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Serration splines, English translation of DIN 5481:2019-04

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Englische Übersetzung von DIN 5481:2019-04

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Foreword

This document has been prepared by Working Committee NA 060-34-31 “Splines” of the Section Gear of *DIN-Normenausschuss Maschinenbau* (DIN Standards Committee Mechanical Engineering).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. DIN shall not be held responsible for identifying any or all such patent rights.

Compatibility of serration splines as in the previous editions of this standard with those as in the present standard has been ensured.

Amendments

This standard differs from DIN 5481:2005-06 and DIN 5481 Corrigendum 1:2009-01 as follows:

a) the corrigendum has been incorporated;

b) figures have been incorporated;

c) the standard has been editorially revised.

The following corrections have been made to DIN 5481:2018-03:

a) Clause 3 has been revised and the symbols for the measuring circle diameter for shafts D_{Re} and the root diameter of hub D_{ei} have been changed;

b) in Table 7, line 6, column 9, the value has been changed from “17,253 8” to “17,269 3”;

c) in Table 7, line 6, column 10, the value has been changed from “17,166 5” to “17,183 8”;

d) in Table 7, line 6, column 11, the value has been changed from “0,895” to “0,900”;

e) in Table 20, line 2, column 8, the value has been changed from “8,186 6” to “8,166 6”;

f) in Table 20, line 7, column 8, the value has been changed from “20,066 2” to “20,006 2”;

g) in Table 22, last line, column 8, the value has been changed from “52,52,826” to “52,826 0”;

h) in Table 24, line 2, column 8, the value has been changed from “6,788 9” to “6,805 9”;

i) in Table 24, line 3, column 8, the value has been changed from “7,898 8” to “7,968 8”;

j) in Table 24, line 4, column 8, the value has been changed from “9,695 8” to “9,782 3”;

k) in Table 24, line 6, column 8, the value has been changed from “14,566 8” to “14,549 7”;

l) in Table 24, line 8, column 8, the value has been changed from “19,850 9” to “20,699 0”;

m) in Table 24, line 9, column 8, the value has been changed from “25,483 8” to “26,327 9”;

n) the standard has been editorially revised.

Previous editions

Kr 231/1 = 5481-2: 1940-11
DIN 5481-1: 1940-11, 1942-07, 1952x-01
DIN 5481-2: 1940-11, 1955-04, 1956-03
DIN 5481-3: 1955-04, 1965-07
DIN 5481-4: 1955-04
DIN 5481-5: 1955-04
DIN 5481: 2005-06, 2018-03
DIN 5481 Corrigendum 1: 2009-01

1 Scope

This standard applies to splines with serrated flanks (serration splines) and external serrations having a constant space angle of 60°, with 28 to 42 teeth and of nominal diameters ranging from 7 mm bis 60 mm.

Serration splines as in this standard are used for connecting hubs to shafts either with a permanent or a removable connection, but which, due to the expected wear, is never a sliding fit connection. As the teeth are relatively small, only small torques can be transmitted by such connections.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

DIN 21772, *Gears — Cylindrical involute gears and gear pairs — Definition of deviations*

DIN 5480-2, *Involute spline based on reference diameters — Part 2: Nominal and inspection dimensions*

DIN 5480-15, *Involute spline based on reference diameters — Part 15: Inspection*

ISO 4156-3, *Straight cylindrical involute splines — Metric module, side fit — Part 3: Inspection*

3 Symbols and abbreviated terms

For the purposes of this document, the following symbols apply.

Symbol	Designation	Unit
D	Pitch diameter	mm
D_{Fe}	Root form circle diameter of shaft	mm
D_{Fi}	Root form circle diameter of hub	mm
D_{Re}	Measuring circle diameter for shafts	mm
D_{Ri}	Measuring circle diameter for hubs	mm
D_{ee}	Tip diameter of shaft	mm
D_{ei}	Tip diameter of hub	mm
D_{ie}	Root diameter of shaft	mm
D_{ii}	Root diameter of hub	mm
E	Space width of hub	mm
E_V	Minimum effective space width	mm
E_{max}	Maximum actual space width	mm
E_{min}	Minimum actual reference space width	mm
F_p	Total cumulative pitch deviation (see DIN 21772)	µm
F_r	Radial runout (see DIN 21772)	µm
F_α	Total profile deviation (see DIN 21772)	µm
F_β	Total helix deviation (see DIN 21772)	µm
M_{Re}	Dimension over measuring circles	mm

Symbol	Designation	Unit
M_{Ri}	Dimension between measuring circles	mm
R_e	Root radius at shaft root diameter	mm
R_i	Root radius at hub root diameter	mm
S	Shaft tooth thickness	mm
S_V	Maximum effective tooth thickness	mm
S_{max}	Maximum actual reference tooth thickness	mm
S_{min}	Minimum actual tooth thickness	mm
T_G	Total tooth thickness/space width tolerance	µm
T_{act}	Actual tooth thickness/space width tolerance	µm
T_{eff}	Effective tooth thickness/space width tolerance	µm
Z	Number of teeth	—
b	Length of serration	mm
d	GO ring gauge external diameter	mm
m	Module	mm
p	Pitch	mm
α	Pressure angle	degrees (°)
γ_e	Space angle of shaft	degrees (°)
γ_i	Space angle of hub	degrees (°)

Abbreviation	Designation
GR	GO ring gauge
GD	GO plug gauge
HD	NO GO plug gauge
HR	NO GO ring gauge

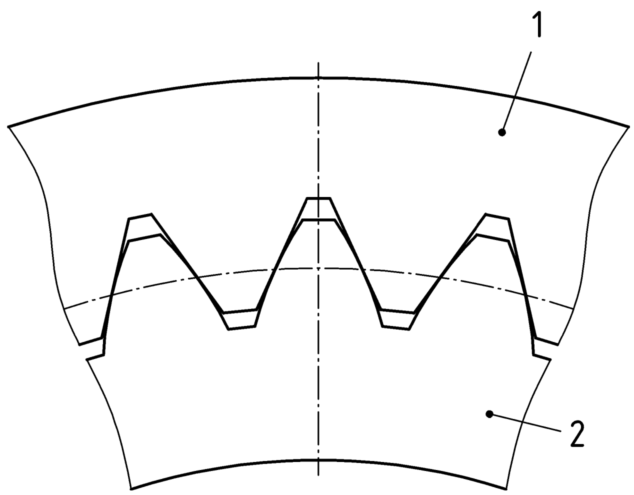
4 Structure

In this standard for serration splines, shaft serrations have a constant space angle $\gamma_e = 60°$. The space angle of serrations of the corresponding hubs varies in relation to the number of teeth. The nominal tooth thickness is equal to half the pitch length on the specified pitch circle.

This standard applies to serration splines with the following principles:

a) the space angle of the shaft is constant;

b) shafts may have curved flanks generated by machining with straight-flanked hobs (see Figure 1);



Key

1 Hub
2 Shaft

Figure 1 — Mating a straight-flank serrated hub to a shaft with involute flanks

c) where hubs may also have curved tooth flanks, to allow for machining by means of involute hobs, this shall be separately agreed between the manufacturer and the customer;

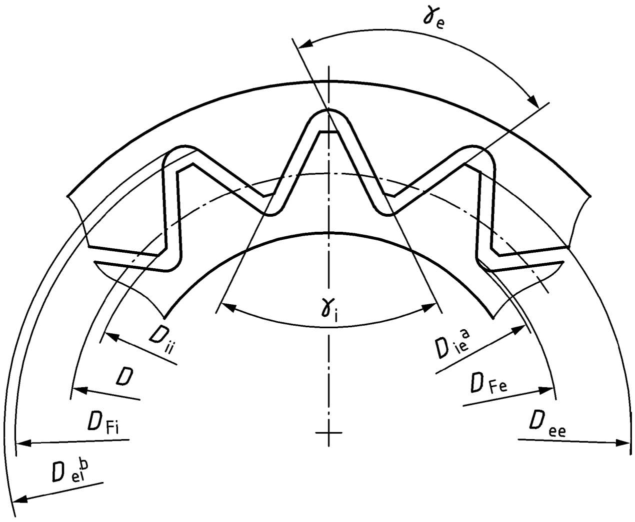
d) “rough” deviations for shafts apply in cases where the force only acts in one direction (torsion bar spring);

e) side fit profile.

5 Diameters

5.1 General

The nominal diameters describe the rounded minor diameter of the hub and the major diameter of the shaft, respectively, e.g. 7 × 8. These diameters have tolerances A11 and a11, respectively. The pitch diameter passes roughly through the centre of the teeth. Along this diameter, the tooth thickness and the space width of any one workpiece are roughly equal. The form circle is generated when the root diameter for the specified maximum radius is generated at a constant tooth thickness or space width (see Figure 2).



Key

a with R_e

b with R_i

Figure 2 — Hub and shaft diameters

5.2 Hub diameters

Table 1 gives the standard hub diameters.

Table 1 — Hub diameters

Nominal diameter mm	Number of teeth Z —	Space angle γ_i	Pitch diameter D mm	Tip diameter D_{ii} Tolerance A11 Nom. dimension mm	Max. dimension $D_{ii\,max}$ mm	Minimum dimension $D_{ii\,min}$ mm	Min. root form circle diameter $D_{Fi\,min}$ mm	Root diameter[a] D_{ei} mm	Max. root radius $R_{i\,max}$ mm
7 × 8	28	47,143°	7,5	6,90	7,27	7,18	8,14	8,21	0,08
8 × 10	28	47,143°	9	8,10	8,47	8,38	9,83	9,93	0,08
10 × 12	30	48,000°	11	10,10	10,50	10,39	11,90	12,01	0,10
12 × 14	31	48,387°	13	12,00	12,40	12,29	14,07	14,19	0,10
15 × 17	32	48,750°	16	14,90	15,30	15,19	17,14	17,32	0,15
17 × 20	33	49,091°	18,5	17,30	17,70	17,59	19,84	20,02	0,15
21 × 24	34	49,412°	22	20,80	21,23	21,10	23,63	23,80	0,15
26 × 30	35	49,714°	28	26,50	26,93	26,80	29,75	30,03	0,25
30 × 34	36	50,000°	32	30,50	30,97	30,81	33,84	34,18	0,30
36 × 40	37	50,270°	38	36,00	36,47	36,31	39,72	40,23	0,45
40 × 44	38	50,526°	42	40,00	40,47	40,31	43,78	44,34	0,50
45 × 50	39	50,769°	47,5	45,00	45,48	45,32	49,84	50,34	0,45
50 × 55	40	51,000°	52,5	50,00	50,48	50,32	54,58	55,25	0,60
55 × 60	42	51,429°	57,5	55,00	55,53	55,34	59,74	60,42	0,60

[a] Guideline value for the root diameter, calculated from $D_{Fi\,min}$ and $R_{i\,max}$ at E_{min}.

