. However, their number is not standardized and must therefore always be indicated on the drawing. It should range between five and ten. Profile filters (Fig. 3) and $k_i$ are applied successively. The waviness profile always results from application of both filters (Fig. 4).

The primary profile is produced by low-pass filtering the measuring values using the cutoff wavelength $\lambda_r$ of the probe. In doing so, the short-wave profile parts are cut-off. The parameters are identified by $P$ and evaluated within the sampling length (cut-off). This equals the measured cutoff wavelength $\lambda_c$ of the filter profile.

### Roughness parameters (DIN EN ISO 4287:1998)

- **Ra**: Arithmetic mean surface roughness: Arithmetic mean of the sum of all profile values $R_a$.
- **Rz**: Material proportion of the profile: Quotient from the sum of all maximal lengths of the profile elements at the specified section height $Z_p$ and the measured length $I_n$.
- **Rsm**: Average groove width: Mean value of the width of the profile elements $W_s$ (formerly $R_{v,9}$) for the evaluation, horizontal and vertical counting thresholds are determined.
- **Rpm**: Total height of the roughness profile: Sum from the height of the highest profile peak and the depth $Z_p$ of the lowest profile valley within a sampling length $I_n$.
- **Rzmax**: Maximum surface roughness: Largest of the five $R_z$ values from the five sampling lengths $I_n$ over the total measured length $I$.
- **Rt**: Total height of the roughness profile $R_t$ as a function of the material portion $P_t$ of the profile at the specified section height $Z_p$ (Abbott-Firestone curve).

### Preferred parameters

- **Maximum surface roughness $R_z$** for surfaces where individual deviations heavily affect the function of the surface, e.g., sealing surfaces.

- **Material portion of the profile $P_t$** for guide surfaces and sealing surfaces moving against each other.

### Surface roughness depth $R_z$, as a rule, is used for all other surfaces.

The arithmetic average roughness value $R_a$ hardly reacts to peaks or valleys due to the mean value formation from all profile values so that its significance is rather low.

### Measurement conditions for roughness measurements (DIN EN ISO 4287:1998)

- **Non-periodic profiles**
  - Grinding, honing, lapping, edging
  - Turning, milling, planing

- **Periodic profiles**
  - Turning and planing
  - Grinding and honing
  - Lapping and edging
  - Turning
  - Milling
  - Planing

### Roughness removal

- **Grinding, honing, lapping, edging**
- **Turning, milling, planing**

### Additional remarks

- The measuring point distance $\Delta_l$ and the cutoff wavelength of the low-pass filter $\lambda_r$ are standardized. However, these values have already been set in the roughness measuring instruments.

### Tip for practice 1:

If the space on the part surface is not sufficient for the required traverse length $R_t$, the number of single measured lengths must be reduced and the reduced number be specified in the drawing.

### Tip for practice 2:

If there is still insufficient space, the total height of the primary profile $R_t$ is measured over the available length instead of $R_t$ or $R_z$. $P_t$ equals $R_t$, but is defined at the primary profile, and the measuring value is always larger.
The roughness profile results from high-pass filtering the primary profile with the cutoff wavelength \( \lambda_c \), in doing so, the long-wave profile parts are cut-off. The parameters are identified by \( \lambda_c \) and evaluated over the measured length \( l \) which is usually composed of single measured lengths \( l_i \). The single measured length \( l_i \) corresponds to the cutoff wavelength \( \lambda_i \) of the profile filter.

Fig. 2: Roughness profile after \( \lambda_c \), high-pass filtering with center line representation according to DIN ISO 4287

The waviness profile results from low-pass filtering the primary profile with the cutoff wavelength \( \lambda_c \), and high-pass filtering with the cutoff wavelength \( \lambda_w \). The parameters are identified by \( \lambda_w \) and evaluated over the measured length \( l \) which is composed of several sampling lengths \( l_i \). The single measured length \( l_i \) corresponds to the cutoff wavelength \( \lambda_i \) of the high-pass filter. However, their number is not standardized and must therefore always be indicated on the drawing. It should range between five and ten. Profile filters and high-pass filtering with the cutoff wavelength \( \lambda_i \) are applied successively. The waviness profile always results from application of both filters (Fig. 4).

