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DIN 5480-1

**Splined connections with involute splines based on reference diameters
— Part 1: Principles**

Passverzahnungen mit Evolventenflanken und Bezugsdurchmesser — Teil 1: Grundlagen

Supersedes
DIN 5480-1:1991-10 and
DIN 5480-14:1986-03

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See foreword for relationship to the International Standard ISO 4156, published by the International Organization for Standardization.

Validity

This standard is valid from 2006-03-01 onwards.

Foreword

This series of standards deals with involute splines and interacting involute splines in the ranges module 0,5 to 10, with a number of teeth ranging from 6 to 82 and a pressure angle of 30°. The DIN 5480 series of standards is limited to splines with a pressure angle of 30°, since pressure angles of 37,5° and 45° are covered by ISO 4156.

Involute splines in accordance with ISO 4156 are based on series of modules. These are not interchangeable with involute splines as described by the DIN 5480 series of standards.

The DIN 5480 series of standards is based on reference diameters that are independent of the module. This makes it possible to adapt the gears to standardized ball and roller bearing diameters and to reduce the number of different tools required for manufacturing. This series of standards has been revised by Technical Committee 2.1 *Passverzahnungen* (NAM "Involute splines"). The revision was considered necessary since a review of the DIN 5480 series of standards in accordance with DIN 820-4 had shown that the series had structural and editorial weaknesses. The object of the revision was to combine the individual parts of this standard in a practical, useful and sensible manner.

The entire series of standards now consists of only four parts instead of the previous sixteen.

DIN 5480 *Splined connections with involute splines based on reference diameters* now comprises:

- *Part 1: Principles*
- *Part 2: Nominal dimensions and inspection dimensions*
- *Part 15: Inspection*
- *Part 16: Tools*

The new edition of DIN 5480-1 deals with fundamental principles, the same as its predecessor, but now also includes fit dimensions and tolerances, these being formerly contained in DIN 5480-14:1986-03. The calculation formulae, tolerances and deviations contained in Part 1 also apply to the other parts of this series of standards. DIN 5480-2 now contains the nominal dimensions and inspection dimensions for the range of items stated above. This part combines the contents of all the former parts DIN 5480-2 ... DIN 5480-13.

DIN 5480-15 covers quality inspections of fitted splined connections.

DIN 5480-16 defines the design features of tools for manufacturing items with involute splines.

Amendments

This standard differs from the DIN 5480-1:1991-04 and DIN 5480-14:1986-03 editions as follows :

- a) the title has been changed to "Splined connections with involute splines based on reference diameters";
- b) the full root radius has been included for shafts;
- c) cold-rolling has been included as a manufacturing process for shafts;
- d) editorial revisions have been made; and
- e) the entire contents of DIN 5480-14:1986-03 have been integrated into DIN 5480-1.

Previous editions

DIN 5480-1: 1966-12, 1974-09, 1986-03, 1991-10

DIN 5480-14: 1966-12, 1974-09, 1986-03

1 Scope

This standard applies to splined connections with involute splines based on reference diameters for connecting hubs and shafts either with a removable connection, a sliding fit or a permanent fit. It lays down the following fundamental principles:

- a) standardized uniform pressure angle of 30°,
- b) the basic rack profile is the same for all pitches, therefore applying a uniform design rule to all profiles;
- c) flank centring; in exceptions, diameter-centring is allowed;
- d) application of profile displacements in order to achieve specific reference diameters;
- e) the fit system includes tolerances for effective form deviations, meaning that the effect of such deviations on the fit backlash is taken into account; and the range of various dimension series and tolerance classes takes due consideration of all requirements.

2 Normative references

This standard incorporates, by dated or undated reference, provisions from other publications. For dated references, only the edition referred to applies to this standard. For undated references, the latest edition (including all amendments) of the publication referred to applies.

DIN 323-1, *Preferred numbers and series of preferred numbers; basic values, calculated values, rounded values*

DIN 780-1, *Series of modules for gears; modules for spur gears*

DIN 3960, *Definitions, parameters and equations for involute cylindrical gears and gear pairs*

DIN 5480-2, *Splined connections with involute splines based on reference diameters – nominal dimensions and inspection dimensions*

DIN 5480-15, *Splined connections with involute splines based on reference diameters – quality inspection*

DIN 5480-16, *Splined connections with involute splines based on reference diameters – tools*

DIN ISO 6413, *Technical drawings – representation of splines and serrations*

3 Symbols, designations and units

Symbol	Designation	Unit
c	bottom clearance	mm
c_F	form clearance	mm
c_{FP}	form clearance of basic rack profile	mm
$c_{F \min}$	minimum form clearance	mm
d	reference circle diameter	mm
d_a	tip circle diameter	mm
d_{a1}	tip circle diameter of shaft	mm
d_{a2}	tip circle diameter of hub	mm
d_b	base diameter	mm
d_f	root circle diameter	mm
d_{f1}	root circle diameter of shaft	mm
d_{f2}	root circle diameter of hub	mm
d_B	reference diameter	mm
d_{Ff1}	root form circle diameter of shaft	mm
d_{Ff2}	root form circle diameter of hub	mm
d_{Nf}	effective root circle diameter	mm
e	space width on hub	mm
e_2	nominal space width on hub	mm
e_{\max}	actual maximum space width	mm
e_{\min}	actual minimum reference space width	mm
$e_{v\min}$	minimum effective space width	mm
f_p	individual pitch deviation	μm
h	tooth depth	mm
h_{aP}	addendum of basic rack profile	mm
h_{aP0}	addendum of tool basic rack profile	mm
h_{fP}	dedendum of basic rack profile	mm
h_K	radial height of top land chamfer or rounding	mm
h_P	tooth depth of basic rack profile	mm
k	number of teeth measured for face width measurement	
m	module	mm
p	pitch	mm
s	shaft tooth thickness	mm
s_1	nominal shaft tooth thickness	mm
s_{\max}	actual maximum reference tooth thickness	mm
s_{\min}	actual minimum tooth thickness	mm
$s_{v \max}$	maximum effective tooth thickness	mm

Symbol	Designation	Unit
x	addendum modification factor	
$x \cdot m$	addendum modification	mm
z	number of teeth	
A	deviation	mm
A_{df1}	deviation of shaft root circle diameter	mm
A_{df2}	deviation of hub root circle diameter	mm
A_e	space width deviation	mm
A_s	tooth thickness deviation	mm
A_{M1}	deviation of inspection dimension M_1	mm
A_{M2}	deviation of inspection dimension M_2	mm
A_{Wk}	deviation of base tangent length W_k	mm
A^*_{M1}	deviation factor for inspection dimension M_1	
A^*_{M2}	deviation factor for inspection dimension M_2	
A^*_{Wk}	deviation factor for base tangent length W_k	
D_M	measuring circle diameter	mm
F_α	total profile deviation	μm
F_β	total helix deviation	μm
F_p	total pitch deviation	μm
F_r	runout	μm
M_1	dimension over measuring circles	mm
M_2	dimension between measuring circles	mm
N	hub	
NA	hub centred on external diameter	
NI	hub centred on internal diameter	
R_S	tooth thickness variation	mm
T_{act}	tooth thickness tolerance, actual space width	mm
T_{eff}	tooth thickness tolerance, effective space width	mm
T_G	total tooth thickness/space width tolerance	mm
W	shaft	
WA	shaft centred on external diameter	
WI	shaft centred on internal diameter	
W_k	base tangent length over k teeth	mm
α	pressure angle	°
α_v	press-fit angle	°
ρ_{fP}	root fillet radius of basic rack profile	mm

Subscript	Refers to	Subscript	Refers to	Index	Refers to
a	tooth tip	G	total	0	tool
e	space width	K	tip land chamfer	1	shaft
f	root of tooth	N	effective diameter	2	hub
s	tooth thickness	P	basic rack profile	*	deviation factor
v	effective tolerance limit	act	actual		
F	form diameter	eff	effective		

4 Structure

The tooth interlock of a shaft and hub splined connection is determined by the basic rack profile, the reference diameter, the module and the number of teeth. The selection of nominal dimensions is essentially determined by the following condition: the shaft cross section remaining available for transmitting torques shall not be reduced more than is necessary to permit easy slip-fitting of components such as, for instance, ball or roller bearings. In connections centred on any reference diameter, this condition is met by making the reference diameter equal to the bore of the bearing and then modifying the profiles of the teeth of the hub and the shaft accordingly.