5.3 Shaft diameters

Table 2 gives the standard shaft diameters.

Table 2 — Shaft diameters

Nominal diameter mm	Number of teeth Z —	Space angle γ_e	Pitch diameter D mm	Tip diameter D_{ee} Tolerance a11 Nom. dimension mm	Maximum dimension $D_{ee\,max}$ mm	Min. dimension $D_{ee\,min}$ mm	Max. root form circle diameter $D_{Fe\,max}$ mm	Root diameter[a] D_{ie} mm	Max. root radius $R_{e\,max}$ mm
7 × 8	28	60°	7,5	8,10	7,82	7,73	6,98	6,90	0,08
8 × 10	28	60°	9	10,10	9,81	9,70	8,33	8,25	0,08
10 × 12	30	60°	11	12,00	11,71	11,60	10,27	10,16	0,10
12 × 14	31	60°	13	14,20	13,91	13,80	12,12	12,02	0,10
15 × 17	32	60°	16	17,20	16,91	16,80	15,05	14,90	0,15
17 × 20	33	60°	18,5	20,00	19,70	19,57	17,53	17,33	0,20
21 × 24	34	60°	22	23,90	23,60	23,47	20,94	20,69	0,25
26 × 30	35	60°	28	30,00	29,70	29,57	26,67	26,36	0,30
30 × 34	36	60°	32	34,00	33,69	33,53	30,72	30,32	0,40
36 × 40	37	60°	38	39,90	39,59	39,43	36,25	35,95	0,30
40 × 44	38	60°	42	44,00	43,68	43,52	40,12	39,72	0,40
45 × 50	39	60°	47,5	50,00	49,68	49,52	45,26	44,86	0,40
50 × 55	40	60°	52,5	54,90	54,56	54,37	50,05	49,64	0,40
55 × 60	42	60°	57,5	60,00	59,66	59,47	55,19	54,69	0,50

[a] Guideline value for the root diameter, calculated from $D_{Fe,max}$ and $R_{e\,max}$ at S_{max}

6 Fit system for tooth thickness/space width

6.1 Fit diagram

Figure 3 illustrates the tolerance positions.

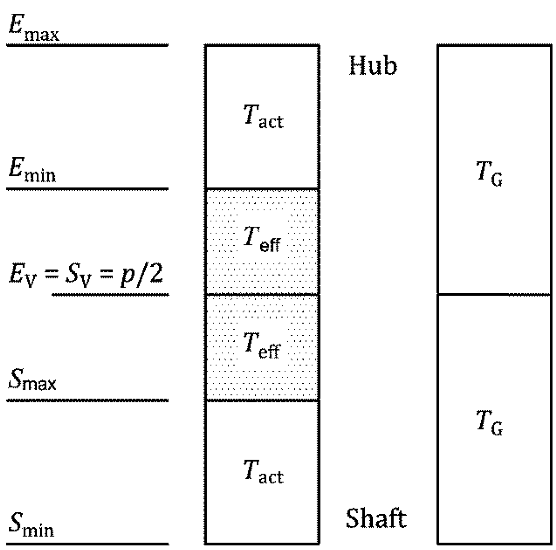
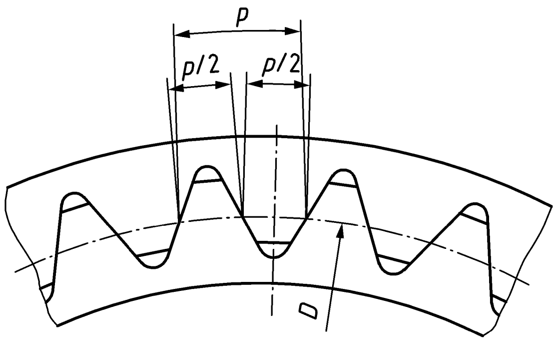


Figure 3 — Tooth thickness/space width fit diagram

6.2 Structure of the tolerance system

The tolerance system is based on the principle that, at the pitch diameter, the nominal tooth thickness of the shaft is equal to the nominal tooth thickness of the hub. Theoretically, the minimum clearance = 0 mm (see Figure 4).



Key

p	pitch
p/2	half pitch
D	pitch diameter

Figure 4 — Nominal tooth thickness = nominal space width = half the pitch

6.3 Total tolerance

The total tolerance contains the actual tolerance and the effective tolerance. There is only one value for the total tolerance of hubs, while shafts are differentiated as having either a “precision fit” or a “rough fit”. In practice, the dimensions of the actual tolerance (T_{act}) in relationship to the effective tolerance (T_{eff}) (see Figure 3) within the overall tolerance T_G vary considerably. For this standard, a ratio of $T_G/T_{act} = 1{,}6$ has been selected, along the lines of DIN 5480-2. In real terms, this means that the tolerances formerly specified as deviations are now deemed to be the total tolerance T_G and have been subdivided into T_{act} and T_{eff} at a ratio of 1,6.

6.4 Actual tolerance T_{act}

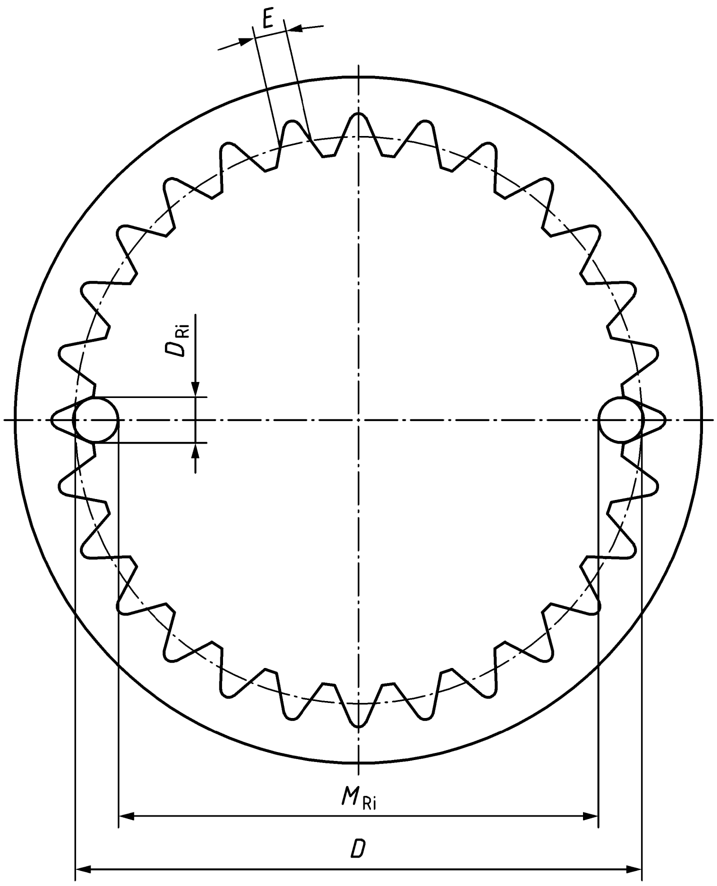
The actual tolerance T_{act} allows for the effects of wear on tool dimensions, the infeed accuracy of machine tools, and dimensional deviations resulting from heat treatment. As it is difficult to measure tooth thicknesses and space widths directly, they are converted to equivalent dimensions between and over measuring circles.

6.5 Effective tolerance T_{eff}

The effective tolerance allows for the fact that the tooth flanks producing the respective fit have individual profile, helix and pitch deviations. These deviations effectively reduce the clearance.

6.6 Space widths and dimensions of hubs

Figure 5 defines space widths and other hub dimensions. Table 3 gives the corresponding values.



Key

M_{Ri} dimension between measuring circles

D pitch diameter

D_{Ri} measuring circle diameter

E space width

Figure 5 — Space widths and dimensions of hubs

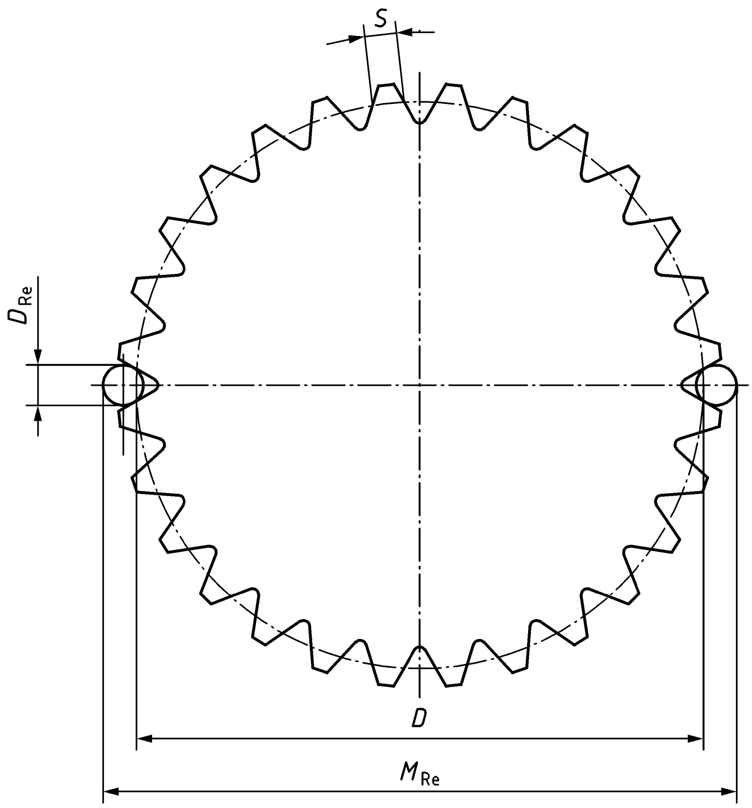
Table 3 — Space widths and dimensions of hubs

