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Determination of values of surface roughness parameters R_a, R_z, R_{max} using electrical contact (stylus) instruments

Concepts and measuring conditions

DIN 4768

Ermittlung der Rauheitskenngrößen R_a, R_z, R_{max} mit elektrischen Tastschnittgeräten; Begriffe, Meßbedingungen

Supersedes August 1974 edition of DIN 4768 Part 1.

See Explanatory notes for connection with Intenational Standards ISO 3274 : 1975 and ISO 4288 : 1985 published by the International Organization for Standardization (ISO).

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

Dimensions in mm

1 Field of application

This standard specifies concepts and measuring conditions to be applied in connection with the determination of comparable surface roughness values for workpieces using contact (stylus) instruments whose range of functions comprises electrical transmission, high-pass filtering and evaluation of the measurand.

Note. Although waviness and deviations of form do not fall within the scope of this standard, there are many applications in which these characteristics may well be of greater significance with respect to the fitness for purpose of a given surface than its relative roughness.

2 Concepts

Concepts are used in this standard as defined in DIN 4760 and ISO 4287-1 : 1984 and, with respect to roughness measurements using phase correct filters, DIN 4777.

Further relevant concepts are defined below in subclauses 2.1 and 2.2.

2.1 Wave filters (high-pass filter)

Wave filters are profile filters[1]) which are designed, as a function of the filter characteristic, to suppress part or all of the long wave components of the actual profile from entering the roughness profile or measurement result. Wave filters are designated according to their upper limit of wavelength transmission.

Note. Wave filters are also commonly referred to as cut-off filters.

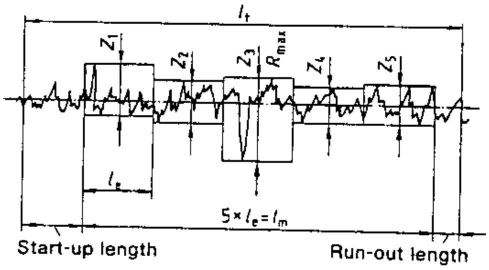

Figure 1. Determination of ten point height of irregularities, R_z, from the roughness profile

2.2 Measuring lengths (see figue 1)

2.2.1 Start-up length

The start-up length is the length of the first section of the traversed length. It is defined by lines drawn perpendicular to the mean line and precedes the evaluation length. It is intended that any initial transient effects should fade within the start-up length.

2.2.2 Evaluation length

The evaluation length, l_m, is the section of the roughness profile, defined by lines drawn perpendicular to the mean line, over which the values of surface roughness parameters are assessed.

2.2.3 Sampling length

The sampling length, l_e, is a fifth of the evaluation length, l_m.

Note. l_e is identical with the reference length, l, as specified in ISO 4287-1.

2.2.4 Run-out length

The run-out length is the length of the final section of the traversed length. It is defined by lines drawn perpendicular to the mean line and follows the evaluation length.

2.2.5 Traversed length

The traversed length, l_t, is the sum of start-up, evaluation and run-out lengths.

2.3 Surface roughness parameters

The values of the surface roughness parameters as defined in this standard are assessed on the basis of the roughness profile[1]).

2.3.1 Arithmetical mean deviation of the profile

The arithmetical mean deviation of the profile, R_a, is the arithmetical mean of the absolute values of the profile departures, y, within the reference length, l[2]).

$$R_a = \frac{1}{l} \int_0^l |y(x)| \, dx$$

Note 1. This is equivalent to the height of a triangle with a length equal to l and with an area equal to the sum of the areas enclosed between the roughness profile and the mean line.

Normally, R_a is determined for an evaluation length equal to $5 \cdot l_e$.

[1]) As defined in DIN 4777, May 1990 edition.

[2]) As defined in ISO 4287-1.

