March 2006

**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

Translated by *technomedia* – Hirsinger, Corte, Gosch & Partner, Berlin

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



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## 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.



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**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*



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## 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 |
| $e_{vmin}$ | 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 |



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| 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 |
| $F_\alpha$ | total profile deviation | µm |
| $F_\beta$ | 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 |
| $\alpha$ | pressure angle | ° |
| $\alpha v$ | press-fit angle | ° |
| $\rho_{fP}$ | root fillet radius of basic rack profile | mm |



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| 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 $\alpha_v$ 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.



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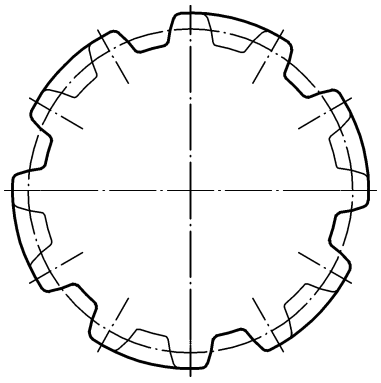

**Figure 1 : Double teeth**

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

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

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

($\pi$ 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.



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**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 |



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

| $d_B$ | Number of teeth $z$ for module $m$ | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 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 |



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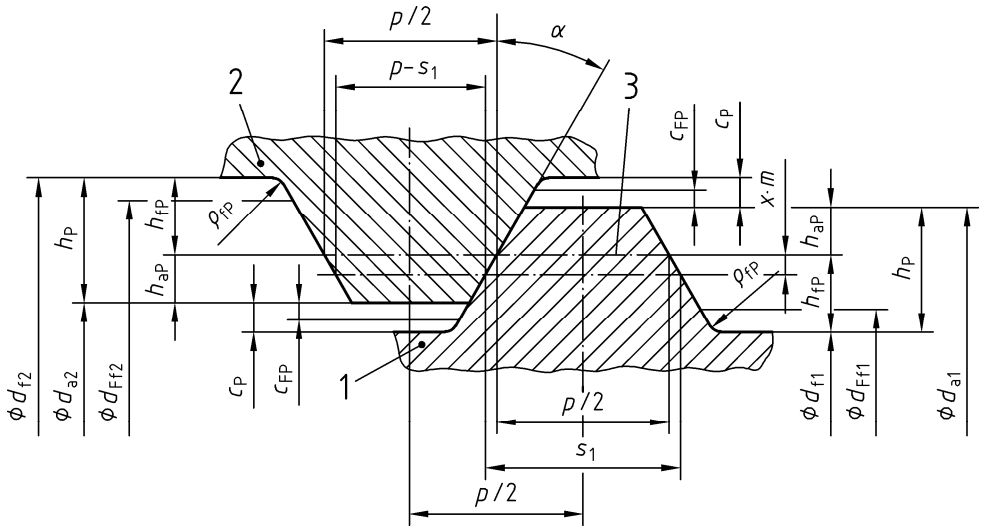
## 6 Basic rack profile

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**



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**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 | | $\alpha$ | 30° |
| Pitch | | $p$ | $m \cdot \pi$ |
| Number of teeth | shaft | $z_1$ | $z_1$ |
| | hub | $z_2$ | $-z_1$ |
| Addendum modification | shaft | $x_1 \cdot m$ | $-0{,}05 \cdot m$ to $+ 0{,}45 \cdot m$ (exceptions up to $+0{,}879 \cdot m$) |
| (nominal value) | 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 | | $h_{fP}$ | $0{,}55 \cdot m$ $0{,}60 \cdot m$ $0{,}65 \cdot m$ $0{,}84 \cdot m$ |
| = addendum of tool basic rack profile | | $= h_{aP0}$ | 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 | | $\rho_{fP}$ | $0{,}16 \cdot m$ 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 | | $d_{Ff1}$ | $\leq \lvert d_{a2} \rvert - 2 \cdot c_{Fmin}$ |
| 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



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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 including12 | 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



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hobbing can be calculated by subtracting 0,1•$m$; those of hubs with teeth made by mill-broaching by adding 0,2•$m$ , and those of shafts with teeth made by mill-broaching by subtracting 0,2•$m$ from the theoretical root circle diameters. Correspondingly, the absolute values of the deviations must then be reduced by 0,1•$m$ or 0,2•$m$, 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•$m$ 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.