The numbers of teeth are selected in such a way that the addendum modification necessitated by the reference diameter is kept within the range

$x_1 \cdot m = -0,05 \cdot m$ to $+0,45 \cdot m$. The mean fit angles range from 30° to more than 40° .

Even numbers of teeth have been given preference in tables 1 and 2. The reasons for this are explained in subclause 7.2.

Values of $-0,05 \cdot m$ and $+0,45 \cdot m$ are specified as limits for the nominal addendum modification of shafts; the limits for the nominal addendum modification of hubs are specified as $+0,05 \cdot m$ and $-0,45 \cdot m$. Exceptions ($x_1 > +0,45$) have been permitted for some larger numbers of teeth ($z_1 \geq 60$) in order to enable even numbers of teeth to be produced and to avoid using prime numbers, since the effect of the addendum modifications on the fit angles α_v on the V circle decreases as the number of teeth increases.

Depending on the respective reference diameter, calculations for the number of teeth for tables 1 and 2 using the formulae given in table 3 will result either in a number teeth with addendum modifications that are within the specified limits or in two consecutive numbers of teeth with equal limit values $x_1 = -0,05$ and $+0,45$, since this range of addendum modifications, $0,5 \cdot m$, corresponds to a difference of 1 tooth. In such cases, the maximum value of the addendum modification ($x_1 = +0,45$) is taken for connections with $z < 10$, and the even number of teeth is taken for connections with $z \geq 10$ to facilitate the production of double teeth on shafts or hubs, which means that the addendum modification can also assume the minimum value ($x_1 = -0,05$). Figure 1 shows an externally-centred shaft with splines. The double spaces of the associated hub or of an internally centred shaft cannot be measured using balls or pins; GO/NOT GO gauges are required.

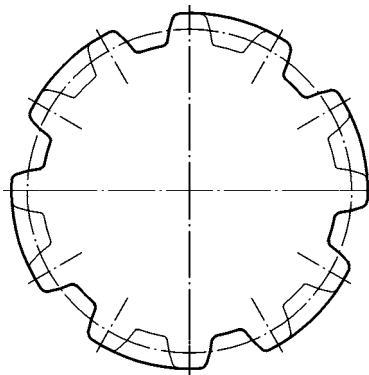


Figure 1 : Double teeth

If the number of spaces which can be measured using pins is an odd number, then the measurements given in the tables can be converted.

$$M_{1,2} = (M_{1,2\text{Tabelle}} - D_M) \cdot \cos(\pi/(2 \cdot z)) + D_M \quad (1)$$

$$A^*_{M1,2} = A^*_{M1,2\text{Tabelle}} \cdot \cos(\pi/(2 \cdot z)) \quad (2)$$

(π is the angle in radians)

In keeping with the rule defined in DIN 3960, M_2 must be a negative value. The symbol z then represents the new odd number of spaces.

A number of teeth expressed as 6 (12) indicates six double teeth out of a total of 12:

EXAMPLE: DIN 5480 – WA 17 × 1,25 × 6 (12) × h6 × 9e

5 Preferred series of modules, reference diameters and numbers of teeth

This standard offers a large selection of fitted splined connections. The module series corresponds to the module series I and II as defined in DIN 780-1 and the metric module series as defined in ISO 54:1977.

Table 1 : Preferred series, reference diameters d_B from 6 mm to 58 mm

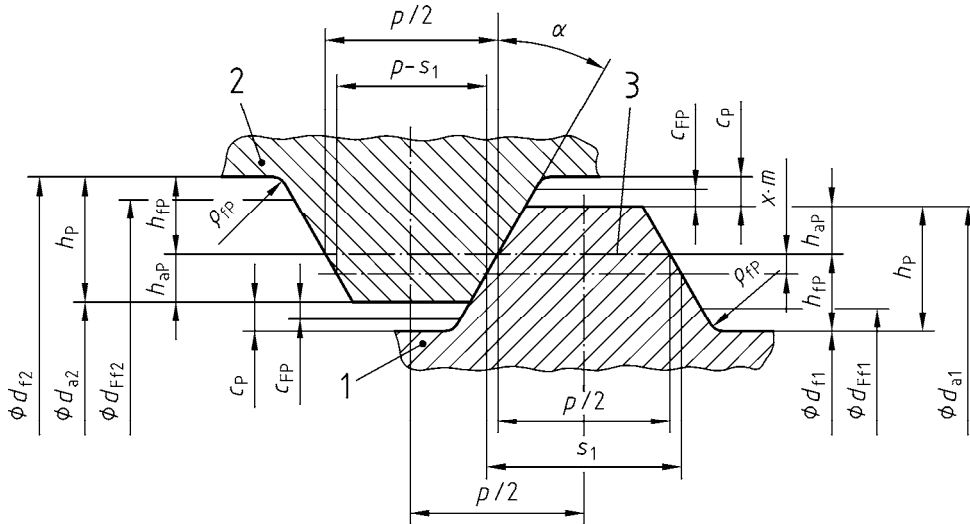
d_B mm	Number of teeth z for module m													
	0,5	0,6	0,75	0,8	1	1,25	1,5	1,75	2	2,5	3	4	5	6
6	10	8	6	6										
7	12	10	8	7										
8	14	12	9	8	6									
9	16	13	10	10	7									
10	18	15	12	11	8	6								
11	20	17	13	12	9	7								
12	22	18	14	13	10	8	6							
13	24	20	16	15	11	9	7	6						
14	26	22	17	16	12	10	8	6						
15	28	23	18	17	13	10	8	7	6					
16	30	25	20	18	14	11	9	8	6					
17	32	27	21	20	15	12	10	8	7					
18	34	28	22	21	16	13	10	9	7					
19	36	30	24	22	17	14	11	9						
20	38	32	25	23,24	18	14	12	10	8	6				
21	40	34	26	25	19	15	12	10						
22	42	35	28	26	20	16	13	11	9	7	6			
23	44	37	29	27	22	17	14	12						
24	46	38	30	28	22	18	14	12						
25	48	40	32	30	24	18	15	13	11	8	7			
26	50	42	33	31	24	19	16	13						
27	52	44	34	32	26	20	16	14						
28	54	45	36	34	26	21	17	14	12	10	8			
29	56	47	37	35	28	22	18	15						
30	58	48	38	36	28	22	18	16	13,14	10	8			
31	60	50	40	37	30	23	19	16						
32	62	52	41	38	30	24	20	17	14	11	9	6		
33	64	54	42	40	32	25	20	17						
34	66	55	44	41	32	26	21	18						
35	68	57	45	42	34	26	22	18	16	12	10	7		
36	70	58	46	44	34	27	22	19						
37	72	60	48	45	36	28	23	20	17	13	11	8		
38	74	62	49	46	36	29	24	20	18	14	11	8		
39	76	64	50	47	38	30	24	21						
40	78	64	52	48	38	30	25	21	18	14	12	8	6	
42		68	54	51	40	32	26	22	20	15	12	9	7	
45		74	58	55	44	34	28	24	21	16	13,14	10	7	
47		76	60	57	46	36	30	25	22	17	14	10	8	
48		78	62	58	46	37	30	26	22	18	14	10	8	6
50			64	60	48	38	32	27	24	18	15	11	9	7
52			68	64	50	40	33	28	24	19	16	11	9	7
55			72	66	54	42	35	30	26	20	17	12	9	8
58				70	56	45	37	32	28	22	18	13	10	8