Nominal diameter mm	Number of teeth Z —	Space angle γ_i	Pitch diameter D mm	Space width max. actual E_{max} mm	Space width min. actual E_{min} mm	Space width min. effective E_v mm	Max. dimension between 2 measuring circles $M_{Ri\ max}$ mm	Min. dimension between 2 measuring circles $M_{Ri\ min}$ mm	Measuring circle diameter D_{Ri} mm
7 × 8	28	47,143°	7,5	0,452 6	0,432 7	0,420 7	6,947 8	6,903 4	0,450
8 × 10	28	47,143°	9	0,537 7	0,516 9	0,505 0	8,115 2	8,068 9	0,600
10 × 12	30	48,000°	11	0,609 8	0,588 8	0,576 0	9,931 0	9,885 1	0,700
12 × 14	31	48,387°	13	0,694 9	0,672 2	0,658 7	11,931 0	11,881 8	0,750
15 × 17	32	48,750°	16	0,823 9	0,799 5	0,785 4	14,715 7	14,663 1	0,900
17 × 20	33	49,091°	18,5	0,921 9	0,896 0	0,880 6	17,067 2	17,011 9	1,000
21 × 24	34	49,412°	22	1,060 4	1,032 9	1,016 4	20,037 7	19,979 3	1,250
26 × 30	35	49,714°	28	1,306 0	1,275 1	1,256 6	25,691 8	25,626 6	1,500
30 × 34	36	50,000°	32	1,448 3	1,415 8	1,396 3	30,022 8	29,954 6	1,500
36 × 40	37	50,270°	38	1,670 7	1,634 7	1,613 2	35,619 3	35,544 3	1,750
40 × 44	38	50,526°	42	1,796 4	1,758 7	1,736 1	39,080 8	39,002 6	2,000
45 × 50	39	50,769°	47,5	1,979 1	1,938 1	1,913 1	44,092 3	44,007 7	2,250
50 × 55	40	51,000°	52,5	2,132 8	2,088 6	2,061 7	48,619 9	48,529 1	2,500
55 × 60	42	51,429°	57,5	2,224 5	2,178 3	2,150 5	52,986 9	52,892 8	2,750

6.7 Tooth thicknesses and dimensions of shafts

6.7.1 Tooth thicknesses and dimensions of shafts with straight flanks

Figure 6 defines tooth thickness and other dimensions of shafts with straight flanks. Table 4 gives the corresponding values for precision fit tooth thickness tolerances, Table 5 contains those for rough fit tolerances.



Key

M_{Re} dimension over measuring circles

D pitch diameter

D_{Re} measuring circle diameter

S tooth thickness

Figure 6 — Tooth thicknesses and dimensions of shafts with straight flanks

Table 4 — Tooth thicknesses and dimensions of shafts with straight flanks, "precision fit"

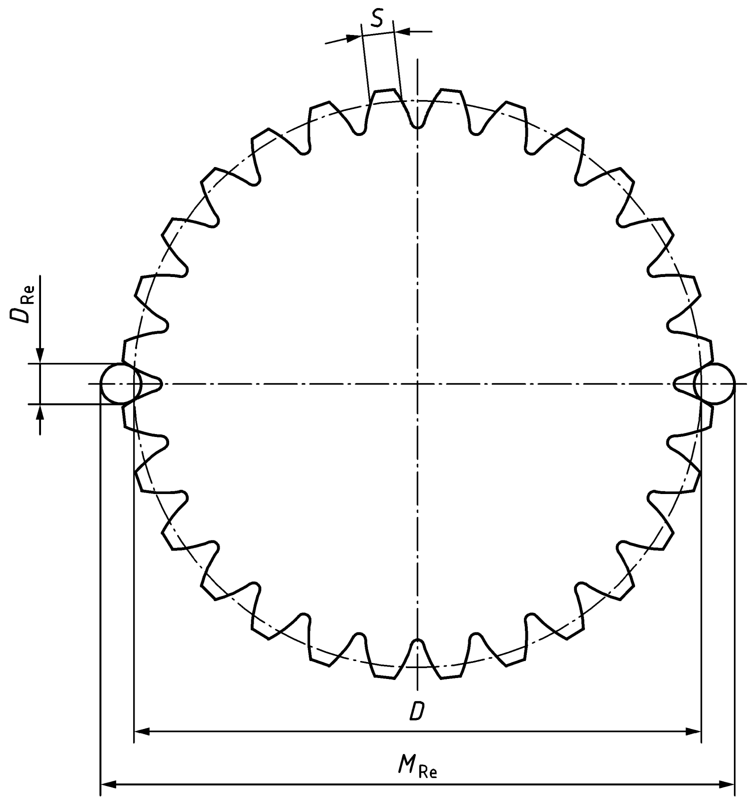
Nominal diameter mm	Number of teeth Z —	Space angle γ_e	Pitch diameter D mm	Tooth thickness max. effective s_V mm	Tooth thickness max. actual s_{max} mm	Tooth thickness min. actual s_{min} mm	Max. dimension over 2 measuring circles $M_{Re\ max}$ mm	Min. dimension over 2 measuring circles $M_{Re\ min}$ mm	Measuring circle diameter D_{Re} mm
7 × 8	28	60°	7,5	0,420 7	0,408 8	0,389 0	8,088 5	8,053 1	0,450
8 × 10	28	60°	9	0,505 0	0,492 7	0,472 1	9,890 0	9,853 2	0,600
10 × 12	30	60°	11	0,576 0	0,563 2	0,541 9	12,065 0	12,027 1	0,700
12 × 14	31	60°	13	0,658 7	0,645 3	0,623 0	14,051 9	14,012 2	0,750
15 × 17	32	60°	16	0,785 4	0,771 0	0,746 9	17,280 3	17,237 4	0,900
17 × 20	33	60°	18,5	0,880 6	0,865 1	0,839 4	19,905 4	19,859 7	1,000
21 × 24	34	60°	22	1,016 4	1,000 4	0,972 5	23,938 3	23,888 7	1,250
26 × 30	35	60°	28	1,256 6	1,238 2	1,207 4	30,234 3	30,179 6	1,500
30 × 34	36	60°	32	1,396 3	1,376 8	1,344 2	34,017 4	33,959 5	1,500
36 × 40	37	60°	38	1,613 2	1,591 7	1,555 9	40,349 4	40,285 9	1,750
40 × 44	38	60°	42	1,736 1	1,713 6	1,675 9	44,917 9	44,851 1	2,000
45 × 50	39	60°	47,5	1,913 1	1,888 5	1,847 5	50,815 6	50,743 0	2,250
50 × 55	40	60°	52,5	2,061 7	2,035 1	1,990 8	56,342 5	56,264 0	2,500
55 × 60	42	60°	57,5	2,150 5	2,122 8	2,076 6	61,936 9	61,855 2	2,750

Table 5 — Tooth thicknesses and dimensions of shafts with straight flanks, "rough fit"

Nominal diameter mm	Number of teeth Z —	Space angle γ_e	Pitch diameter D mm	Tooth thickness max. effective s_V mm	Tooth thickness max. actual s_{max} mm	Tooth thickness min. actual s_{min} mm	Max. dimension over 2 measuring circles $M_{Re\ max}$ mm	Min. dimension over 2 measuring circles $M_{Re\ min}$ mm	Measuring circle diameter D_{Re} mm
7 × 8	28	60°	7,5	0,420 7	0,396 9	0,357 3	8,067 2	7,996 3	0,450
8 × 10	28	60°	9	0,505 0	0,480 4	0,439 4	9,868 0	9,794 6	0,600
10 × 12	30	60°	11	0,576 0	0,550 0	0,506 7	12,041 5	11,964 2	0,700
12 × 14	31	60°	13	0,658 7	0,631 9	0,587 2	14,028 0	13,948 4	0,750
15 × 17	32	60°	16	0,785 4	0,756 4	0,708 4	17,269 3	17,183 8	0,900
17 × 20	33	60°	18,5	0,880 6	0,849 7	0,798 2	19,878 0	19,786 4	1,000
21 × 24	34	60°	22	1,016 4	0,983 4	0,928 5	23,908 1	23,810 4	1,250
26 × 30	35	60°	28	1,256 6	1,219 6	1,158 1	30,201 3	30,092 1	1,500
30 × 34	36	60°	32	1,396 3	1,357 3	1,292 2	33,982 8	33,867 1	1,500
36 × 40	37	60°	38	1,613 2	1,572	1,498 5	40,311 2	40,184 1	1,750
40 × 44	38	60°	42	1,736 1	1,691 0	1,615 8	44,877 9	44,744 5	2,000
45 × 50	39	60°	47,5	1,913 1	1,864 0	1,782 1	50,772 3	50,627 2	2,250
50 × 55	40	60°	52,5	2,061 7	2,008 5	1,919 8	56,295 4	56,138 2	2,500
55 × 60	42	60°	57,5	2,150 5	2,095 0	2,002 5	61,887 7	61,724 0	2,750

6.7.2 Tooth thicknesses and dimensions of shafts with involute flanks

The tooth flanks of shaft serrations may also be involute (see Figure 7). Tables 6 and 7 give the corresponding values.



Key

M_{Re} dimension over measuring circles
D pitch diameter
D_{Re} measuring circle diameter
S tooth thickness

Figure 7 — Tooth thicknesses and dimensions of shafts with involute flanks

Table 6 — Tooth thicknesses and dimensions of shafts with involute flanks, “precision fit”

Nominal diameter mm	Number of teeth Z —	Module m mm	Pressure angle α	Pitch diameter D mm	Tooth thickness max. effective S_V mm	Tooth thickness max. actual S_{max} mm	Tooth thickness min. actual S_{min} mm	Max. dimension over 2 measuring circles $M_{Re\ max}$ mm	Min. dimension over 2 measuring circles $M_{Re\ min}$ mm	Measuring circle diameter D_{Re} mm
7 × 8	28	0,267 86	26,786°	7,5	0,420 7	0,408 8	0,389 0	8,086 8	8,049 7	0,450
8 × 10	28	0,321 43	26,786°	9	0,505 0	0,492 7	0,472 1	9,890 0	9,853 2	0,600
10 × 12	30	0,366 67	27,000°	11	0,576 0	0,563 2	0,541 9	12,064 8	12,027 2	0,700
12 × 14	31	0,419 35	27,097°	13	0,658 7	0,645 3	0,623 0	14,051 5	14,011 3	0,750
15 × 17	32	0,500 00	27,188°	16	0,785 4	0,771 0	0,746 9	17,295 2	17,251 8	0,900
17 × 20	33	0,560 61	27,273°	18,5	0,880 6	0,865 1	0,839 4	19,905 2	19,859 0	1,000
21 × 24	34	0,647 06	27,353°	22	1,016 4	1,000 4	0,972 5	23,937 3	23,888 4	1,250
26 × 30	35	0,800 00	27,428°	28	1,256 6	1,238 2	1,207 4	30,234 1	30,179 7	1,500
30 × 34	36	0,888 89	27,500°	32	1,396 3	1,376 8	1,344 2	34,014 2	33,954 8	1,500
36 × 40	37	1,027 03	27,567°	38	1,613 2	1,591 7	1,555 9	40,346 7	40,281 7	1,750
40 × 44	38	1,105 26	27,631°	42	1,736 1	1,713 9	1,675 9	44,918 3	44,850 6	2,000
45 × 50	39	1,217 95	27,692°	47,5	1,913 1	1,888 5	1,847 5	50,815 7	50,743 0	2,250
50 × 55	40	1,312 50	27,750°	52,5	2,061 7	2,035 1	1,990 8	56,341 5	56,263 7	2,500
55 × 60	42	1,369 05	27,857°	57,5	2,150 5	2,122 8	2,076 6	61,931 2	61,851 3	2,750