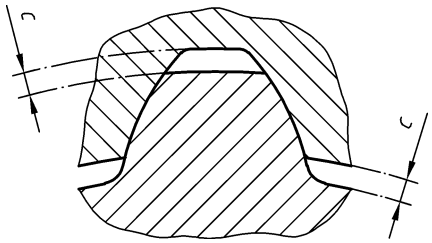

**Figure 3 : Bottom clearance of flank-centred connections**

## 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.



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### 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.

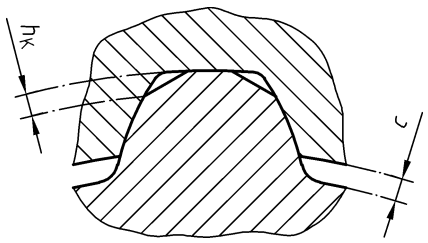


**Figure 4 : External diameter centring**

### 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.

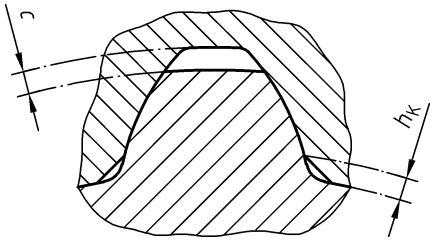


**Figure 5 : Internal diameter centring**



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**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



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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 |



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# 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 | $\alpha$ | 30° | Pressure angle | $\alpha$ | 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 | $s_{vmax}$ | 6,243 |
| Actual minimum reference space width | $e_{min}$ | 6,305 | Actual maximum reference tooth thickness | $s_{max}$ | 6,220 |
| Minimum effective space width | $e_{vmin}$ | 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 | $M_{2max}$ | 109,266 | Max. ref. dimension over measuring circles | $M_{1max}$ Ref. | (126,017) |
| Min ref. dist. betw. measuring circles | $M_{2min}$ Ref. | (109,169) | Min. dimension over measuring circles | $M_{1min}$ | 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.”.



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## 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.



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# 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.