Continued on pages 2 and 3

$$\Sigma A_{oi} = \Sigma A_{ui}$$
$$\Sigma_g = \Sigma A_{oi} + \Sigma A_{ui}$$

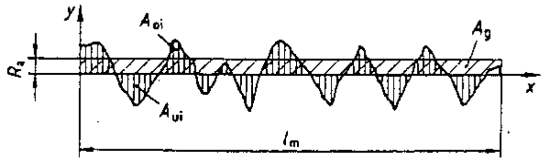

Figure 2. Arithmetical mean deviation of the profile, R_a

Note 2. DIN 4775 and ISO 4288 specify that, in the case of R_a and R_z, up to 16% of the individual measured values obtained for a given surface area may exceed the specified limiting value.

2.3.2 Two point height of irregularities (see figure 1)

The two point height of irregularities, Z_i (Z_i represents Z_1 to Z_5), is the distance between two lines parallel to the mean line and passing, respectively, through the highest and lowest point of the profile within a given sampling length.

2.3.3 Ten point height of irregularities

The ten point height of irregularities, R_z, is the arithmetic mean of the two point height of irregularties of five consecutive sampling lengths.

Note 1. In ISO 4287-1 : 1984, this parameter is represented by the symbol R_{y5}.

Note 2. The definition given for R_z in this standard differs from its definition in ISO 4287-1. Should it be necessary to distinguish which definition of this parameter is intended, the symbols R_{zDIN} and R_{zISO} may be used. For metrological reasons, it is virtually everywhere the practice for the conditions specified in DIN 4768 for measuring R_{zDIN} (and which correspond to those specified in ISO 4288) to be applied when measuring R_z as specified in ISO 4287-1. An upper limiting value specified for R_{zISO} can thus be deemed maintained if it is not exceeded by the value obtained for R_{zDIN}.

Note 3. See note 2 in subclause 2.3.1.

2.3.4 Maximum two point height of the profile (see figure 1)

The maximum two point height of the profile, R_{max}, is the largest of the two point height of irregularities, Z_i, occurring over the evaluation length, l_m.

Note 1. In DIN 4775 and ISO 4288 it is specified that no single measured value of R_{max} shall exceed the given limiting value. That may be necessary in the case of surfaces subjected to alternating stress.

Note 2. In ISO 4287-1 and ISO 4288, this parameter is represented by the symbol R_{ymax}.

3 Measuring conditions

3.1 Tracing direction

Tracing shall proceed in the direction giving the largest roughness value. In special cases, the tracing direction shall be agreed.

3.2 Cut-off and sampling lengths

3.2.1 Cut-off, λ_c, sampling length, l_e, and evaluation length, l_m, for periodic profiles (e.g. produced by turning or planing)

For measurements of the surface roughness of periodic profiles, λ_c, l_e and l_m shall be selected as a function of the groove spacing as shown in table 1.

Table 1. λ_c, l_e and l_m as a function of groove spacing

Groove spacing, S_m, (feed)	λ_c	l_e	l_m min.
Over 0,01 up to 0,04	0,08	0,08	0,4
Over 0,04 up to 0,13	0,25	0,25	1,25
Over 0,13 up to 0,4	0,8	0,8	4
Over 0,4 up to 1,3	2,5	2,5	12,5
Over 1,3 up to 4	8	8	40

The groove spacing may be determined from a short surface profile diagram or by taking measurements, e.g. of ten groove widths, on the workpiece.

3.2.2 Cut-off, λ_c, sampling length, l_e, and evaluation length, l_m, for aperiodic profiles (e.g. produced by grinding, peripheral milling, face-milling with camber, reaming, forming)

Table 2. λ_c, and l_m as a function of R_z

R_z, in µm	λ_c	l_e	l_m
0,1	0,08	0,08	0,4
Over 0,1 up to 0,5	0,25	0,25	1,25
Over 0,5 up to 10	0,8	0,8	4
Over 10 up to 50	2,5	2,5	12,5
Over 50	8	8	40

Table 3. λ_c, and l_m as a function of R_a

R_a, in µm	λ_c	l_m min.
0,02	0,08	0,4
Over 0,02 up to 0,1	0,25	1,25
Over 0,1 up to 2	0,8	4
Over 2 up to 10	2,5	12,5
Over 10	8	40

For measurements of the surface roughness of aperiodic profiles, λ_c, l_e and l_m shall be selected as a function of R_z and R_a, as shown in tables 2 and 3 respectively. The cut-off for measurements of R_{max} on aperiodic profiles shall be the same as that for R_z.