Fig. 3: Representation after \( \lambda_c \), low-pass filtering

The waviness profile results from high-pass filtering with center line representation according to DIN ISO 4287

Fig. 4: Waviness profile before \( \lambda_c \), low-pass filtering and \( \lambda_w \), high-pass filtering with center line representation according to DIN ISO 4287

The measured surface profile is the profile after tracing the actual surface profile using a probe. In doing so, the measured values are filtered through the effect of the stylus tip radius \( r_{tip} \) and - where applicable - through the sliding skid of the probe system. Imperfections of the surface, like cracks, scratches and dents do not count as roughness and should not be measured. If necessary, tolerances must be determined for this according to DIN EN ISO 8789.

The primary profile is the profile after low-pass filtering the measuring values using the cutoff wavelength \( \lambda_c \), in doing so, the short-wave profile parts are cut-off. The parameters are identified by \( \lambda_c \) and evaluated within the sampling length \( l \). This equals the measured length of the measured surface profile.

Fig. 5: Transmission characteristics of the filters for the different profiles, Gaussian filter according to DIN EN ISO 11562:1998

The roughness parameters (DIN EN ISO 4287:1998)

Ra – Arithmetic mean surface roughness: Arithmetical mean of the sums of all profile values

\[
Ra = \frac{1}{l} \int_{0}^{l} h(x) \, dx
\]

Rms – Material proportion of the profile: Quotient from the sum of all maximal lengths of the profile elements: at the specified section height \( z \) in \( \mu m \) and the measured length \( l \) measured in \( \mu m \)

\[
Rms = \frac{1}{l} \int_{0}^{l} h(x)^2 \, dx
\]

Rz – Maximum height of the roughness profile: Sum from the height \( z_p \) of the highest profile peak and the depth \( z_d \) of the lowest profile valley within the measured length \( l \)

\[
Rz = \frac{1}{l} \sum_{i=1}^{n} \left( z_p - z_d \right)
\]

Rt – Total height of the roughness profile: From the height of the highest profile peak and the depth of the lowest profile valley within a sampling length \( l_i \)

\[
Rt = \frac{1}{l_i} \sum_{i=1}^{n} \left( z_p - z_d \right)
\]

Rz1max – Maximum surface roughness: Length of the five \( R_z \) values from the five sampling lengths \( l_i \) over the total measured length \( l \)

\[
Rz1max = \frac{1}{5} \sum_{i=1}^{5} R_z_i
\]

\* The \( R_z \) value is measured over the available length instead of \( l \).

Maximum stylus tip radius \( r_{tip} \) and Total measured length \( l \) in \( \mu m \); Total sampling length \( l_i \) in \( \mu m \) and \( l \) in \( \mu m \).

Additional, the measuring point distance \( \lambda_i \) and the cutoff wavelength of the low-pass filter \( \lambda_c \) is standardized. However, these values have already be set in the roughness measuring instruments.

Tip for practice 1: If the space on the part surface is not sufficient for the required traversed length \( l \), the number of single measured lengths must be reduced and the reduced number be specified in the drawing.

Tip for practice 2: If there is still insufficient space, the total length of the primary profile \( Pt \) is measured over the available length instead of \( R_z \); \( Pt \) equals \( R_t \), but it is defined at the primary profile, and the measuring value is always larger.