Table 2 : Preferred series, reference diameters d_B from 60 mm to 500 mm

d_B mm	Number of teeth z for module m												
	0,8	1	1,25	1,5	1,75	2	2,5	3	4	5	6	8	10
60	74	58	46	38	33	28	22	18	13,14	10	8	6	
62			48	40	34	30	23	19	14	11	9		
65			50	42	36	31	24	20	15	11	9	7	
68			53	44	37	32	26	21	15,16	12	10		
70			54	45	38	34	26	22	16	12	10	7	
72			56	46	40	34	27	22	16	13	10		
75			58	48	41	36	28	24	17	13,14	11	8	
78			60	50	43	38	30	24	18	14	11,12		
80			62	52	44	38	30	25	18	14	12	8	6
82				53	45	40	31	26	19	15	12		
85				55	47	41	32	27	20	15,16	13	9	7
88				57	49	42	34	28	20	16	13		
90				58	50	44	34	28	21	16	13,14	10	7
92				60	51	44	35	29	22	17	14		
95				62	53	46	36	30	22	18	14	10	8
98				64	54	48	38	31	23	18	15		
100				64	56	48	38	32	24	18	15	11	8
105				68	58	51	40	34	25	20	16	12	9
110				72	60,61	54	42	35	26	20	17	12	9
120					66,67	58	46	38	28	22	18	13,14	10
130						64	50	42	31	24	20	15	11,12
140						68	54	45	34	26	22	16	12
150						74	58	48	36	28	24	17	13,14
160								52	38	30	25	18	14
170								55	41	32	27	20	15,16
180								58	44	34	28	21	16
190								62	46	36	30	22	17,18
200								65	48	38	32	24	18
210								68,69	51	40	34	25	20
220										42	35	26	20
240										46	38	28	22
250										48	40	30	24
260										50	42	31	24
280										54	45	34	26
300										58	48	36	28
320										62	52	38	30
340											55	41	32
360											58	44	34
380											62	46	36
400											65	48	38
420											68	51	40
440											72	54	42
450											74	55	44
460											75	56	44
480											78	58	46
500											82	61	48

6 Basic rack profile

Figure 2 shows the basic rack profile. The corresponding descriptive parameters, tooth interlock data and calculation formulae are given in table 3.



Key

- 1 shaft
- 2 hub
- 3 profile reference line

Figure 2 : Basic rack profile

Table 3 : Basic rack profile

Parameters	Sym- bol	Spline data and calculation formulae
Module	m	0,5-0,6-0,75-0,8-1,0-1,25-1,5-1,75-2-2,5-3-4-5-6-8-10
Pressure angle	α	30°
Pitch	p	$m \cdot \pi$
Number of teeth	shaft z_1	z_1
	hub z_2	$-z_1$
Addendum modification (nominal value)	shaft $x_1 \cdot m$	$-0,05 \cdot m$ to $+0,45 \cdot m$ (exceptions up to $+0,879 \cdot m$)
	hub $x_2 \cdot m$	$-x_1 \cdot m = +0,05 \cdot m$ to $-0,45 \cdot m$ (exceptions up to $-0,879 \cdot m$)
Addendum of basic rack profile	h_{aP}	$0,45 \cdot m$
Dedendum of basic rack profile = addendum of tool basic rack profile	h_{fP} $= h_{aP0}$	$0,55 \cdot m$ $0,60 \cdot m$ $0,65 \cdot m$ $0,84 \cdot m$ broaching hobbing mill-broaching cold rolling
Tooth depth of basic rack profile	h_P	$h_{aP} + h_{fP}$
Bottom clearance of basic rack profile	c_P	$h_{fP} - h_{aP}$
Root fillet radius of basic rack profile	ρ_P	$0,16 \cdot m$ chip-removal machining $0,54 \cdot m$ cold rolling
Reference circle diameter	d	$m \cdot z$
Base diameter	d_b	$m \cdot z \cdot \cos \alpha$
Reference diameter	d_B	$m \cdot z_1 + 2 \cdot x_1 \cdot m + 1,1 \cdot m$, . Diameters with standard numbers in accordance with DIN 323-1 and ball/roller bearing diameters, integer values with increments of one for the range $d_B < 40$ mm and $m \leq 1,75$ mm.
Tip circle diameter of hub	d_{a2}	$m \cdot z_2 + 2 \cdot x_2 \cdot m + 0,9 \cdot m$
Root circle diameter of hub	d_{f2}	$m \cdot z_2 + 2 \cdot x_2 \cdot m - 2 \cdot h_{fP}$ (see 7.1)
Root form circle diameter of hub	d_{Ff2}	$\leq - (d_{a1} + 2 \cdot c_{Fmin})$
Tip circle diameter of shaft	d_{a1}	$m \cdot z_1 + 2 \cdot x_1 \cdot m + 0,9 \cdot m$
Root circle diameter of shaft	d_{f1}	$m \cdot z_1 + 2 \cdot x_1 \cdot m - 2 \cdot h_{fP}$ (see 7.1)
Base form circle diameter of shaft	d_{Ff1}	$\leq d_{a2} - 2 \cdot c_{Fmin}$
Form clearance of basic rack profile	c_{FP}	$0,02 \cdot m$ $0,07 \cdot m$ $0,12 \cdot m$ $0,12 \cdot m$ broaching hobbing mill-broaching cold rolling
Minimum form clearance	c_{Fmin}	see table 4
Nominal space width of hub	e_2	$e_2 = s_1$
Nominal tooth thickness of shaft	s_1	$m \cdot \pi/2 + 2 \cdot x_1 \cdot m \cdot \tan \alpha$

In the formulae given in table 3, the signs for the number of teeth and addendum modification factors of internal gear splines as defined in DIN 3960 have been introduced in order to facilitate the use of computers

for all calculations in respect of fitted splined connections. These lead to negative signs for all hub diameters and dimensions (see DIN 3960). In the tables of dimensions given in DIN 5480-2, only the absolute values of diameters and inspection dimensions are listed, i. e. the values are to be understood as absolute values in order to avoid any misunderstanding.

The form clearance c_F is the distance between the effective root circle diameter and the root form circle diameter created by the tool. The minimum form clearance c_{Fmin} values given in table 4 provide an adequate excess length of the root involute so that disturbance-free contact between the involute flanks of the hub and shaft is ensured even when there are eccentricities in the motion of the interacting tip circle.

Table 4 : Minimum form clearance

d_B mm	Minimum form clearance		
	c_{Fmin} μm		
	Module 0,5 to 1,5	Module 1,75 to 4	Module 5 to 10
Up to and including 12	25	–	–
13 to 25	28	30	–
26 to 50	30	35	40
51 to 100	35	40	45
101 to 200	40	45	50
201 to 400	–	50	55
Greater than 400	–	–	65

7 Diameters

The DIN 5480 series of standards applies to flank-centred fitted splined connections. The flanks of the teeth are used both for transmitting the torque and for centring the hub and shaft relative to one another. This standard can also be applied, however, to design diameter-centred connections.

7.1 Diameters in flank-centred fitted splined connections

In flank-centred connections, the flanks of the teeth serve to transmit the forces as well as to centre the parts. The diameters of the tip and root circles of the shaft differ from the respective diameters of the hub by at least the bottom clearance c (see figure 3).

The fit and the centring accuracy are determined by the deviations of the space widths and thicknesses as well as by the tolerances achieved or specified. For limits of centring accuracy, see DIN 5466-1. The property defining the fit is the fit of the flanks, the backlash. Refer to clause 10 for the relationship between space width tolerance and tooth thickness tolerance, measurement methods, spline mesh quality and backlash.