For the practical implementation of the data given in tables 2 and 3, the roughness value may first be estimated visually by inspection of the workpiece or profile record in order to determine the relevant cut-off.

In the case of surfaces where waviness is superimposed on the roughness, it may be found that with a cut-off value of 0,25 mm, for example, the value obtained for R_z is less than 0,5 µm, while with a cut-off value of 0,8 mm, the R_z value is greater than 0,5 µm. In this particular case, the smaller of the two roughness values shall be taken as the result. The same applies for R_z values around 0,1 µm, 10 µm, 50 µm, and in the corresponding cases, for R_a.

3.3 Measuring lengths

If the workpiece is such that the requirement for the evaluation length to comprise five sampling lengths as specified in tables 1 to 3 cannot be complied with, then an evaluation length consisting of fewer sampling lengths is also acceptable. This shall be indicated when stating the roughness value, e.g. 'R_a = 1,1 µm with $l_m = 3 \cdot l_e$'.

If there are special reasons which require cut-off correlations differing from those specified in tables 1 to 3, the cut-off value concerned shall be indicated when stating the roughness value, e.g. 'R_a = 1,1 µm with λ_c = 0,25 mm'. λ_c and l_e shall invariably be of equal length.

3.4 Cases of arbitration

In cases of arbitration, a reference surface stylus system as specified in DIN 4772 with a stylus tip radius of 5 µm shall be used if the R_z and R_a values may be expected to be larger than 2 µm and 0,4 µm respectively. For lower values, a stylus with a tip radius of 2 µm shall be used.

Standards referred to

DIN 4760	Deviations of form; concepts and classification
DIN 4772	Electrical contact (stylus) instruments for measuring surface roughness by the profile method
DIN 4775	Checking the surface roughness of workpieces; visual check and measurement using contact (stylus) instruments
DIN 4777	Assessment of surface texture; profile filters for use in electrical contact stylus instruments; phase correct filters
ISO 4287-1 : 1984[3]	Surface roughness; terminology; surface and its parameters
ISO 4288 : 1985[3]	Rules and procedures for the measurement of surface roughness using stylus instruments

Other relevant standard

ISO 3274 : 1975[3]	Instruments for the measurement of surface roughness by the profile method; contact (stylus) instruments of consecutive profile transformation; contact profile meters, system M

Previous editions

DIN 4768 Part 1: 10.70, 08.74.

Amendments

The following amendments have been made to the August 1974 edition of DIN 4768 Part 1.

a) Specifications with respect to filters have been transferred to DIN 4777.

b) The grading of the groove spacing given in table 1 has been changed slightly in order to permit comparable results to be obtained when using phase correct filters as specified in DIN 4777 or the 2 RC filters generally used hitherto. See Explanatory notes for further details.

c) Subclause 3.4 on the procedure in cases of arbitration has been included.

d) The standard has been editorially revised.

Explanatory notes

The wave filter specifications previously incorporated in DIN 4768 Part 1, August 1974 edition, related to 2 RC filters and have now been superseded by the specification in the present standard that phase correct filters complying with DIN 4777 are to be used. This amendment permits the use in future of complementary filters both for the measurement of surface roughness and for the measurement of waviness as specified in DIN 4774. Table 1 was amended slightly so that it can now also be used for the measurement of waviness.

These two amendments have virtually no influence on the measurement results obtained for R_{max}, R_z, and R_a, i.e. new and old instrument types can be used concurrently.

At international level, the same trend is developing. DIN 4777 and tables 1 to 3 of this standard have been submitted to ISO/TC 57 as proposals for the amendment of ISO 3274 : 1975 and ISO 4288 : 1985.

International Patent Classification

G 01 B

[3] Obtainable from *Beuth Verlag GmbH (Auslandsnormenverkauf)*, Burggrafenstraße 6, D-1000 Berlin 30.