Table 7 — Tooth thicknesses and dimensions of shafts with involute flanks, “rough fit”

Nominal diameter mm	Number of teeth Z —	Module m mm	Pressure angle α	Pitch diameter D mm	Tooth thickness max. effective S_V mm	Tooth thickness max. actual S_{max} mm	Tooth thickness min. actual S_{min} mm	Max. dimension over 2 measuring circles $M_{Re\ max}$ mm	Min. dimension over 2 measuring circles $M_{Re\ min}$ mm	Measuring circle diameter D_{Re} mm
7 × 8	28	0,267 86	26,786°	7,5	0,420 7	0,396 9	0,357 3	8,064 6	7,989 1	0,450
8 × 10	28	0,321 43	26,786°	9	0,505 0	0,480 4	0,439 4	9,868 1	9,793 7	0,600
10 × 12	30	0,366 67	27,000°	11	0,576 0	0,550 0	0,506 7	12,041 5	11,964 1	0,700
12 × 14	31	0,419 35	27,097°	13	0,658 7	0,631 9	0,587 2	14,027 4	13,945 8	0,750
15 × 17	32	0,500 00	27,188°	16	0,785 4	0,756 4	0,708 4	17,269 3	17,183 8	0,900
17 × 20	33	0,560 61	27,273°	18,5	0,880 6	0,849 7	0,798 2	19,877 5	19,784 0	1,000
21 × 24	34	0,647 06	27,353°	22	1,016 4	0,983 2	0,928 5	23,907 2	23,810 6	1,250
26 × 30	35	0,800 00	27,428°	28	1,256 6	1,219 6	1,158 1	30,201 2	30,092 2	1,500
30 × 34	36	0,888 89	27,500°	32	1,396 3	1,357 3	1,292 2	33,978 7	33,859 2	1,500
36 × 40	37	1,027 03	27,567°	38	1,613 2	1,570 2	1,498 5	40,307 7	40,176 9	1,750
40 × 44	38	1,105 26	27,631°	42	1,736 1	1,691 0	1,615 8	44,877 5	44,742 8	2,000
45 × 50	39	1,217 95	27,692°	47,5	1,913 1	1,864 0	1,782 1	50,772 3	50,626 3	2,250
50 × 55	40	1,312 50	27,750°	52,5	2,061 7	2,008 5	1,919 8	56,294 8	56,138 4	2,500
55 × 60	42	1,369 05	27,853°	57,5	2,150 5	2,095 0	2,002 5	61,883 2	61,722 4	2,750

7 Guideline values for individual deviations

7.1 General

Guideline values for individual deviations can be entered directly in the data field. However, a note should be added stating that the GO gauge has priority. This means that the respective workpieces shall not be rejected on the basis of individual deviations if the GO gauge shows the workpiece to be acceptable. If, in special cases, it is necessary to give permissible individual deviations as a tolerance, this shall be indicated by the word “max”.

7.2 Guideline values for individual deviations of hubs

Table 8 gives guideline values for the individual deviations of hubs

Table 8 — Guideline values for individual deviations of hubs

Nominal diameter	F_α	F_p	F_β **for serrated widths** b **in mm**		
			up to 10	over 10 up to 20	over 20 up to 50
mm	µm	µm	µm	µm	µm
7 × 8	11	20	8	9	11
8 × 10	11	20	8	9	11
10 × 12	12	22	10	11	13
12 × 14	12	22	10	11	13
15 × 17	13	25	10	11	13
17 × 20	13	25	10	11	13
21 × 24	15	28	10	11	13
26 × 30	17	32	12	13	16
30 × 34	19	36	12	13	16
36 × 40	21	40	12	13	16
40 × 44	21	40	12	13	16
45 × 50	23	45	12	13	16
50 × 55	23	45	12	13	16
55 × 60	25	50	14	16	20

7.3 Guideline values for individual deviations of shafts

Tables 9 and 10 give guideline values for the individual deviations of shafts.

Table 9 — Guideline values for individual deviations of shafts "precision fit"

Nominal diameter	F_α	F_p	F_β **for serrated widths *b* in mm**		
			up to 10	over 10 up to 20	over 20 up to 50
mm	µm	µm	µm	µm	µm
7 × 8	11	20	8	9	11
8 × 10	11	20	8	9	11
10 × 12	12	22	10	11	13
12 × 14	12	22	10	11	13
15 × 17	13	25	10	11	13
17 × 20	13	25	10	11	13
21 × 24	15	28	10	11	13
26 × 30	17	32	12	13	16
30 × 34	19	36	12	13	16
36 × 40	21	40	12	13	16
40 × 44	21	40	12	13	16
45 × 50	23	45	12	13	16
50 × 55	23	45	12	13	16
55 × 60	25	50	14	16	20

Table 10 — Guideline values for individual deviations of shafts "rough fit"

Nominal diameter	F_α	F_p	F_β **for serrated widths *b* in mm**		
			up to 10	over 10 up to 20	over 20 up to 50
mm	µm	µm	µm	µm	µm
7 × 8	21	40	12	13	16
8 × 10	23	45	12	13	16
10 × 12	23	45	12	13	16
12 × 14	25	50	14	16	20
15 × 17	25	50	14	16	20
17 × 20	28	56	14	16	20
21 × 24	28	56	14	16	20
26 × 30	31	63	14	16	20
30 × 34	34	71	17	21	25
36 × 40	37	80	17	21	25
40 × 44	37	80	17	21	25
45 × 50	41	90	17	21	25
50 × 55	41	90	17	21	25
55 × 60	41	90	17	21	25

7.4 Reference values for radial runout

Radial runout is largely a deviation of position and is specified relative to other geometrical elements. It is therefore not possible to give guideline values for this parameter. Table 11 gives reference values for radial runout of the pitch diameter relative to a reference axis.

Table 11 — Radial runout reference values

Pitch diameter D mm	**Radial runout** F_r µm
< 18	20
18 up to < 30	30
30 up to < 50	40
50 up to 60	50

8 Designation

Serrated splines as in this standard shall be designated by the standard number, DIN 5481, the rounded nominal major diameter of the shaft (in mm) and the rounded minor diameter of the hub (in mm). If a “g” (for “*grob*” = rough) is added, this means that the tooth thickness tolerance of the shaft is a rough fit. Because the standard case is a precision fit (“f” for “*fein*” = fine/precise), no specific indication of this needs to be made.

EXAMPLE 1 Serrated spline DIN 5481 — 12 × 14g

EXAMPLE 2 Serrated spline DIN 5481 — 12 × 14

9 Data to be shown on drawings

The geometrical data for serrated splines are normally too extensive to be written directly in the drawings as dimensions. It is therefore recommended that these be indicated in the form of a data field (see Table 12).

EXAMPLE Serrated spline DIN 5481 — 12 × 14

Table 12 — Data field for example “Serrated spline DIN 5481 — 12 × 14”

Hub DIN 5481 — 12 × 14			**Shaft DIN 5481 — 12 × 14**		
Number of teeth	Z	31	Number of teeth	Z	31
Module	m	(0,419 3)	Module	m	(0,419 3)
Space angle	γ_i	48,387°	Space angle	γ_e	60°
Pitch diameter	D	13	Pitch diameter	D	13
Maximum root radius	$R_{i\,max}$	0,10	Tip diameter	D_{ee}	14,2 a11
Root form circle diameter	D_{Fi}	14,07 min.	Root form circle diameter	D_{Fe}	12,12 max.
Tip diameter	D_{ii}	12,0 A11	Maximum root radius	$R_{e\,max}$	0,10
Maximum actual space width	E_{max}	0,694 9	Maximum effective tooth thickness	S_V	0,658 7
Minimum actual reference space width	E_{min}	0,672 2	Maximum actual reference tooth thickness	S_{max}	0,645 3
Minimum effective space width	E_V	0,658 7	Minimum actual tooth thickness	S_{min}	0,623 0

Hub DIN 5481 — 12 × 14			Shaft DIN 5481 — 12 × 14		
Measuring circle diameter[a]	D_{Ri}	0,750	Measuring circle diameter[a]	D_{Re}	0,750
Maximum dimension between measuring circles	$M_{Ri\ max}$	11,931 0	Maximum reference dimension over measuring circles	$M_{Re\ max}$	14,051 9
Minimum reference dimension between measuring circles	$M_{Ri\ min}$	11,881 8	Minimum dimension over measuring circles	$M_{Re\ min}$	14,012 2
Total profile deviation	F_α	0,012	Total profile deviation	F_α	0,012
Total helix deviation	F_β	0,013	Total helix deviation	F_β	0,013
Total cumulative pitch deviation	F_p	0,022	Total cumulative pitch deviation	F_p	0,022
Radial runout	F_r	0,020	Radial runout	F_r	0,020

[a] It is also possible to give the ball or pin diameter instead of the measuring circle diameter, if this is so specified. The dimension over or between measuring circles is then given either as the dimension over or between balls or pins, accordingly.

The designations specified in DIN 21772 for gear teeth are also permitted.

10 Quality characteristics

Quality assurance of splines involves three main areas: dimensions, individual deviations and positional deviations (see Figure 8). Each of these in turn involve several individual parameters.