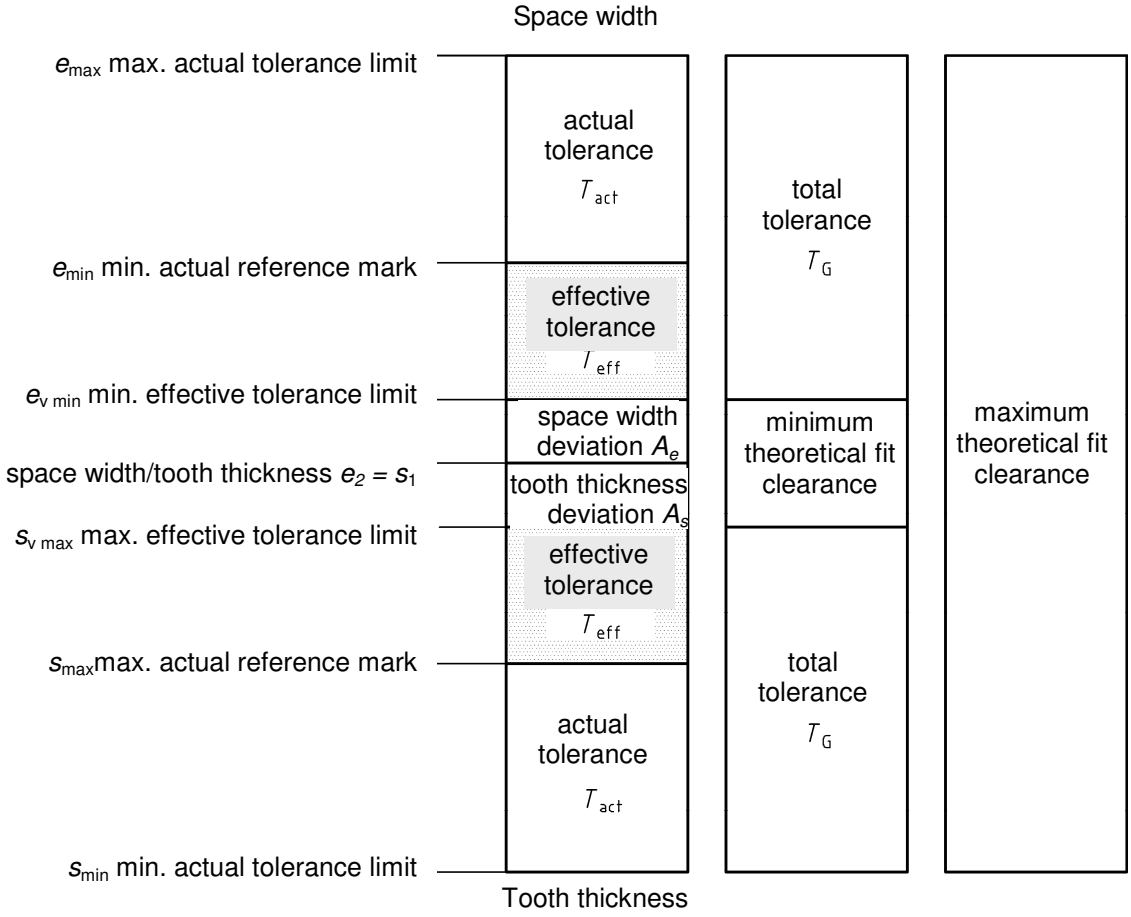


**Figure 7 : Schematic diagram of space width / tooth thickness fit**

## 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



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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.



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**Table 6 : Calculation of tolerance limits**

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

In addition to showing the actual and effective tolerances, table 7 also contains guideline values for individual deviations $F_p$, $f_p$ and $F_\alpha$, $F_\beta$. 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.



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## 10.9 Deviations and tolerances

**Table 7 : Deviations and tolerances**

Reference diameters

Modules

| über | 400 | 200 | 100 | 50 | 25 | 12 |
|---|---|---|---|---|---|---|
| bis | 400 | 200 | 100 | 50 | 25 | 12 |

0,5 to 1,5

1,75 to 4

5 to 10

| Deviation series | | deviations: space width $A_e$ and tooth thickness $A_s$ in µm | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | v | 200 | 180 | 160 | 140 | 125 | 110 | 100 | 90 | 80 |
| | u | 180 | 162 | 144 | 126 | 112 | 99 | 90 | 81 | 72 |
| | t | 160 | 144 | 128 | 112 | 100 | 88 | 80 | 72 | 64 |
| | s | 140 | 126 | 112 | 98 | 88 | 77 | 70 | 63 | 56 |
| | r | 120 | 108 | 96 | 84 | 75 | 66 | 60 | 54 | 48 |
| | p | 100 | 90 | 80 | 70 | 62 | 55 | 50 | 45 | 40 |
| | n | 80 | 72 | 64 | 56 | 50 | 44 | 40 | 36 | 32 |
| | m | 60 | 54 | 48 | 42 | 37 | 33 | 30 | 27 | 24 |
| F | k | 40 | 36 | 32 | 28 | 25 | 22 | 20 | 18 | 16 |
| G | j | 20 | 18 | 16 | 14 | 12 | 11 | 10 | 9 | 8 |
| H | h | 0 | | | | | | | | |
| J | g | -20 | -18 | -16 | -14 | -12 | -11 | -10 | -9 | -8 |
| K | f | 40 | 36 | 32 | 28 | 25 | 22 | 20 | 18 | 16 |
| M | e | -60 | -54 | -48 | -42 | -37 | -33 | -30 | -27 | -24 |
| | d | -80 | -72 | -64 | -56 | -50 | -44 | -40 | -36 | -32 |
| | c | -120 | -108 | -96 | -84 | -75 | -66 | -60 | -54 | -48 |
| | b | -160 | -144 | -128 | -112 | -100 | -88 | -80 | -72 | -64 |
| | a | -200 | -180 | -160 | -140 | -125 | -110 | -100 | -90 | -80 |