The nominal dimensions of the root circle diameters of flank-centred joints are the “theoretical root circle diameters” calculated using $h_{fP} = 0,55 \cdot m$. The deviations applicable to chip-cutting manufacturing methods cover the associated maximum possible dedendum $h_{fP} = 0,65 \cdot m$ and the root diameter deviations, which correspond to the space width / tooth thickness tolerance fields 9H and 11a. These determine the design dimension of the connection diameters where the chip-cutting manufacturing method is not yet known and the tool run-out spaces are free. The machining-method-dependent root circle diameters of shafts created by

hobbing can be calculated by subtracting $0,1 \cdot m$; those of hubs with teeth made by mill-broaching by adding $0,2 \cdot m$, and those of shafts with teeth made by mill-broaching by subtracting $0,2 \cdot m$ from the theoretical root circle diameters. Correspondingly, the absolute values of the deviations must then be reduced by $0,1 \cdot m$ or $0,2 \cdot m$, respectively. The deviations applicable to cold-rolling splines for shaft connections cover the associated dedendum $h_{FP} = 0,84 \cdot m$ and the root circle deviations which would be needed to implement fully-rounded roots at a tolerance 11 and deviation a . They determine the design value of the connection diameter. Root circle diameters of shafts with cold-rolled splines are calculated by subtracting $0,58 \cdot m$ from the theoretical root circle diameters. Refer to table 5 for recommended tolerance fields and deviations of the root circle and tip circle diameters.

The exact root circle diameters of hubs and shafts with splines created by rolling are calculated using the formulae given in DIN 5480-16, taking into account the particular features of the respective rolling method, the deviations of the space widths and tooth thicknesses and, where necessary, a machining addition. DIN 5480-16 also contains formulae for calculating the exact root circle diameters of shafts with cold-rolled splines.

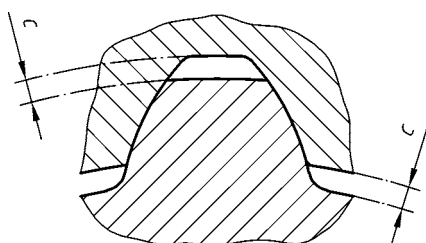


Figure 3 : Bottom clearance of flank-centred connections

7.2 Diameters for diameter-centred fitted splined connections

7.2.1 General

Diameter-centred connections are centred on the outer diameters (hub root circle diameter and shaft tip circle diameter = external diameter centring) or on the inner diameters (hub tip circle diameter and shaft root circle diameter = internal diameter centring). The teeth merely serve to transmit the forces. Such connections must always be given enough backlash in order to prevent over-determination of the centring (see figures 4 and 5).

The fit and accuracy of concentricity are determined by the selected ISO tolerance fields of the centring diameters.

The nominal dimensions of the centring diameters of diameter-centred connections are the reference diameters for external diameter centring or of the hub tip circle diameters for internal diameter centring.

In the case of numbers of teeth which are not prime numbers, the centring surfaces can be widened by multiple teeth on the shaft and multiple spaces in the hub, for instance in order to make diameter-centred connections stronger or to allow diameter centring with small modules (see figure 1).

Diameter-centred connections necessitate greater manufacturing effort due to the small tolerances of the centring diameters and the measures required to limit the offsets between the centring diameter centre and the centre of the tooth circle. These should therefore only be used in a few exceptional cases.

See table 5 for recommended tolerance fields of the root circle and tip circle diameters.

7.2.2 External diameter centring

The parameters for the fit of such connections are:

- the clearance between the hub root circle diameter and the shaft tip circle diameters, which are both assigned the same nominal dimension d_B , i. e., d_{f2} and d_{a1} are both equal to d_B ;
- the flank backlash which, because of the centring action of the flank fit, must always be positive and large enough to prevent overdetermination of the centring.

The edges of the tip lands of teeth on external-diameter centred shafts must be chamfered (a minimum value of $h_K = 0,1 \cdot m$ is recommended) in order to prevent interference with the fillets of the roots of the hub teeth, see figure 4. Refer to table 5 for recommended tolerance fields of the root circle and tip circle diameters.

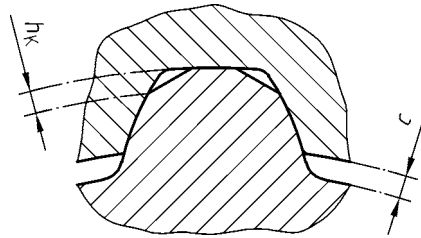


Figure 4 : External diameter centring

7.2.3 Internal diameter centring

The parameters for the fit of such connections are:

- the clearance between the tip circle diameter d_{a2} of the hub and the root circle diameter d_{f1} of the shaft (which is the centring diameter in this case), both of which are assigned the same nominal diameter here;
- the flank backlash which, because of the centring action of the flank fit, must always be positive and large enough to prevent overdetermination of the centring.

The edges of the tip lands of teeth on external-diameter centred shafts must be chamfered (a minimum value of $h_K = 0,1 \cdot m$ is recommended) in order to prevent interference with the fillets of the roots of the hub teeth, see figure 5. Refer to table 5 for recommended tolerance fields of the root circle and tip circle diameters.

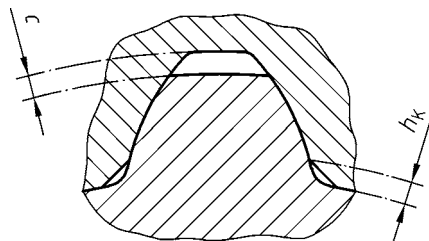


Figure 5 : Internal diameter centring

Table 5 : Recommended tolerances and deviations for tip and root circle diameters

	Flank centring	Diameter centring	
		External diameter centring ^c	Internal diameter centring ^c
Tip circle diameter of hub, d_{a2}	H11	H11	H7
Tip circle diameter of shaft, d_{a1}	h11	h6	h11
Deviation for the hub root circle diameter d_{f2}	$A_{df2} = (0,2 \cdot m + 1,73 \cdot (A_e + T_G))^a$	H7	H14
Deviation for the shaft root circle diameter d_{f1}	Chip-removal machining: $A_{df1} = -(0,2 \cdot m + 1,73 \cdot (-A_s + T_G))^b$ Cold rolling: $A_{df1} = -0,76 \cdot m$ (max.)	h14	h6
^a A_e and T_G in series 9H (see 7.1). ^b A_s and T_G in series a11 (see 7.1). ^c For flank fit: 9H/9e.			

8 Designations

Fitted splined connections in accordance with this standard are designated by the main standard number (i. e. DIN 5480), an N for a hub or W for a shaft, followed by an A for externally-centred connections or an I for internally-centred connections (only in the case of diameter-centred connections), then by the module, the number of teeth, the tolerance class and the deviation series. For diameter-centring, the tolerance class and the deviation series are placed in front of the respective data of the tooth flanks.

EXAMPLE 1

Designation of a flank-centred fitted splined connection

Reference diameter	d_B	120 mm
Module	m	3 mm
Number of teeth	z	38
Flank fit		9H 8f

Fitted splined connection DIN 5480 – 120 × 3 × 38 × 9H 8f

Hub DIN 5480 – N 120 x 3 × 38 × 9H

Shaft DIN 5480 – W 120 × 3 × 38 × 8f

DIN 5480-1

EXAMPLE 2

Designation of a diameter-centred fitted splined connection

Reference diameter	d_B	120 mm
Module	m	3 mm
Number of teeth	z	38
Flank fit		9H 9e
Diameter fit		H7 h6

Fitted splined connection DIN 5480 – A 120 × 3 × 38 × H7 h6 × 9H 9e

Hub DIN 5480 – NA 120 × 3 × 38 × H7 × 9H

Shaft DIN 5480 – WA 120 × 3 × 38 × h6 × 9e

EXAMPLE 3

Designation of an external-diameter-centred fitted splined connection with double teeth on the shaft

Reference diameter	d_B	120 mm
Module	m	3 mm
Number of teeth	z	38
Flank fit		9H 9e
Diameter fit		H7 h6

Fitted splined connection DIN 5480 – A 120 × 3 × 19 (38) × H7 h6 × 9H 9e

Hub DIN 5480 – NA 120 × 3 × 19 (38) × H7 × 9H

Shaft DIN 5480 – WA 120 × 3 × 19 (38) × h6 × 9e

EXAMPLE 4

Designation of an internal-diameter-centred fitted splined connection

Reference diameter	d_B	120 mm
Module	m	3 mm
Number of teeth	z	38
Flank fit		9H 9e
Diameter fit		H7 h6

Fitted splined connection DIN 5480 – I 120 × 3 × 38 × H7 h6 × 9H 9e

Hub DIN 5480 – NI 120 × 3 × 38 × H7 × 9H

Shaft DIN 5480 – WI 120 × 3 × 38 × h6 × 9e

9 Data to be shown on drawings

9.1 Data table

The geometrical data for the teeth are 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 figure 6.