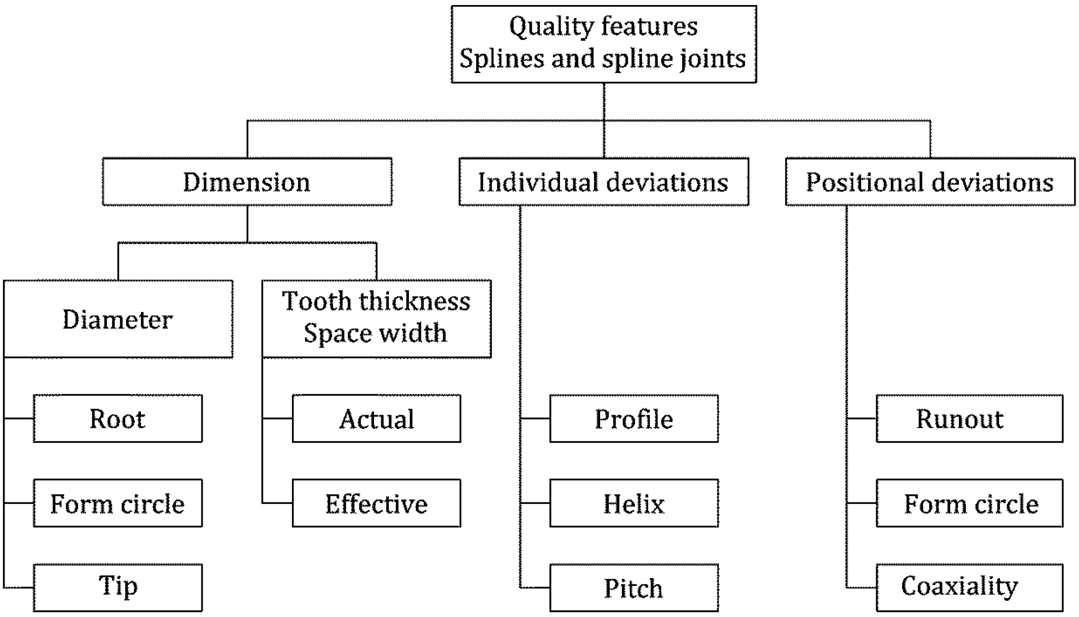


Figure 8 — Quality characteristics

In the manufacturing sector, measuring the values of the deviations is becoming increasingly more important than simply ensuring that the tolerance limits have been adhered to. However, this standard is restricted to inspection by attribute. The use of composite GO gauges and sector NO GO gauges ensures that diameters and the actual and effective tooth thicknesses/space widths are within the tolerance limits.

If necessary, individual deviations can be measured and measurements using indicating instruments can be carried out. DIN 5480-15 specifies such for involute splines.

11 Gauges/general

11.1 Types of gauge and gauge dimensions

11.1.1 Composite GO gauges

Composite GO gauges are used to check that the minimum effective space width and the maximum effective tooth thickness are within the tolerance limits along the entire length of the GO gauge and that the form circle diameter of the part is within the permitted form diameter.

The length of the measuring part of GO gauges should be equal to at least 50 % of the active spline length. In the case of long joints it may be necessary to increase the length of GO gauges to 100 % of the active spline length. In the case of GO ring gauges, the length of the splines is often limited by the ability to manufacture them.

11.1.2 Sector NO GO gauges

NO GO gauges always have teeth on one sector of their diameter and are used to check adherence to the actual tolerance limit. In the case of hubs, this is the maximum actual space width, and in the case of shafts it is the minimum actual tooth thickness. NO GO gauges have two diametrically opposed groups of teeth. The outermost tooth flanks of each sector are relieved by an adequate distance, since these cannot be measured precisely. The number of teeth of sector NO GO gauges depends on the number of teeth of the part to be tested. The following numbers of teeth for NO GO gauges as given in Table 13 are recommended:

Table 13 — Number of teeth for sector NO GO gauges

Number of teeth of part to be inspected	Number of teeth of NO GO gauge
up to 31	2 + 2
from 32 up to 45	3 + 3

Essentially, the splines of NO GO gauges can be as short as is practical. However, they should be long enough to prevent the gauge tilting and jamming in the teeth of the part under inspection.

As NO GO gauges use the entire flanks of several teeth to check for conformity with the actual tolerance limits, they do not make a single-point contact. Since it is not permitted to fit NO GO gauges with the workpiece being inspected, only the end face of the splines of the workpiece is checked, not their whole length. For this reason, measuring the respective actual dimension with a relevant indicating instrument is to be given priority. The inspection result obtained with a NO GO gauge can be overridden by the results of measurements made with indication.

A workpiece should be inspected with the NO GO gauge in at least three angular positions, these being as equally spaced as possible. The NO GO gauge shall not fit into or pass over the workpiece being inspected at any of these angular positions.

11.1.3 Plug gauges

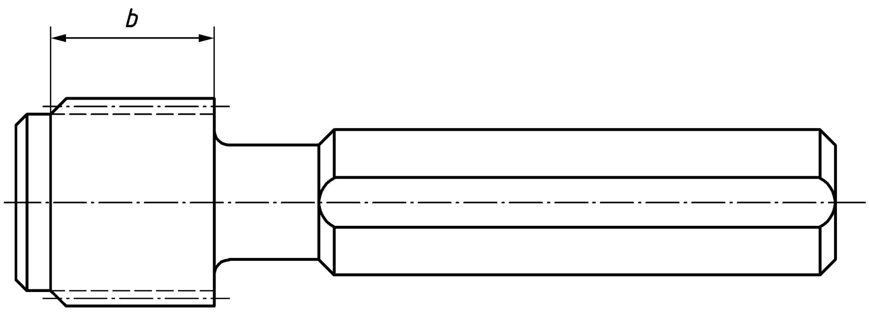
Plug gauges shall have a handle which is adapted to the size of the pitch diameter and the weight of the gauge. Small gauges can be designed as limit plug gauges with both a GO end and a NO GO end on one handle. All plug gauges have a pilot to facilitate insertion of the gauge into the splined bore of the part being inspected. Plug gauges shall be designed so that they can be aligned on a measuring machine in order to check the individual deviations. This can be achieved by means of centring holes, whereby an external alignment shoulder or a hole is used as a reference. Plug gauges with large pitch diameters shall be made as light as possible by turning relief grooves and drilling relief holes.

In many cases, the active spline length is not known when the gauge is designed. In such cases, the use of dimensions based on the values given in Table 14 is recommended.

Essentially, the splines of NO GO gauges can be as short as is practical. However, they should be long enough to prevent the gauge tilting and jamming in the teeth of the part under inspection. Table 14 gives recommended spline lengths for NO GO plug gauges of sizes 1 to 6 (see Figure 9).

Table 14 — Plug gauge lengths

Size	**Pitch diameter** *D* mm	**GO gauge length** GD mm	**NO GO gauge length** HD mm
1	7 up to 12	8	6
2	over 12 up to 17	12	8
3	over 17 up to 22	15	10
4	over 22 up to 30	20	10
5	over 30 up to 40	25	15
6	over 40	30	18



Key

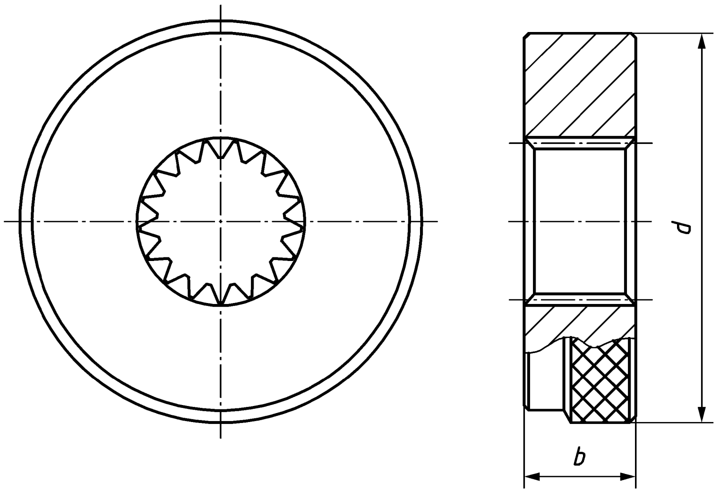
b gauge length

Figure 9 — Plug gauges, sizes 1 to 6

11.1.4 Ring gauges

The external circumference surfaces of GO and NO GO ring gauges have an easy-to-grip finish, making them easier to hold. This finish can be achieved by means of knurled surfaces. Ring gauges shall have an alignment shoulder which serves as a reference for individual deviation determination on a measuring machine. The end faces of the splines of ring gauges are chamfered, making it easier to fit them over the part to be inspected (see Figure 10).

In many cases, the active spline length is not known when the gauge is designed. In such cases, the use of dimensions based on the values given in Table 15 is recommended. Essentially, the splines of NO GO gauges can be as short as is practical. However, they should be long enough to prevent the gauge tilting and jamming in the teeth of the part under inspection. Table 15 gives recommended spline lengths of ring gauges.



Key

b Length
d Outer diameter

Figure 10 — Ring gauge

Table 15 — External dimensions of ring gauges

Size	**Pitch diameter** *D* mm	**Major diameter** mm	**GO gauge length** GD mm	**NO GO gauge length** HD mm
1	up to 17	53	12	8
2	over 17 up to 30	70	16	11
3	over 30 up to 50	100	20	15
4	over 50	125	25	15

Standard cylindrical limit gauges can be used to check the minor diameter of hubs and major diameter of shafts.

11.2 Materials, surface finishes, reference temperature, insertion force for inspection

Spline gauges shall be made of low-deformation materials and hardened accordingly. The gauge hardness should be at least 4 HRC higher than that of the parts to be inspected, but at least HRC 60. As the material structure transformation is not fully concluded during the hardening process, the gauges shall be artificially aged. This prevents subsequent material expansion to a large extent. The tip diameter surface of GO gauges, and the tooth flanks of all gauges, shall have a maximum surface roughness $Rz = 1,5$.

The reference temperature for length and form measurement shall be 20 °C. All measurements (and inspections) shall be carried out at this temperature. It is also possible to take measurements at other temperatures and to convert the results to the equivalent values at the reference temperature. However, (inspections and) measurements carried out at the reference temperature shall be given priority.

As opposed to workpiece inspections using other types of gauge, an insertion force is permitted and is even necessary when using spline gauges. The gauge’s own weight is often not sufficient without additional application of force. However, the insertion force should not exceed 150 N.

11.3 Calculating gauge dimensions

11.3.1 Tolerance diagram

Figure 11 illustrates the tolerance positions.

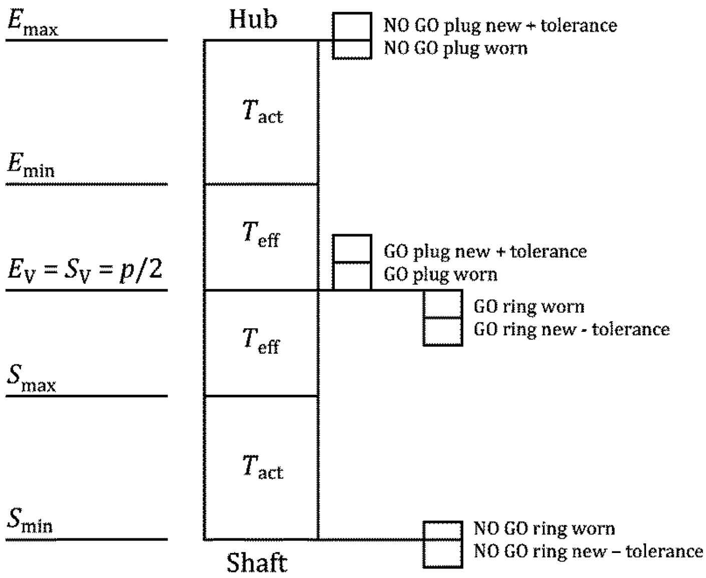


Figure 11 — Tolerance diagram

11.3.2 Determining measurements over/between pins

The tooth thickness of plug gauges can be checked by calculating the dimension over two measuring pins, and the space widths of ring gauges can be checked by means of the dimension between two measuring pins (see Figures 5 and 6). The measuring pin diameters shall be taken from the corresponding tables for workpiece inspections. Measuring balls can be used instead of pins, provided the balls do not have any “flats” (worn surfaces).