Non-periodic profiles

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Typical Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ra</td>
<td>( \mu m )</td>
<td>&gt; 0.005…0.1</td>
</tr>
<tr>
<td>Rz</td>
<td>( \mu m )</td>
<td>&gt; 0.01…0.5</td>
</tr>
<tr>
<td>Rt</td>
<td>( \mu m )</td>
<td>&gt; 0.01…5</td>
</tr>
<tr>
<td>Rz1max</td>
<td>( \mu m )</td>
<td>&gt; 0.1…5</td>
</tr>
</tbody>
</table>

Periodic profiles

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Typical Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ra</td>
<td>( \mu m )</td>
<td>&gt; 0.025…0.1</td>
</tr>
<tr>
<td>Rz</td>
<td>( \mu m )</td>
<td>&gt; 0.05…0.2</td>
</tr>
<tr>
<td>Rt</td>
<td>( \mu m )</td>
<td>&gt; 0.1…1.0</td>
</tr>
<tr>
<td>Rz1max</td>
<td>( \mu m )</td>
<td>&gt; 0.2…1.0</td>
</tr>
</tbody>
</table>

Measurement conditions for roughness measurements (DIN EN ISO 4288:1998)

The material proportion of waviness \( I_w \) and of the profile as a function of the section height \( z \) (Abbott-Firestone curve) is used for the material proportions of waviness \( I_w \) and of the profile as a function of the section height \( z \) (Abbott-Firestone curve). Additionally, the measuring point distance \( \lambda_i \) and the cutoff wavelength of the low-pass filter \( \lambda_c \) are standardized. However, these values have already be set in the roughness measuring instruments.

Tip for practice 1: If the space on the part surface is not sufficient for the required traversed length \( l \), the number of single measured lengths must be reduced and the reduced number be specified in the drawing.

Tip for practice 2: If there is still insufficient space, the total length of the primary profile \( Pt \) is measured over the available length instead of \( R_z \); \( Pt \) equals \( R_t \), but it is defined at the primary profile, and the measuring value is always larger.

Roughness measuring values – especially the vertical parameters (amplitude parameters) Rz, Ra, Rmax and Rle have a spread between -20% and +30%. A single measuring value can therefore not provide a complete statement concerning the observance of the permissible parameter tolerances. DIN EN ISO 4288 Appendix A specifies the following procedure:

Max-rule:
All roughness parameters with the addition “max” as mean value from the five single measured lengths: 16% rule:
16% of the measuring values may exceed the limit value, step by step procedure:
1. If the first measuring value is smaller than 70% of the limit value the latter is considered to be observed.
2. Otherwise two further measurements at other points on the surface. If all three measuring values are smaller than the limit value, the latter is considered to be observed.
3. Otherwise three further measurements at other points on the surface. If more than two measuring values exceed the limit, the latter is considered to be observed.

Note: All information regarding our products, and in particular the illustrations, drawings, dimensional and performance data contained in this pamphlet, as well as other technical data are to be regarded as approximate average values. The statement of the technical data is only an approximate indication and does not apply. Only quotations taken from our mail order catalogues may be regarded as definitive.

The stated standards, similar technical regulations, descriptions and illustrations of the products were valid at the time of printing. Only quotations submitted by ourselves may be regarded as definitive. Technical data are to be regarded as approximate average values. We therefore reserve the right to make changes to the corresponding designs, dimensions and weights.

Roughness measuring values – especially the vertical parameters (amplitude parameters) Rz, Ra, Rmax and Rle have a spread between -20% and +30%. A single measuring value can therefore not provide a complete statement concerning the observance of the permissible parameter tolerances. DIN EN ISO 4288 Appendix A specifies the following procedure:

Max-rule:
All roughness parameters with the addition “max” as mean value from the five single measured lengths: 16% rule:
16% of the measuring values may exceed the limit value, step by step procedure:
1. If the first measuring value is smaller than 70% of the limit value the latter is considered to be observed.
2. Otherwise two further measurements at other points on the surface. If all three measuring values are smaller than the limit value, the latter is considered to be observed.
3. Otherwise three further measurements at other points on the surface. If more than two measuring values exceed the limit, the latter is considered to be observed.