Hub DIN 5480 – N120 × 3 × 38 × 9H			Shaft DIN 5480 – W120 × 3 × 38 × 8f		
Number of teeth	z	38	Number of teeth	z	38
Module	m	3	Module	m	3
Pressure angle	α	30°	Pressure angle	α	30°
Root diameter	d_{f2}	120 + 0,76	Tip circle diameter	d_{a1}	119,40 h11
Root form circle diameter	d_{Ff2}	119,49 min.	Root form circle diameter	d_{Ff1}	113,91 max.
Tip circle diameter	d_{a2}	114 H11	Root circle diameter, cold-rolled	d_{f1}	113,4 – 1,74
Actual maximum space width	e_{\max}	6,361	Max. effective tooth thickness	$s_{v\max}$	6,243
Actual minimum reference space width	e_{\min}	6,305	Actual maximum reference tooth thickness	s_{\max}	6,220
Minimum effective space width	$e_{v\min}$	6,271	Actual minimum tooth thickness	s_{\min}	6,180
Measuring circle diameter	D_M	5,250	Measuring circle diameter	D_M	6,000
Max. dist. betw. measuring circles	$M_{2\max}$	109,266	Max. ref. dimension over measuring circles	$M_{1\max}$ Ref.	(126,017)
Min ref. dist. betw. measuring circles	$M_{2\min}$ Ref.	(109,169)	Min. dimension over measuring circles	$M_{1\min}$	125,956

Figure 6 : Example of a data field in a drawing

If the method of measurement has to be specified, it is also possible to state a measuring ball or measuring pin diameter instead of the measuring circle diameter. The dimension over or between measuring circles is then stated either as the dimension over or between balls or pins, accordingly. The designations given in DIN 3960 for gear teeth are also permitted.

9.2 Indication of individual deviations

Guideline values for individual deviations can be entered directly in the data field in addition. However, in this case a note must be added stating that the GO gauge has priority. This means that the respective workpieces may not be rejected because of individual deviations. If, in special cases, it is necessary to state permissible individual deviations as a tolerance, this shall be identified as such by the supplementary note "max."

9.3 Statistical actual tolerance limit (STA)

Particularly when a dimension is checked across and between measurement circles, the actual measurement will depend very strongly on the angular position and the measuring plane. If very many measurements are taken in different angular positions and measuring planes, it may be useful to apply statistical concepts when evaluating the actual tolerance limit. This avoids excessive reject rates, which would not occur if fewer measurements were to be taken. The statistical actual tolerance limit permits a certain number of measurements to exceed the tolerance limits by a specific value. For details, see DIN 5480-15, 5.3.6. Where necessary, the data for the statistical actual tolerance limit STA are entered at the bottom of the data field of the fitted splined connection.

9.4 Representation in drawings

DIN ISO 6413 specifies how fitted splined connections are to be represented in drawings.

10 Fit system for space width / tooth thickness

10.1 General

The flanks of the teeth of fitted splined connections are used both for transmitting the torque and for centring the hub and shaft relative to one another. The difference between the space width and the tooth thickness determines the rotational backlash. For space widths of hubs and tooth thicknesses of shafts, this standard provides deviation series and tolerances based on the nominal dimensions, see figure 7. The deviation series permits the definition of free fits, transitions fits and interference fits. The tolerance classes define the manufacturing tolerances.

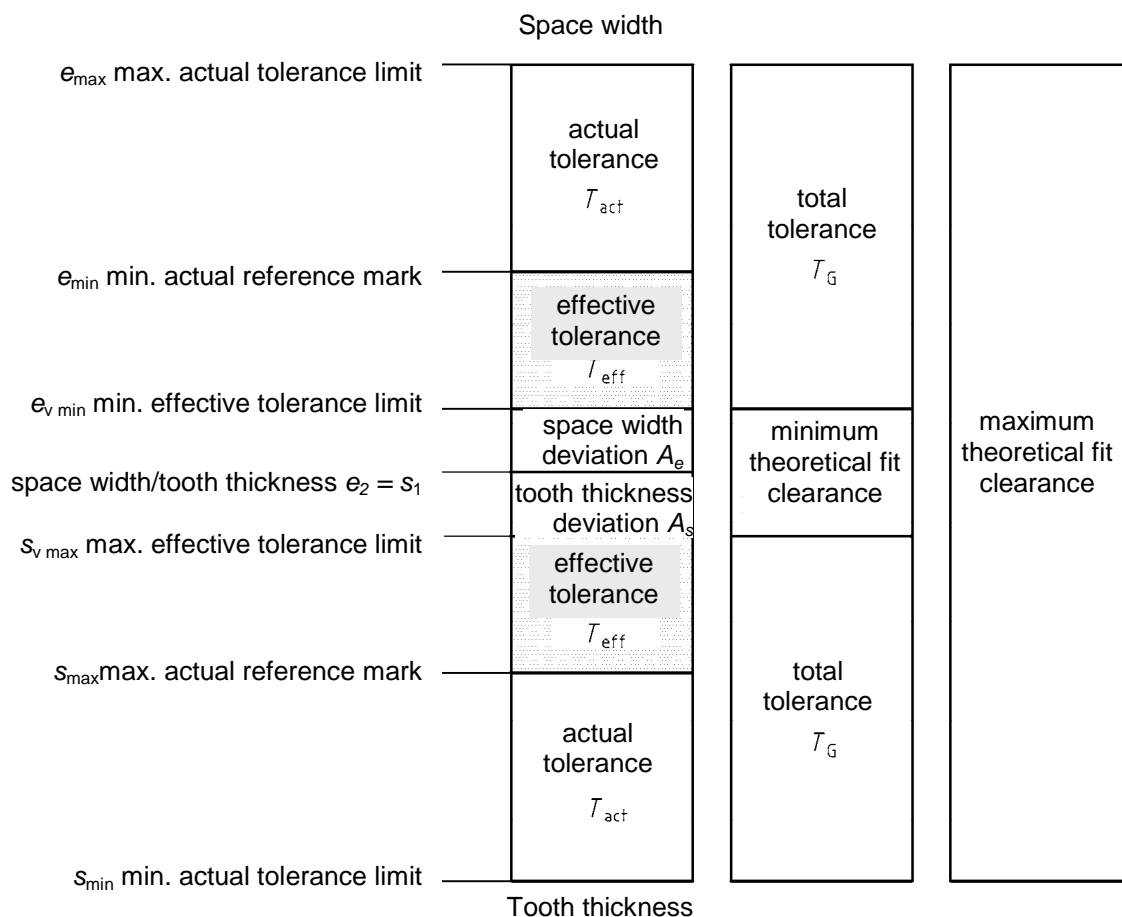


Figure 7 : Schematic diagram of space width / tooth thickness fit

10.2 Structure of the tolerance system

The tolerance system of fitted splined connections is based on the theoretical minimum fit clearance. A design fit clearance of zero ensures that the hub can be fitted on the shaft. For a minimum fit clearance of zero, it is better to set the effective tolerance limits to the dimension of the nominal space width e_2 and the nominal tooth thickness s_1 .