11.3.3 Individual deviations and positional deviations

The individual deviations of spline gauges are expressed as maximum deviations from the ideal geometry. They are to be taken from the relevant tolerance table in relation to the gauge quality.

The individual deviations of spline gauges are: $F_{p,}$ $F_{\alpha,}$ $F_{ß}$

For plug gauges, the individual deviations are measured with reference to the centring holes or the reference hole, and in ring gauges, with reference to the alignment shoulder and the plane face. Small positional deviations of the serrations relative to the reference basis have an adverse effect on the individual deviation measurements. Modern spline measuring machines can either use the actual set of splines as a basis or can filter out the positional deviation data. This is permissible if the inspection report contains a corresponding note to this effect.

The position of the spline section of a gauge relative to its reference basis is expressed in terms of radial runout, F_r (see Figure 12).

The maximum permissible radial runout of splines relative to the centring hole, reference hole or alignment shoulder is given in Table 16. The positional deviation tolerance defines limits for the incorrectness of individual deviation measurements caused by positional deviations. If the gear measuring machine uses alignment software or filtering of eccentricity data to prevent such inaccuracies, the radial runout tolerance may be exceeded. In this case a corresponding note shall be included in the inspection report.

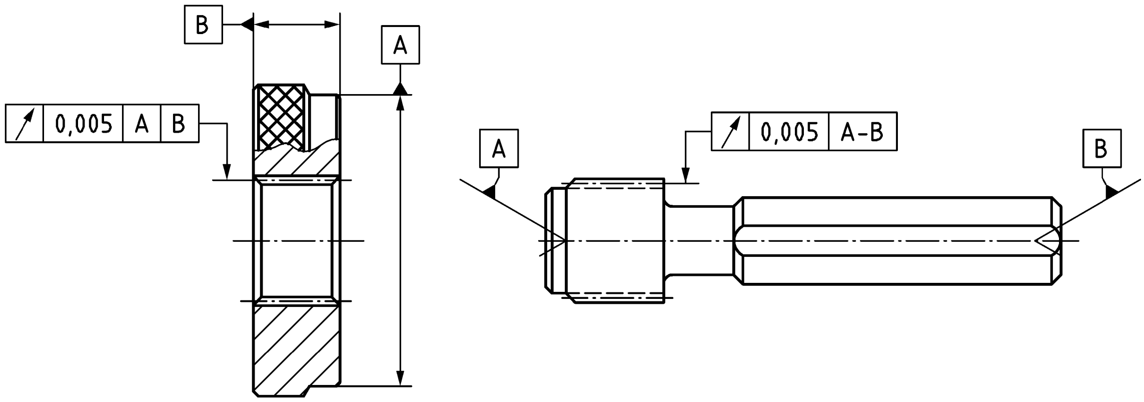


Figure 12 — Radial runout of gauges

To enable accurate gauge inspection, a “worn” dimension (wear limit) has been introduced for NO GO gauges. According to this standard, the profile of a worn GO gauge may be worn down to the theoretical profile (half the pitch).

The values of individual deviations shall be taken from Table 16.

Table 16 — Individual deviations of plug gauges and of “precision fit” and “rough fit” ring gauges

Pitch diameter *D* mm	**Individual deviations** µm New condition				Wear limit			
	F_r	F_p	F_β	F_α	F_r	F_p	F_β	F_α
up to 11	4	4	3	4	5,5	6	4	6
over 11 up to 18,5	4,5	4,5	3	4	6	6,5	4	6
over 18,5 up to 38	5	5	3,5	4,5	7	7	4,5	6,5
over 38 up to 57,5	5,5	6	3,5	5	8	9	4,5	7

11.4 Gauges for hubs

11.4.1 GO plug gauges

Table 17 gives diameters of GO plug gauges.

Table 17 — Diameters of GO plug gauges

Nominal diameter mm	**Number of teeth** Z —	**Space angle** γ_e	**Pitch diameter** D mm	**Tip diameter** mm	**Tolerance tip diameter** µm	**Root form circle diameter** mm	**Root radius** max. mm
7 × 8	28	60°	7,5	7,82	±5	7,13	0,11
8 × 10	28	60°	9	9,81	±5	8,35	0,07
10 × 12	30	60°	11	11,71	±5	10,34	0,11
12 × 14	31	60°	13	13,91	±5	12,24	0,12
15 × 17	32	60°	16	16,91	±5	15,14	0,16
17 × 20	33	60°	18,5	19,70	±5	17,54	0,19
21 × 24	34	60°	22	23,60	±6	21,00	0,23
26 × 30	35	60°	28	29,70	±6	26,70	0,26
30 × 34	36	60°	32	33,69	±6	30,71	0,37
36 × 40	37	60°	38	39,59	±9	36,21	0,33
40 × 44	38	60°	42	43,68	±9	40,21	0,40
45 × 50	39	60°	47,5	49,68	±9	45,22	0,35
50 × 55	40	60°	52,5	54,56	±10	50,22	0,43
55 × 60	42	60°	57,5	59,66	±10	55,24	0,49

Table 18 gives tooth thicknesses of GO plug gauges.

Table 18 — Tooth thicknesses of GO plug gauges

Nominal diameter mm	Number of teeth Z —	Space angle γ_e	Pitch diameter D mm	Tooth thickness, new mm	Tooth thickness tolerance µm	Tooth thickness worn down to mm	Dimension over pins, new mm	Tolerance for dimension over pins, new µm	Dimension over pins worn down to mm	Measuring pin diameter mm
7 × 8	28	60°	7,5	0,423 7	+3	0,420 7	8,115 1	+5,4	8,109 7	0,450
8 × 10	28	60°	9	0,508 0	+3	0,505 0	9,917 3	+5,4	9,912 0	0,600
10 × 12	30	60°	11	0,579 0	+3	0,576 0	12,093 2	+5,3	12,087 9	0,700
12 × 14	31	60°	13	0,661 7	+3	0,658 7	14,081 0	+5,3	14,075 7	0,750
15 × 17	32	60°	16	0,788 4	+3	0,785 4	17,326 3	+5,3	17,320 9	0,900
17 × 20	33	60°	18,5	0,884 6	+4	0,880 6	19,940 0	+7,1	19,932 9	1,000
21 × 24	34	60°	22	1,020 4	+4	1,016 4	23,973 8	+7,1	23,966 7	1,250
26 × 30	35	60°	28	1,260 6	+4	1,256 6	30,274 0	+7,1	30,266 9	1,500
30 × 34	36	60°	32	1,400 3	+4	1,396 3	34,059 1	+7,1	34,052 0	1,500
36 × 40	37	60°	38	1,617 2	+4	1,613 2	40,394 5	+7,1	40,387 4	1,750
40 × 44	38	60°	42	1,741 1	+5	1,736 1	44,966 7	+8,9	44,957 8	2,000
45 × 50	39	60°	47,5	1,918 1	+5	1,913 1	50,868 0	+8,8	50,859 2	2,250
50 × 55	40	60°	52,5	2,066 7	+5	2,061 7	56,398 4	+8,8	56,389 6	2,500
55 × 60	42	60°	57,5	2,155 5	+5	2,150 5	61,994 7	+8,8	61,985 9	2,750

11.4.2 NO GO plug gauges

Table 19 gives diameters of NO GO plug gauges.

Table 19 — Diameters of NO GO plug gauges

Nominal diameter mm	Number of teeth Z —	Space angle γ_e	Tip diameter mm	Tolerance tip diameter µm	Pitch diameter D mm	Root form circle diameter mm	Root radius max. mm
7 × 8	2 + 2 (28)	60°	7,8	±10	7,5	7,13	0,10
8 × 10	2 + 2 (28)	60°	9,5	±10	9	8,35	0,05
10 × 12	2 + 2 (30)	60°	11,5	±10	11	10,34	0,09
12 × 14	2 + 2 (31)	60°	13,6	±10	13	12,24	0,10
15 × 17	3 + 3 (32)	60°	16,6	±10	16	15,14	0,14
17 × 20	3 + 3 (33)	60°	19,2	±10	18,5	17,54	0,22
21 × 24	3 + 3 (34)	60°	23,0	±12	22	21,00	0,25
26 × 30	3 + 3 (35)	60°	29,0	±12	28	26,70	0,29
30 × 34	3 + 3 (36)	60°	32,9	±12	32	30,71	0,35
36 × 40	3 + 3 (37)	60°	38,8	±18	38	36,21	0,30
40 × 44	3 + 3 (38)	60°	42,8	±18	42	40,21	0,37
45 × 50	3 + 3 (39)	60°	48,7	±18	47,5	45,22	0,31
50 × 55	3 + 3 (40)	60°	53,6	±20	52,5	50,22	0,39
55 × 60	3 + 3 (42)	60°	58,6	±20	57,5	55,24	0,45

Table 20 gives tooth thicknesses of NO GO plug gauges.

Table 20 — Tooth thicknesses of NO GO plug gauges

Nominal diameter mm	Number of teeth Z —	Space angle γ_e	Pitch diameter D mm	Tooth thickness, new mm	Tooth thickness tolerance µm	Tooth thickness worn down to mm	Dimension over pins, new mm	Tolerance Dimension over pins, new µm	Dimension over pins worn down to mm	Measuring pin diameter mm
7 × 8	2 + 2 (28)	60°	7,5	0,452 6	+3	0,451 1	8,166 6	+5,3	8,164 0	0,450
8 × 10	2 + 2 (28)	60°	9	0,537 7	+3	0,536 2	9,970 3	+5,3	9,967 6	0,600
10 × 12	2 + 2 (30)	60°	11	0,609 8	+3	0,608 3	12,148 0	+5,3	12,145 4	0,700
12 × 14	2 + 2 (31)	60°	13	0,694 9	+3	0,693 4	14,140 0	+5,3	14,137 4	0,750
15 × 17	3 + 3 (32)	60°	16	0,823 9	+3	0,822 4	17,389 4	+5,3	17,386 7	0,900
17 × 20	3 + 3 (33)	60°	18,5	0,921 9	+4	0,919 9	20,006 2	+7,1	20,002 7	1,000
21 × 24	3 + 3 (34)	60°	22	1,060 4	+4	1,058 4	24,044 8	+7,1	24,041 3	1,250
26 × 30	3 + 3 (35)	60°	28	1,306 0	+4	1,304 0	30,354 5	+7,1	30,350 9	1,500
30 × 34	3 + 3 (36)	60°	32	1,448 3	+4	1,446 3	34,144 2	+7,1	34,140 6	1,500
36 × 40	3 + 3 (37)	60°	38	1,670 7	+4	1,668 7	40,489 2	+7,1	40,485 7	1,750
40 × 44	3 + 3 (38)	60°	42	1,796 4	+5	1,793 9	45,064 6	+8,9	45,060 2	2,000
45 × 50	3 + 3 (39)	60°	47,5	1,979 1	+5	1,976 6	50,975 9	+8,8	50,971 5	2,250
50 × 55	3 + 3 (40)	60°	52,5	2,132 8	+5	2,130 3	56,515 4	+8,8	56,511 0	2,500
55 × 60	3 + 3 (42)	60°	57,5	2,224 5	+5	2,222 0	62,116 7	+8,8	62,112 3	2,750

11.5 Gauges for shafts

11.5.1 GO ring gauges

Table 21 gives diameters of GO ring gauges.