Drawing symbols (DIN EN ISO 1302:2002)

Basic symbol
- Single surface finish requirement
- Further surface requirement

Material removal through machining required
- Machining process (e.g. turned, ground, chroma-plated)

Material removal not permissible
- Symbol for the direction of the surface grooves
- Machining allowance (in mm)

Identical texture for all surfaces
- Letter for ease of benchmarking if space is limited

Entry at symbol top
- Symbol for the direction of the surface groove (position d, bottom)
• Evaluation of Roughness Measurements (DIN EN ISO 4288:1998)

Roughness measuring values – especially the vertical parameters (amplitude parameters) Rz, Rλ, Rcx and Rmr – have a spread between 30% and 35%. A single measuring value can therefore not provide a complete statement concerning the observance of the permissible parameter tolerances. DIN EN ISO 4288 Appendix A specifies the following procedure:

Max-rule:

All roughness parameters with the addition “max” as mean value from the five single measured lengths:

15% rule:

All roughness parameters without the addition “max” as mean value from the five single measured lengths:

If the first measuring value is smaller than 70% of the limit value the latter is considered to be observed.

1. Otherwise two further measurements at other points on the surface; if all these measuring values are smaller than the limit value the latter is considered to be observed.

2. Otherwise nine further measurements at other points on the surface; if no more than two measuring values exceed the limit value, the latter is considered to be observed.

• Drawing symbols (DIN EN ISO 1302-2002)

Basic symbol
- Single surface finish requirement
- Further surface requirement

Material removal through mechanical machining required
- Machining process (e.g. turned, ground, chromed-plated)

Material removal not permissible
- Symbol for the direction of the surface grooves
- Machining allowance (in mm)

Identical texture for all surfaces
- Letter for ease of benchmarking if space is limited

Entry at symbol (top)
- Symbol for the direction of the surface groove (position: top, bottom)

Examples

<table>
<thead>
<tr>
<th>Symbols</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rz 100</td>
<td>Chip removing process, rule transmission characteristic, Rz profile, 10%-value, surface roughness depth 1 µm (upper limit value)</td>
</tr>
<tr>
<td>Rz 20</td>
<td>Chip removing process, rule transmission characteristic, Rz profile, max-value, maximum surface roughness 3 µm (upper limit value), machining allowance 0.2 mm</td>
</tr>
<tr>
<td>Rz 5</td>
<td>Chip removing process, rule transmission characteristic, Rz profile, machining path from 3 single measured lengths, 10%-value, surface roughness depth 4 µm (upper limit value); constant surface processes</td>
</tr>
<tr>
<td>Rz 3</td>
<td>Chip removing process, rule transmission characteristic, Rz profile, 15%-value, surface roughness depth 5 µm, arithmetic average roughness value 3 µm (upper limit value)</td>
</tr>
<tr>
<td>Rz 1</td>
<td>Chip removing process, rule transmission characteristic, Rz profile, 16%-value, surface roughness depth between 1 µm (lower limit value) and 3 µm (upper limit value)</td>
</tr>
<tr>
<td>Rz 0.8</td>
<td>Chip removing process, rule transmission characteristic, Rz profile, 16%-value, surface roughness depth between 0.8 µm (lower limit value) and 2.5 µm (upper limit value)</td>
</tr>
<tr>
<td>Rz 0.2</td>
<td>Chip removing process, rule transmission characteristic, Rz profile, measuring path equals part length, 10%-value, total height of primary profile 0.25 µm (upper limit value)</td>
</tr>
<tr>
<td>Rz 0.15</td>
<td>Chip removing process, rule transmission characteristic for Rz, Rλ, Rcx, Rmr, profile, measuring path equals part length, 10%-value, total height of primary profile 0.15 µm (upper limit value)</td>
</tr>
<tr>
<td>Rλ 1.5</td>
<td>Chip removing process, rule transmission characteristic, Rλ profile, 15%-value, total height of roughness profile 1 µm (upper limit value); material portion of the profile 60%, in the cutting height 60%, in the bottom limit value</td>
</tr>
<tr>
<td>Rλ 0.8</td>
<td>Chip removing process, rule transmission characteristic, Rλ profile, groove width between 0.8 mm (lower limit value) and 3.0 mm (upper limit value)</td>
</tr>
<tr>
<td>Rλ 0.2</td>
<td>Chip removing process, rule transmission characteristic, Rλ profile, groove width between 0.2 mm (lower limit value) and 0.3 mm (upper limit value)</td>
</tr>
</tbody>
</table>