10.3 Deviations

Both positive and negative minimum fit clearances can be designed using the space width deviation A_e and the tooth thickness deviation A_s . The magnitudes of the deviations are identified by upper-case characters and

can be selected individually for hubs and shafts as shown in table 9. There are six deviations, from F to M for hubs and 18 deviations from v to a for shafts.

10.4 Overall tolerance T_G

The theoretical maximum fit clearance is determined by adding the deviations and the tolerance values of the overall tolerances T_G for the hub and the shaft. The overall tolerance combines the actual tolerance and the effective tolerance. Eight tolerance classes are available for the magnitude of the overall tolerances of hubs and shafts. They determine the magnitude of the overall tolerance as well as the actual and effective individual tolerances. These have predefined relationships to one another. In practice, the size of the actual tolerance T_{act} in relationship to the effective tolerance T_{eff} within the overall tolerance T_G varies very strongly. A ratio of $T_G/T_{act} \approx 1,6$ has been chosen in this standard as this seemed to be most suitable. If it becomes necessary to change the size ratio, then the actual tolerances and the effective tolerances as stated in this standard can be selected separately from the different tolerance classes and will, when added, lead to an overall tolerance deviating from this standard.

10.5 Actual tolerance T_{act}

The actual tolerance provides for the wear-dependent change of tool dimensions, the infeed accuracy of machine tools and dimension deviations in heat treatment. In the data field of the workpiece drawing, it is given as the actual tolerance limit and as the reference mark actual Ref. Since it is difficult to measure tooth thickness and space widths directly, they are converted to dimensions across and between measuring circles and are entered in this form into the data field. In practice, measuring balls or measuring pins are used as measuring circles. The manufacturing tolerance should be at least twice the expected tooth thickness variation R_s .

10.6 Effective tolerance T_{eff}

For fitted splined connections, the effective tolerance is stated separately. This is necessary because the fit is created for all left and right flanks of all teeth. The flanks of the teeth are subject to individual deviations from the profile, the flank line and the pitch. These deviations reduce the fit clearance of a fitted splined connection so severely that provision must be made for this reducing effect. In hubs, the superposition of all individual deviations leads to an effective space width that is smaller than the actual space that can be measured. In shafts, the superposition of all individual deviations lead to an effective tooth thickness that is greater than the actual thickness which can be measured.

10.7 Design specifications

When designing a fitted splined connection, the maximum and minimum permissible fit clearance is defined in the technical specifications. Given these values, it is the designer's task to select the deviations and tolerance classes. A certain amount of experience is needed in selecting the deviations and tolerances suitable for practical applications.

10.8 Calculation of tolerance limits

Tolerance limits are calculated on the basis of the nominal space width e_2 of the hub and the tooth thickness s_1 , using the formulae given in table 6. The deviations A_e and A_s as well as the tolerances T_{act} and T_{eff} of the tolerance class are selected as shown in table 7.

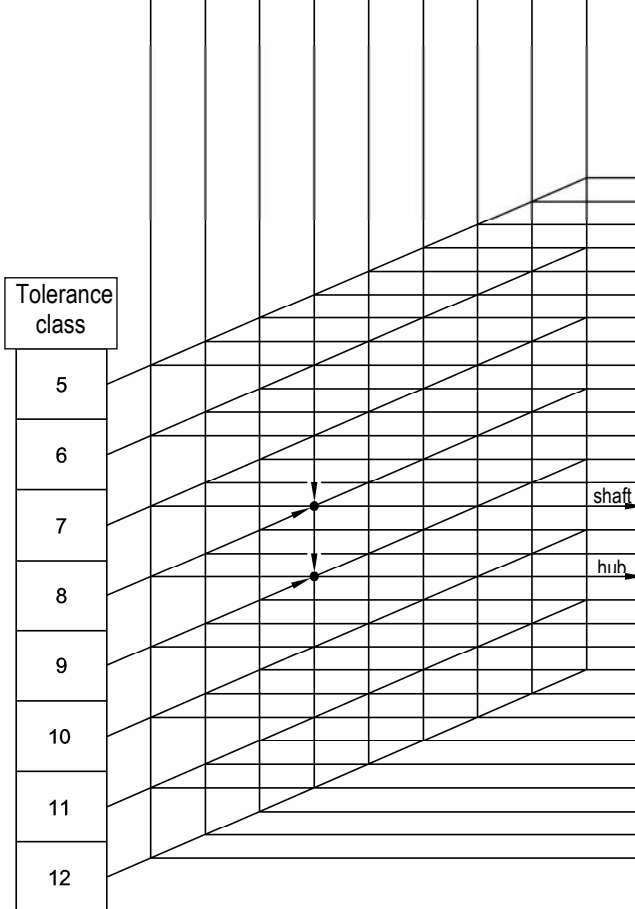
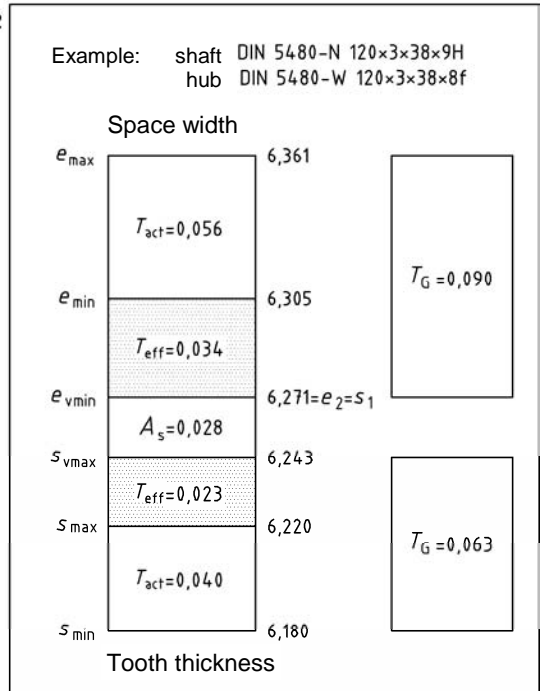
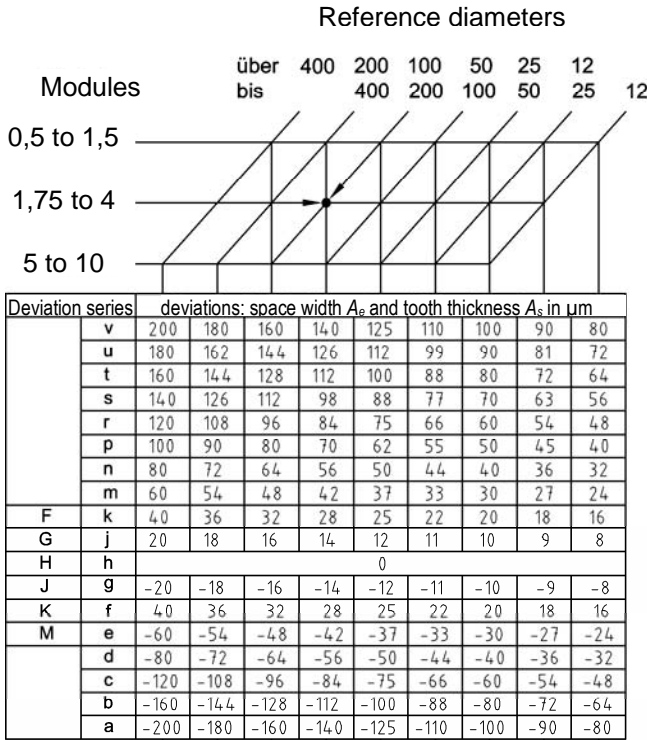
Table 6 : Calculation of tolerance limits

Space width	max. actual	$e_{\max} = e_2 + A_e + T_G = e_2 + A_e + T_{\text{act}} + T_{\text{eff}}$
Space width	min. actual Ref.	$e_{\min} = e_2 + A_e + T_{\text{eff}}$
Space width	min. effective	$e_{\text{vmin}} = e_2 + A_e$
Tooth thickness	max. effective	$s_{\text{vmax}} = s_1 + A_s$
Tooth thickness	max. actual Ref.	$s_{\max} = s_1 + A_s - T_{\text{eff}}$
Tooth thickness	min. actual	$s_{\min} = s_1 + A_s - T_G = s_1 + A_s - T_{\text{act}} - T_{\text{eff}}$

In addition to showing the actual and effective tolerances, table 7 also contains guideline values for individual deviations F_p, f_p and F_α, F_β . These values do not constitute a tolerance, but are used to track down the cause of nonconformities in cases where GO gauges will not fit. If a GO gauge does fit, this will in all cases effectively ensure adherence to the tolerance limit.