Example: shaft DIN 5480-N 120×3×38×9H
hub DIN 5480-W 120×3×38×8f

Space width

$e_{max}$ 6,361

$T_{act}$=0,056

$e_{min}$ 6,305

$T_{eff}$=0,034

$e_{vmin}$ 6,271=$e_2$=$s_1$

$A_s$=0,028

$s_{vmax}$ 6,243

$T_{eff}$=0,023

$s_{max}$ 6,220

$T_{act}$=0,040

$s_{min}$ 6,180

$T_G$ =0,090

$T_G$ =0,063

Tooth thickness

Tolerance class

5

6

7

8

9

10

11

12

shaft

hub

| Dimension tolerances in µm | | | Standard values for individual deviations in µm | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | $F_\beta$ up to length (mm) | | |
| $T_G$ | $T_{act.}$ | $T_{eff.}$ | $f_p$ | $F_p$ | $F_\alpha$ | 50 | 100 | 200 |
| 12 | 8 | 4 | 3,5 | 8 | 5 | 5 | 8 | 10 |
| 14 | 9 | 5 | 4 | 9 | 5,5 | 5 | 8 | 10 |
| 16 | 10 | 6 | 4,5 | 10 | 6 | 5 | 8 | 11 |
| 18 | 11 | 7 | 5 | 11 | 6 | 6 | 9 | 11 |
| 20 | 12 | 8 | 5,5 | 12 | 7 | 6 | 9 | 12 |
| 22 | 14 | 8 | 6 | 14 | 8 | 6 | 9 | 13 |
| 25 | 16 | 9 | 7 | 16 | 9 | 7 | 10 | 13 |
| 28 | 18 | 10 | 8 | 18 | 10 | 7 | 10 | 14 |
| 32 | 20 | 12 | 9 | 20 | 11 | 8 | 11 | 14 |
| 36 | 22 | 14 | 10 | 22 | 12 | 8 | 11 | 15 |
| 40 | 25 | 15 | 11 | 25 | 13 | 9 | 12 | 16 |
| 45 | 28 | 17 | 12 | 28 | 15 | 9 | 12 | 17 |
| 50 | 32 | 18 | 13 | 32 | 17 | 10 | 13 | 18 |
| 56 | 36 | 20 | 15 | 36 | 19 | 10 | 13 | 19 |
| 63 | 40 | 23 | 17 | 40 | 21 | 11 | 14 | 20 |
| 71 | 45 | 26 | 19 | 45 | 23 | 12 | 15 | 21 |
| 80 | 50 | 30 | 21 | 50 | 25 | 13 | 16 | 22 |
| 90 | 56 | 34 | 24 | 56 | 28 | 14 | 17 | 23 |
| 100 | 63 | 37 | 27 | 63 | 31 | 15 | 18 | 24 |
| 112 | 71 | 41 | 30 | 71 | 34 | 16 | 19 | 25 |
| 125 | 80 | 45 | 34 | 80 | 37 | 17 | 20 | 26 |
| 140 | 90 | 50 | 38 | 90 | 41 | 18 | 21 | 27 |
| 160 | 100 | 60 | 43 | 100 | 45 | 19 | 22 | 28 |
| 180 | 112 | 68 | 48 | 112 | 49 | 20 | 23 | 29 |
| 200 | 125 | 75 | 53 | 125 | 53 | 21 | 24 | 30 |
| 224 | 140 | 84 | 60 | 140 | 58 | 22 | 25 | 31 |
| 250 | 160 | 90 | 68 | 160 | 63 | 23 | 26 | 32 |
| 280 | 175 | 105 | 75 | 175 | 68 | 24 | 27 | 33 |
| 320 | 200 | 120 | 85 | 200 | 73 | 25 | 28 | 34 |
| 360 | 225 | 135 | 96 | 225 | 78 | 26 | 29 | 35 |



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## 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<br>$d$<br>mm | Radial runout<br>$F_r$<br>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.



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Deviation of the measurements between/over measuring circles:

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

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



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# 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*



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