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• Evaluation of Roughness Measurements (DIN EN ISO 4288:1998)

Roughness measuring values - especially the vertical parameters (amplitude parameters) Rz, Ra, Rt, Rmax and R1a - have a spread between ±20% and ±30%. A single measuring value can therefore not provide a complete statement concerning the observance of the permissible parameter tolerances. DIN EN ISO 4288 Appendix A specifies the following procedure:

Max-rule:
All roughness parameters with the addition "max" as maximum value of the average value from the five single measured lengths. Measurement at least three points on the surface where the highest values are to be expected, the limit value must not be exceeded at any point.
15%-rule:
All roughness parameters without the addition "max" as mean value from the five single measured lengths: 15% of the measuring values may exceed the limit value, step-by-step procedure:
1. If the first measuring value is smaller than 70% of the limit value the latter is considered to be observed.
2. Otherwise two further measurements at other points on the surface; if all these measuring values are smaller than the limit value, the latter is considered to be observed.
3. Otherwise nine further measurements at other points on the surface; if no more than two measuring values exceed the limit value, the latter is considered to be observed.

• Drawing symbols (DIN EN ISO 1302:2002)

Basic symbol
Single surface finish requirement
Further surface requirement
Material removal through mechanical machining required

Material removal not permissible

Identical texture for all surfaces

Entry at symbol (top)
Symbol for the direction of the surface groove (position 4, bottom)

Examples

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rp 5</td>
<td>No chip removing process permissible, rule transmission characteristic, profile, 10%-rule, surface roughness depth 1 µm (upper limit value)</td>
</tr>
<tr>
<td>Rz 2.5</td>
<td>Chip removing process, rule transmission characteristic, profile, 10%-rule, maximum surface roughness 3.5 µm (upper limit value), maximum allowance 0.2 mm</td>
</tr>
<tr>
<td>Rz 4</td>
<td>Chip removing process, rule transmission characteristic, profile, mean path length from 3 single measured lengths, 10%-rule, surface roughness depth 4 µm (upper limit value), concentric surface processes</td>
</tr>
<tr>
<td>Rz 5</td>
<td>Chip removing process, rule transmission characteristic, profile, 15%-rule, surface roughness depth 5 µm, arithmetic average roughness value 1 µm (upper limit value)</td>
</tr>
<tr>
<td>Rz 2.5</td>
<td>Chip removing process, rule transmission characteristic, profile, 15%-rule, surface roughness depth between 1 µm (lower limit value) and 3 µm (upper limit value)</td>
</tr>
<tr>
<td>Rz 2.5</td>
<td>Chip removing process, rule transmission characteristic, profile, 10%-rule, total height of primary profile 25 µm (upper limit value)</td>
</tr>
<tr>
<td>Rp 3, Rz 2.5</td>
<td>Chip removing process, rule transmission characteristic for Rz, ±5µ, filter, profile, measuring path equals part length, 10%-rule, total height of primary profile 25 µm (upper limit value)</td>
</tr>
<tr>
<td>Rz 2.5</td>
<td>Chip removing process, rule transmission characteristic for Rz, ±5µ, filter, mean path length from 5 single measured lengths (25/75555/75), 10%-rule, total height of profile 10 µm (upper limit value)</td>
</tr>
<tr>
<td>Rz 2.5, Rz 2.5</td>
<td>Chip removing process, rule transmission characteristic, profile, 10%-rule, total height of roughness profile 1 µm (upper limit value), material portion of the profile 66%, in the cutting height 403µm (lower limit value)</td>
</tr>
<tr>
<td>Rz 2.5, Rz 2.5</td>
<td>Chip removing process, rule transmission characteristic, profile, mean groove width between 0.1 mm (lower limit value) and 0.3 mm (upper limit value)</td>
</tr>
</tbody>
</table>

* Explanation of the meaning (right) of simplified benchmarking (left) if space is limited.

Previous processing:...