10.9 Deviations and tolerances

Table 7 : Deviations and tolerances



Dimension tolerances in μm		
T_G	$T_{act.}$	$T_{eff.}$
12	8	4
14	9	5
16	10	6
18	11	7
20	12	8
22	14	8
25	16	9
28	18	10
32	20	12
36	22	14
40	25	15
45	28	17
50	32	18
56	36	20
63	40	23
71	45	26
80	50	30
90	56	34
100	63	37
112	71	41
125	80	45
140	90	50
160	100	60
180	112	68
200	125	75
224	140	84
250	160	90
280	175	105
320	200	120
360	225	135

Standard deviations for individual deviations in μm					
f_p	F_p	F_α	F_G up to length (mm)		
			50	100	200
3,5	8	5	5	8	10
4	9	5,5	5	8	10
4,5	10	6	5	8	11
5	11	6	6	9	11
5,5	12	7	6	9	12
6	14	8	6	9	13
7	16	9	7	10	13
8	18	10	7	10	14
9	20	11	8	11	14
10	22	12	8	11	15
11	25	13	9	12	16
12	28	15	9	12	17
13	32	17	10	13	18
15	36	19	10	13	19
17	40	21	11	14	20
19	45	23	12	15	21
21	50	25	13	16	22
24	56	28	14	17	23
27	63	31	15	18	24
30	71	34	16	19	25
34	80	37	17	20	26
38	90	41	18	21	27
43	100	45	19	22	28
48	112	49	20	23	29
53	125	53	21	24	30
60	140	58	22	25	31
68	160	63	23	26	32
75	175	68	24	27	33
85	200	73	25	28	34
96	225	78	26	29	35

10.10 Guide values for radial runout

Radial runout is largely a deviation of position and is specified relative to other geometrical elements. It is not possible to state standard values for this. Table 8 shows, as guide values, radial runouts of the reference circle of external splines relative to a reference axis.

Table 8 : Guide values for radial runout

Reference circle diameter d mm	Radial runout F_r μm
< 18	20
18 to < 30	30
30 to < 50	40
50 to < 100	50
100 to < 200	60
200 to < 500	80

10.11 Implementation of fit types

Interference fits, transitional fits and free fits can be implemented by applying the deviation and tolerance combinations given in table 9, for example.

Table 9 : Types of fit

Type of fit	Deviations / tolerances							
	Hub			Shaft				
Rough interference fit			9H	9v				
Fine interference fit	7H	8H		7p	8s			
Rough transitional fit			9H	9p				
Fine transitional fit	7H	8H		7m	8n			
Rough free fit			9H	9g	9e	9d	10c	11a
Fine free fit	7H	8H		7h	7g	8f		

10.12 Quality assurance

Quality assurance is described in DIN 5480-15. Compliance with the effective tolerance limit is checked using fully-splined GO gauges. Actual tolerance limits are checked with the aid of the auxiliary dimensions across and between measuring circles (using measuring balls or pins), or alternatively using sector NOT GO gauges. The method of calculating the inspection dimensions over and between measuring circles from the dimensions of the space widths and the tooth thicknesses is described in DIN 5480-15, 5.2.4.3. As an alternative, this can also be done using the deviation factors as described in DIN 5480-2.

Deviation of the measurements between/over measuring circles:

$$A_{M2} = A_e \cdot A_{M2}^* \quad (3)$$

$$A_{M1} = A_s \cdot A_{M1}^* \quad (4)$$

Bibliography

DIN 3961, *Tolerances for cylindrical gear teeth; basics*

DIN 3977:1981-02, *Measuring element diameters for the radial or diametral dimension for testing tooth thickness of cylindrical gears*

DIN ISO 6413:1990-03, *Technical drawings; representation of splines and serrations; identical with ISO 6413:1988*

ISO 54:1996, *Cylindrical gears for general engineering and for heavy engineering - Modules*

ISO 4156, *Straight cylindrical involute splines; Metric module, side fit*

DIN 5480-2**Splined connections with involute splines based on reference diameters
— Part 2: Nominal and Inspection Dimensions**

Passverzahnungen mit Evolventenflanken und Bezugsdurchmesser — Teil 2: Nennmaße und Prüfmaße

Supersedes

DIN 5480-2:1991-10,
DIN 5480-3:1991-10,
DIN 5480-4:1991-10,
DIN 5480-5:1991-10,
DIN 5480-6:1991-10,
DIN 5480-7:1991-10,
DIN 5480-8:1991-10,
DIN 5480-9:1991-10,
DIN 5480-10:1991-10,
DIN 5480-11:1991-10,
DIN 5480-12:1991-10,
DIN 5480-13:1991-10 and
DIN 5480 Ber. 1:1995-11

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See foreword for relationship to the International Standard ISO 4156, including ISO 4156 AMD 1:1992, published by the International Organization for Standardization (ISO).

Validity

This standard is valid from 2006-05-01 onwards.

Foreword

This series of standards deals with involute splines and interacting involute splines in the ranges module 0,5 to 10, with a number of teeth ranging from 6 to 82 and a pressure angle of 30°. The DIN 5480 series of standards is limited to splines with a pressure angle of 30°, since pressure angles of 37,5° and 45° are covered by ISO 4156.

Involute splines in accordance with ISO 4156 are based on series of modules. These are not interchangeable with involute splines as described by the DIN 5480 series of standards.

The DIN 5480 series of standards is based on reference diameters that are independent of the module. This makes it possible to adapt the gears to standardized ball and roller bearing diameters and to reduce the number of different tools required for manufacturing. This series of standards has been revised by Technical Committee 2.1 "Passverzahnungen" (NAM "Involute splines"). The revision was considered necessary since a review of the DIN 5480 series of standards in accordance with DIN 820-4 had shown that the series had structural and editorial weaknesses. The object of the revision was to combine the individual parts of this standard in a practical, useful and sensible manner.

The entire series of standards now consists of only four parts instead of the previous sixteen.

DIN 5480 *Splined connections with involute splines based on reference diameters* now comprises:

- *Part 1: Principles*
- *Part 2: Nominal dimensions and inspection dimensions*
- *Part 15: Inspection*
- *Part 16: Tools*

The new edition of DIN 5480-1 deals with fundamental principles, the same as its predecessor, but now also includes fit dimensions and tolerances, these being formerly contained in DIN 5480-14:1986-03. The calculation formulae, tolerances and dimensions contained in Part 1 also apply to the other parts of this series of standards. DIN 5480-2 now contains the nominal dimensions and inspection dimensions for the range of items stated above. This part combines the contents of all the former parts DIN 5480-2 ... DIN 5480-13.

DIN 5480-15 covers quality inspections of fitted splined connections.

DIN 5480-16 defines the design features of tools for manufacturing items with involute splines.