Table 21 — Diameters of GO ring gauges

Nominal diameter mm	Number of teeth Z —	Space angle γ_i	Pitch diameter D mm	Tip diameter mm	Tolerance tip diameter µm	Root form circle diameter mm	Root radius max. mm
7 × 8	28	47,143°	7,5	7,18	±5	7,85	0,14
8 × 10	28	47,143°	9	8,38	±5	9,86	0,06
10 × 12	30	48,000°	11	10,39	±5	11,76	0,12
12 × 14	31	48,387°	13	12,29	±5	13,96	0,11
15 × 17	32	48,75°	16	15,19	±5	16,96	0,18
17 × 20	33	49,091°	18,5	17,59	±5	19,75	0,16
21 × 24	34	49,412°	22	21,10	±6	23,65	0,13
26 × 30	35	49,714°	28	26,80	±6	29,80	0,22
30 × 34	36	50,000°	32	30,81	±6	33,79	0,30
36 × 40	37	50,270°	38	36,31	±9	39,69	0,44
40 × 44	38	50,526°	42	40,31	±9	43,80	0,47
45 × 50	39	50,769°	47,5	45,32	±9	49,80	0,44
50 × 55	40	51,000°	52,5	50,32	±10	54,80	0,51
55 × 60	42	51,429°	57,5	55,34	±10	59,80	0,56

Table 22 gives space widths of GO ring gauges.

Table 22 — Space widths of GO ring gauges

Nominal diameter mm	Number of teeth Z —	Space angle γ_i	Pitch diameter D mm	Space width, new mm	Tolerance space width, new µm	Space width worn to mm	Dimension between pins, new mm	Tolerance for dimension between pins, new µm	Dimension between pins worn down to mm	Measuring pin diameter mm
7 × 8	28	47,143°	7,5	0,417 7	0 −3	0,420 7	6,870 0	0 −6,7	6,876 6	0,450
8 × 10	28	47,143°	9	0,502 0	0 −3	0,505 0	8,035 6	0 −6,7	8,042 3	0,600
10 × 12	30	48,000°	11	0,573 0	0 −3	0,576 0	9,850 5	0 −6,6	9,857 0	0,700
12 × 14	31	48,387°	13	0,655 7	0 −3	0,658 7	11,846 0	0 −6,5	11,852 5	0,750
15 × 17	32	48,750°	16	0,782 4	0 −3	0,785 4	14,626 3	0 −6,5	14,632 7	0,900
17 × 20	33	49,091°	18,5	0,876 6	0 −4	0,880 6	16,970 4	0 −8,6	16,978 9	1,000
21 × 24	34	49,412°	22	1,012 4	0 −4	1,016 4	20,783 9	0 −8,5	20,792 4	1,000
26 × 30	35	49,714°	28	1,252 6	0 −4	1,256 6	26,423 3	0 −8,4	26,431 8	1,250
30 × 34	36	50,000°	32	1,392 3	0 −4	1,396 3	29,905 3	0 −8,4	29,913 7	1,500
36 × 40	37	50,270°	38	1,609 2	0 −4	1,613 2	35,491 1	0 −8,3	35,499 4	1,750
40 × 44	38	50,526°	42	1,731 1	0 −5	1,736 1	38,945 3	0 −10,4	38,955 7	2,000
45 × 50	39	50,769	47,5	1,908 1	0 −5	1,913 1	43,945 8	0 −10,3	43,956 1	2,250
50 × 55	40	51,000°	52,5	2,056 7	0 −5	2,061 7	48,463 5	0 −10,3	48,473 8	2,500
55 × 60	42	51,429°	57,5	2,145 5	0 −5	2,150 5	52,826 0	0 −10,2	52,836 2	2,750

11.5.2 NO GO ring gauges, "precision fit"

Table 23 gives diameters of NO GO ring gauges.

Table 23 — Diameters of "precision fit" NO GO ring gauges

Nominal diameter mm	Number of teeth Z —	Space angle γ_i	Pitch diameter D mm	Tip diameter mm	Tolerance tip diameter µm	Root form circle diameter mm	Root radius max. mm
7 × 8	2 + 2 (28)	47,143°	7,5	7,29	±10	7,85	0,12
8 × 10	2 + 2 (28)	47,143°	9	8,59	±10	9,86	0,04
10 × 12	2 + 2 (30)	48,000°	11	10,59	±10	11,76	0,10
12 × 14	2 + 2 (31)	48,387°	13	12,53	±10	13,96	0,10
15 × 17	3 + 3 (32)	48,750°	16	15,46	±10	16,96	0,16
17 × 20	3 + 3 (33)	49,091°	18,5	17,89	±10	19,75	0,14
21 × 24	3 + 3 (34)	49,412°	22	21,40	±12	23,65	0,11
26 × 30	3 + 3 (35)	49,714°	28	27,20	±12	29,80	0,20
30 × 34	3 + 3 (36)	50,000°	32	31,21	±12	33,79	0,27
36 × 40	3 + 3 (37)	50,270°	38	36,87	±18	39,69	0,41
40 × 44	3 + 3 (38)	50,526°	42	40,87	±18	43,80	0,45
45 × 50	3 + 3 (39)	50,769°	47,5	46,04	±18	49,80	0,41
50 × 55	3 + 3 (40)	51,000°	52,5	51,05	±20	54,80	0,48
55 × 60	3 + 3 (42)	51,429°	57,5	56,06	±20	59,80	0,53

Table 24 gives space widths of NO GO ring gauges.

Table 24 — Space widths of "precision fit" NO GO ring gauges

Nominal diameter mm	Number of teeth Z —	Space angle γ_i	Pitch diameter D mm	Space width, new mm	Tolerance space width, new µm	Space width worn to mm	Dimension between pins, new mm	Tolerance for dimension between pins, new µm	Dimension between pins worn down to mm	Measuring pin diameter mm
7 × 8	2 + 2 (28)	47,143°	7,5	0,389 0	0 −3	0,390 5	6,805 9	0 −6,7	6,809 2	0,450
8 × 10	2 + 2 (28)	47,143°	9	0,472 1	0 −3	0,473 6	7,968 8	0 −6,7	7,972 1	0,600
10 × 12	2 + 2 (30)	48,000°	11	0,541 9	0 −3	0,543 4	9,782 3	0 −6,6	9,785 6	0,700
12 × 14	2 + 2 (31)	48,387°	13	0,623 0	0 −3	0,624 5	11,775 0	0 −6,5	11,778 3	0,750
15 × 17	3 + 3 (32)	48,750°	16	0,746 9	0 −3	0,748 4	14,549 7	0 −6,5	14,552 9	0,900
17 × 20	3 + 3 (33)	49,091°	18,5	0,839 4	0 −4	0,841 4	16,890 8	0 −8,6	16,895 1	1,000
21 × 24	3 + 3 (34)	49,412°	22	0,972 5	0 −4	0,974 5	20,699 0	0 −8,5	20,703 3	1,000
26 × 30	3 + 3 (35)	49,714°	28	1,207 4	0 −4	1,209 4	26,327 9	0 −8,4	26,332 2	1,250
30 × 34	3 + 3 (36)	50,000°	32	1,344 2	0 −4	1,346 2	29,804 3	0 −8,4	29,808 5	1,500
36 × 40	3 + 3 (37)	50,270°	38	1,555 9	0 −4	1,557 9	35,379 9	0 −8,3	35,384 1	1,750
40 × 44	3 + 3 (38)	50,526	42	1,675 9	0 −5	1,678 4	38,830 6	0 −10,4	38,835 8	2,000
45 × 50	3 + 3 (39)	50,769°	47,5	1,847 5	0 −5	1,850 0	43,820 7	0 −10,3	43,820 7	2,250
50 × 55	3 + 3 (40)	51,000°	52,5	1,990 8	0 −5	1,993 3	48,328 0	0 −10,3	48,333 1	2,500
55 × 60	3 + 3 (42)	51,429°	57,5	2,076 6	0 −5	2,079 1	52,685 6	0 −10,2	52,690 7	2,750

11.5.3 NO GO ring gauges, “rough fit”

Table 25 gives diameters of NO GO ring gauges.

Table 25 — Diameters of “rough fit” NO GO ring gauges

Nominal diameter mm	**Number of teeth** Z —	**Space angle** γ_i	**Pitch diameter** D mm	**Tip diameter** mm	**Tolerance tip diameter** µm	**Root form circle diameter** mm	**Root radius** max. mm
7 × 8	2 + 2 (28)	47,143°	7,5	7,29	±10	7,85	0,11
8 × 10	2 + 2 (28)	47,143°	9	8,59	±10	9,86	0,04
10 × 12	2 + 2 (30)	48,000°	11	10,59	±10	11,76	0,08
12 × 14	2 + 2 (31)	48,387°	13	12,53	±10	13,96	0,08
15 × 17	3 + 3 (32)	48,750°	16	15,46	±10	16,96	0,14
17 × 20	3 + 3 (33)	49,091°	18,5	17,89	±10	19,75	0,12
21 × 24	3 + 3 (34)	49,412°	22	21,40	±12	23,65	0,08
26 × 30	3 + 3 (35)	49,714°	28	27,20	±12	29,80	0,17
30 × 34	3 + 3 (36)	50,000°	32	31,21	±12	33,79	0,24
36 × 40	3 + 3 (37)	50,270°	38	36,87	±18	39,69	0,38
40 × 44	3 + 3 (38)	50,526°	42	40,87	±18	43,80	0,41
45 × 50	3 + 3 (39)	50,769°	47,5	46,04	±18	49,80	0,37
50 × 55	3 + 3 (40)	51,000°	52,5	51,05	±20	54,80	0,44
55 × 60	3 + 3 (42)	51,429°	57,5	56,06	±20	59,80	0,48

Table 26 gives space widths of NO GO ring gauges.