Amendments

This standard differs from the editions DIN 5480-2:1991-10, DIN 5480-3:1991-10, DIN 5480-4:1991-10, DIN 5480-5:1991-10, DIN 5480-6:1991-10, DIN 5480-7:1991-10, DIN 5480-8:1991-10, DIN 5480-9:1991-10, DIN 5480-10:1991-10, DIN 5480-11:1991-10, DIN 5480-12:1991-10, DIN 5480-13:1991-10 and DIN 5480 Corrigendum 1:1995-11 as follows:

- a) the title has been changed to "Splined connections with involute splines based on reference diameters;
- b) the full root radius has been included for shafts;
- c) cold-rolling has been included as a manufacturing process for shafts;
- d) with one exception, the measuring circle diameters have been taken from DIN 3977 and
- e) editorial revisions have been made.

Previous editions

DIN 5480-2: 1966-12; 1974-09; 1986-03; 1991-10

DIN 5480-3: 1966-12; 1974-09; 1986-03; 1991-10

DIN 5480-4: 1966-12; 1974-09; 1986-03; 1991-10

DIN 5480-5: 1966-12; 1974-09; 1986-03; 1991-10

DIN 5480-6: 1966-12; 1974-09; 1986-03; 1991-10

DIN 5480-7: 1966-12; 1974-09; 1986-03; 1991-10

DIN 5480-8: 1966-12; 1974-09; 1986-03; 1991-10

DIN 5480-9: 1966-12; 1974-09; 1986-03; 1991-10

DIN 5480-10: 1966-12; 1974-09; 1986-03; 1991-10

DIN 5480-11: 1966-12; 1975-12; 1986-03; 1991-10

DIN 5480-12: 1966-12; 1974-09; 1986-03; 1991-10

DIN 5480-13: 1966-12; 1974-09; 1986-03; 1991-10

DIN 5480 Corrigendum 1: 1995-11

1 Scope

This standard applies to splined connections with involute splines based on reference diameters for connecting hubs and shafts either with a removable connection, a sliding fit or a permanent fit. It lays down the following fundamental principles:

- a) standardized uniform pressure angle of 30° ,
- b) the basic rack profile is the same for all pitches, therefore applying a uniform design rule to all profiles;
- c) flank centring; in exceptions, diameter-centring is allowed;
- d) application of profile displacements in order to achieve favourable nominal diameters;
- e) the fit system includes tolerances for effective shape deviations, meaning that the effect of such deviations on the fit backlash is taken into account; and the range of various deviation series and tolerance classes takes due consideration of all requirements.

Fitted spline connections with involute splines as defined in this standard are used for connecting hubs and shafts either with a removable connection, a sliding fit or a permanent fit. They have all the characteristics required for centring the parts and transmitting torques, as well as meeting all the requirements for economical manufacturing.

The theoretical root circle diameters for hubs and shafts for $h_{fP} = 0,55 \cdot m$. The dedendum depends on the manufacturing method used, and can therefore have various values (see DIN 5480-1, table 3). The root diameters depend on the dedendum.

2 Normative references

This standard incorporates, by dated or undated reference, provisions from other publications. For dated references, only the edition referred to applies to this standard. For undated references, the latest edition (including all amendments) of the publication referred to applies.

DIN 5480-1, *Splined connections with involute splines based on reference diameters – Part 1: Principles*

DIN 5480-15, *Splined connections with involute splines based on reference diameters – Part 15: Inspection*

DIN 5480-16, *Splined connections with involute splines based on reference diameters – Part 16: Tools*

3 Graphic representation of dimensions and measurements

3.1 Space width / tooth thickness

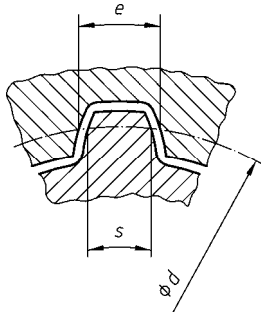
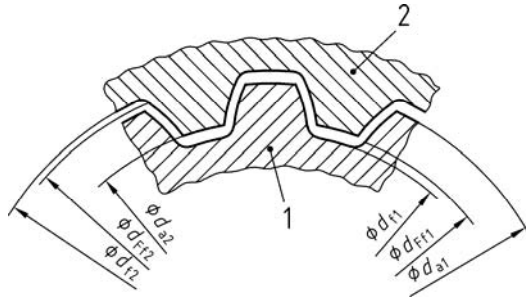


Figure 1 : Space width / tooth thickness

3.2 Diameters

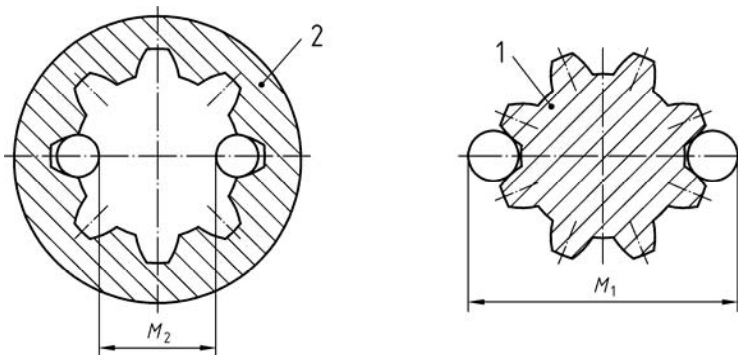


Key

- 1 Shaft
- 2 Hub

Figure 2: Diameters

3.3 Inspection dimensions



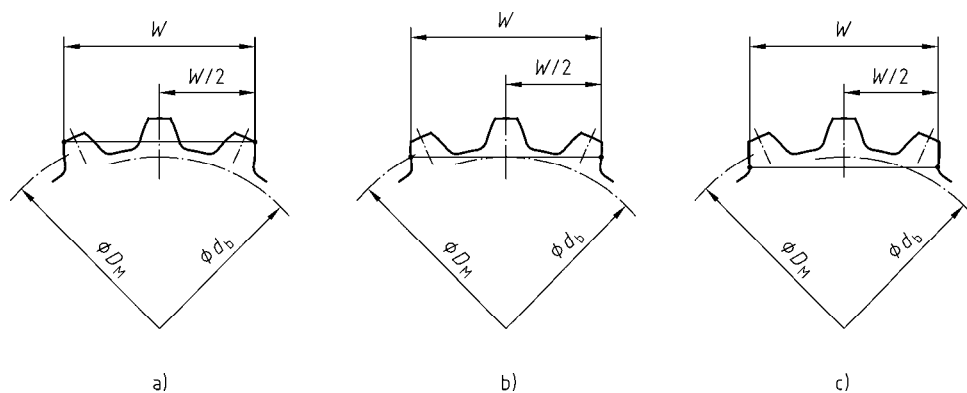
Key

- 1 Shaft
- 2 Hub

Dimension M_2 over 2 measuring circles

Dimension M_1 over 2 measuring circles

Figure 3 : Inspection dimensions

**Key**

- a) Unfavourable position near the tip circle
- b) Favourable position near the V circle
- c) Unfavourable position near the root form circle

Figure 4 : Tooth thickness measurement**Table 1 : Root fillet radii and deviation factors**

Dimensions in mm

Module m mm	Minimum root fillet radius for chip-removal manufacturing methods $\rho_{F \min}$	Nominal value for cold-rolling ρ_F	Deviation factor A^*_{wk}
0,5	0,08	0,27	0,866
0,6	0,10	0,32	0,866
0,75	0,12	0,40	0,866
0,8	0,13	0,43	0,866
1	0,16	0,54	0,866
1,25	0,20	0,67	0,866
1,5	0,24	0,81	0,866
1,75	0,28	0,94	0,866
2	0,32	1,08	0,866
2,5	0,40	1,35	0,866
3	0,48	1,62	0,866
4	0,64	2,16	0,866
5	0,80	–	0,866
6	0,96	–	0,866
8	1,28	–	0,866
10	1,60	–	0,866