Table 26 — Space widths of "rough fit" NO GO ring gauges

Nominal diameter mm	Number of teeth Z —	Space angle γ_i	Pitch diameter D mm	Space width, new mm	Tolerance space width µm	Space width worn to mm	Dimension between pins, new mm	Tolerance for dimension between pins, new µm	Dimension between pins worn down to mm	Measuring pin diameter mm
7 × 8	2 + 2 (28)	47,143°	7,5	0,357 3	0 −3	0,358 8	6,734 8	0 −6,7	6,738 2	0,450
8 × 10	2 + 2 (28)	47,143°	9	0,439 4	0 −3	0,440 9	7,895 6	0 −6,7	7,899 0	0,600
10 × 12	2 + 2 (30)	48,000°	11	0,506 7	0 −3	0,508 2	9,705 0	0 −6,6	9,708 3	0,700
12 × 14	2 + 2 (31)	48,387°	13	0,587 2	0 −3	0,588 7	11,697 2	0 −6,5	11,770 5	0,750
15 × 17	3 + 3 (32)	48,75°	16	0,708 4	0 −3	0,709 9	14,466 6	0 −6,5	14,469 8	0,900
17 × 20	3 + 3 (33)	49,091°	18,5	0,798 2	0 −4	0,800 2	16,802 6	0 −8,6	16,806 9	1,000
21 × 24	3 + 3 (34)	49,412°	22	0,928 5	0 −4	0,930 5	20,605 4	0 −8,5	20,609 7	1,000
26 × 30	3 + 3 (35)	49,714°	28	1,158 1	0 −4	1,160 1	26,223 8	0 −8,5	26,228 0	1,250
30 × 34	3 + 3 (36)	50,000°	32	1,292 2	0 −4	1,294 2	29,695 0	0 −8,4	29,699 2	1,500
36 × 40	3 + 3 (37)	50,270°	38	1,498 5	0 −4	1,500 5	35,260 1	0 −8,4	35,264 3	1,750
40 × 44	3 + 3 (38)	50,526°	42	1,615 8	0 −5	1,618 3	38,705 7	0 −10,4	38,710 9	2,000
45 × 50	3 + 3 (39)	50,769°	47,5	1,782 1	0 −5	1,784 6	43,685 6	0 −10,3	43,690 8	2,250
50 × 55	3 + 3 (40)	51,000°	52,5	1,919 8	0 −5	1,922 3	48,181 9	0 −10,3	48,187 0	2,500
55 × 60	3 + 3 (42)	51,429°	57,5	2,002 5	0 −5	2,005 0	52,534 4	0 −10,2	52,539 5	2,750

11.6 Inspecting gauges

11.6.1 Inspection of gauges in new condition

Spline gauges have more complicated geometries than cylindrical limit gauges, and appropriate care shall be taken when inspecting them. It is not sufficent to simply check an actual measurement; rather, the compliance of all indivudal deviations with manufacturing tolerances shall be checked before using the gauges. Inspection certificates are only valid if they include a written record of the individual deviation measurements (see Table 27).

Table 27 — Inspecting spline gauges

Feature	Inspection method	Remarks
Damage	Visual inspection of spline	Damage or corrosion is not permitted.
Identity	Visual inspection of the markings	The markings shall be durable and meet the relevant requirements.
Tip diameter	Abbe measuring method or 3D measuring machine	Abbe mesuring methods are not possible for an odd number of teeth.
Form circle diameter	Over the rolling length, rolling angle or rolling diameter on gear measuring machine or 3D measuring machine	
Tooth thickness, plug gauges	Measurement over two pins. As an alternative, the dimension over two balls can be measured if the balls do not exceed the permissible out-of-roundness value at the point where they touch the tooth flanks, and if the actual ball diameter is determined. The actual dimension shall be measured at the start, the middle and the end of the splines over two diameters at 90° to one another. Measuring pins shall be slipped in and rubbed against the flanks in order to ensure dust-free contact with the flanks. Experience has shown that it is difficult to achieve an adequate degree of accuracy when using a 3D measuring machine to determine the very narrow gauge tolerances.	Measuring force: 1,0 N to 1,5 N The maximum permissible out-of-roundness of measuring pins or balls is 0,5 µm. The permitted deviation of measuring pins or balls from their nominal dimension is 0,001 mm. Within these allowances, the inspection dimensions over measuring circles are to be converted to correspond to the actual dimensions of the measuring pins or balls.
Space width, ring gauges	The provisions regarding the tooth thickness of plug gauges apply to ring gauges by analogy.	Ring gauges are usually inspected using measuring pins and gauge blocks. The actual dimension of a ring gauge is determined as the gauge block which will just fit between the pins and can be moved without jamming and without any lateral tilt clearance.
Individual dimensions	Gear measuring machine or high-precision 3D measuring machine with integrated circular table. The profile form and the helix line are to be measured separately at four left and four right flanks at roughly 90° to one another. For GO gauges, the individual and total pitch deviations shall be checked as well.	If the eccentricity of the splines relative to the reference basis is not eliminated by computational methods, then adherence to the permitted runout tolerance shall be checked. This is necessary because the eccentricity and pitch deviations are superimposed, and incorrect inspection values may result if the deviations occur at opposite phases.

11.6.2 Gauge wear inspection

Spline gauges are to be inspected for wear using the same procedure as for new gauges by analogy. The inspection intervals for inspection equipment shall be selected so as to prevent the use of worn gauges. A gauge is deemed as being worn out if the “worn” dimension over/between pins is not achieved/ is exceeded or an individual deviation, as stated in the drawing, exceeds the respective permitted value given in the gauge drawing.

11.6.3 Master ring gauges

In most cases, master ring gauges are not required. Master gauges have their own individual deviations which can affect the actual gauge dimensions to such an extent that gauges produced with the master gauges can have different dimensions from those of gauges produced without master gauges. Use of master gauges is only expedient for very small ring gauges, which are difficult to measure directly. Master plug gauges for GO and NO GO ring gauges are tapered, the left flanks of all teeth being straight, and the right flanks of all teeth being tapered. This means that the thickness of the resulting tapered teeth increases from the front to back (see Figure 13). For further information on the design of master plug gauges for GO and NO GO ring gauges, see ISO 4156-3. The use of a master plug gauge is not a substitute for checking the individual deviations of ring gauges. This procedure is to be carried out for new gauges and when inspecting the condition of gauges in use, whether or not a master plug gauge is used. In addition, master plug gauges shall also be checked, both when new and during use.

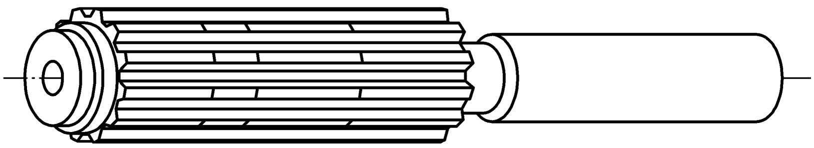


Figure 13 — Master plug gauge with teeth tapered on one side

11.7 Marking

Spline gauges shall be marked with the type of spline and the spline data of the parts to be inspected using these gauges. The type of gauge (as shown below) shall be indicated in front of the spline data. In addition, spline gauges shall be marked with the manufacturer's symbol, the manufacturer's drawing number, and the date of manufacture. Markings shall be durable. If the workpieces to be inspected or the gauges do not conform to this standard, the gauge shall be marked "similar to DIN 5481" (German: "*ähnlich DIN 5481*") or with additional information (e.g. prior to hardening).

— GO plug gauge GD

— NO GO plug gauge HD

— GO ring gauge GR

— NO GO ring gauge HR

EXAMPLE 1 DIN 5481 — GR 12 × 14 Manufacturer, drawing number, date of manufacture

EXAMPLE 2 DIN 5481 — HD 12 × 14g Manufacturer, drawing number, date of manufacture

11.8 Data to be shown on drawings

Formerly, the spline data were almost always only shown on the drawings. However, due to the large number of parameters used to describe modern serrated splines, it is expedient to include a dedicated data field. A data field of this type can be given a clear structure and can be used both for the workpiece under inspection (see Table 28) and for the gauge itself (see Table 29).

Table 28 — Data field for workpiece to be inspected

Hub DIN 5481 — 12 × 14		
Number of teeth	z	31
Module	m	(0,419 3)
Space angle	γ_i	48,387°
Pitch diameter	D	13
Root radius max.	$R_{i\ max}$	0,10
Root form circle diameter	D_{Fi}	14,04 min.
Tip diameter	D_{ii}	12,0 A11
Maximum actual space width	E_{max}	0,694 9
Minimum actual reference space width	E_{min}	0,672 2
Minimum effective space width	E_v	0,658 7
Measuring circle diameter	D_{Ri}	0,750
Maximum dimension between measuring circles	$M_{Ri\ max}$	11,931 0
Minimum reference dimension between measuring circles	$M_{Ri\ min}$	11,881 8

Table 29 — Data field for gauge

DIN 5481 — 12 × 14					
Spline plug gauges	Unit	GO plug gauge		NO GO plug gauge	
Number of teeth	—	31		(31) 2 + 2	
Module	mm	(0,419 35)			
Space angle	°	60°			
Pitch diameter	mm	13			
Root radius max.	mm	0,13			
Root form circle diameter	mm	12,24			
Tip diameter	mm	13,910 ± 0,005		13,600 ± 0,010	
Measuring pin/wire diameter	mm	0,750			
Tooth thickness	mm	0,661 7 + 0,003		0,694 9 +0,003	
Dimension over pins, new	mm	14,081 0 + 0,005 3		14,140 0 + 0,005 3	
Tooth thickness, worn down to	mm	0,658 7		0,693 4	
Dimension over pins, worn down to	mm	14,075 7		14,137 4	
Individual deviations	mm	new	worn down to	new	worn down to
Total profile deviation	mm	0,004	0,006	0,004	0,006
Total helix deviation	mm	0,003	0,004	0,003	0,004
Total cumulative pitch deviation	mm	0,004 5	0,006 5	0,004 5	0,006 5
Radial runout	mm	0,004 5	0,006	0,004 5	0,006

Bibliography

DIN 3961, *Tolerances for cylindrical gears — Principles*

ISO 4156-1, *Straight cylindrical involute splines — Metric module, side fit — Part 1: Generalities*

ISO 4156-2, *Straight cylindrical involute splines — Metric module, side fit — Part 2: Dimensions*