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**Straight cylindrical involute
splines—side fit—Generalities,
dimensions and inspection**

ICS 21.200

Descriptors : involute splines, gear drives

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of International Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law:

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Straight cylindrical involute splines— side fit—Generalities, dimensions and inspection

Forward for Japanese Industrial Standard

This Japanese Industrial Standard has been prepared based on the first edition of **ISO 4156** *Straight cylindrical involute splines—Metric module, side fit—Generalities, dimensions and inspection* published in 1981 without modifying the technical contents. Addition the specification contents of the conventional **JIS D 2001**, which have been applied, are stated in a compact form in the annex to this Standard.

The portions indicated with dotted lines are the matters not stated in the original International Standard.

Section one : Generalities

1 Scope and field of application This Standard provides data and guidance for the design, manufacture and inspection of straight (non-helical) cylindrical involute splines with side fit (hereafter referred to as “splines”). It establishes a specification based on the module within the range 0.25 to 10 inclusive, relating to nominal pressure angles of 30°, 37.5° and 45°. (For electronic data processing purposes, the form of expression “37.5°” has been adopted instead of 37° 30’.)

Limiting dimensions, tolerances, manufacturing errors and their effects on the fit between connecting co-axial spline elements are defined and tabulated. Linear dimensions are expressed in millimetres and angular dimensions in degrees.

Informative references: The corresponding standards to this Standard are as follows.

ISO 3 *Preferred numbers—Series of preferred numbers*

JIS Z 8601-1954 *Preferred numbers* is equivalent to the said standard.

ISO/R286 *ISO system of limits and fits—Part 1 : General, tolerances and deviations*

JIS B 0401-1986 *ISO system of limits and fits* is equivalent to the said standard.

ISO 286 *ISO system of limits and fits*

JIS B 0401-1986 *ISO system of limits and fits* is equivalent to the said standard.

ISO 1328 *Parallel involute gears—ISO system of accuracy*

ISO/R1938 *ISO system of limits and fits—Part 2 : Inspection of plain workpieces*

ISO 3670 *Blanks for plug gauges and handles (taper lock and trilock) and ring gauges—Design and general dimensions*

2 Terms and definitions relating to splines

2.1 spline joint : Connecting, co-axial elements that transmit torque through the simultaneous engagement of equally spaced teeth situated around the periphery of a cylindrical external member with similar spaced mating spaces situated around the inner surface of the related cylindrical internal member.

2.2 involute spline : One member of spline joint having teeth or spaces that have involute flank profiles.

2.3 internal spline : A spline formed on the inner surface of a cylinder.

2.4 external spline : A spline formed on the outer surface of a cylinder.

2.5 fillet : The concave surface of the tooth or space connecting the involute flank and the root circle. This curved surface as generated varies and cannot be properly specified by a radius of any given value (see figure 12).

2.6 fillet root spline : A spline having a tooth or space profile in which the opposing involute flanks are connected to the root circle (D_{ei} or D_{ie} diameter) by a single fillet (see figure 13).

2.7 flat root spline : A spline having a tooth or space profile in which each of the opposing involute flanks are connected to the root circle (D_{ei} or D_{ie} diameter) by a fillet (see figure 12).

2.8 module, m : The ratio of the circular pitch, expressed in millimetres, to the number π (or the ratio of the pitch diameter, expressed in millimetres, to the number of teeth).

2.9 pitch circle : The reference circle from which all normal spline dimensions are derived, and the circle on which the specified pressure angle has its nominal value.

2.10 pitch diameter, D : The diameter of the pitch circle, in millimetres, equal to the number of teeth multiplied by the module (see figure 12).

2.11 pitch point : The intersection of the spline tooth profile with the pitch circle (see reference figure 1).

2.12 circular pitch, p : A length of arc of the pitch circle between two consecutive pitch points of left- (or right-) hand flanks, which has a normal value of the number π multiplied by the module (see figure 12).

2.13 pressure angle, α : The acute angle between a radial line passing through any point on a tooth flank and the tangent plane to the flank at that point.

2.14 standard pressure angle, α_D : The pressure angle at the specified pitch point (see reference figure 1).

2.15 base circle : The circle from which involute spline tooth profiles are generated.

2.16 base diameter, D_b : The diameter of the base circle.

2.17 base pitch, P_b : The arc length of the base circle between two consecutive corresponding flanks.

2.18 major circle : The circle formed by the outermost surface of the spline. It is the outside circle (tooth tip circle) of the external spline or the root circle of the internal spline.

2.19 major diameter, D_{ee} , D_{ei} : The diameter of the major circle (see figure 12).

2.20 minor circle : The circle formed by the innermost surface of the spline. It is the root circle of the external spline or the inside circle (tooth tip circle) of the internal spline.

2.21 minor diameter, D_{ie} , D_{ii} : The diameter of the minor circle (see figure 12).

2.22 form circle : The circle which establishes the deepest points of involute form control of the tooth profile. This circle along with the tooth tip circle (or start of chamfer circle) determines the limits of tooth profile requiring control. It is located near and below the major circle on the internal spline and near and above the minor circle on the external spline.

2.23 form diameter, D_{Fe} , D_{Fi} : The diameter of the form circle (see figure 12).

2.24 depth of engagement : The radial distance from the minor circle of the internal spline to the major circle of the external spline, minus corner clearance and/or chamfer depth (see reference figure 2).

2.25 basic (circular) space width or tooth thickness at the pitch diameter, E or S : For 30°, 37.5° and 45° pressure angle splines, half the circular pitch (see figure 12)

Informative reference : Unless otherwise indicated, the basic (circular) space width and basic tooth thickness are the arc lengths at the pitch diameter.

2.26 actual space width : The practically measured circular space width, on the pitch circle, of any single space width within the limit values $E_{max.}$ and $E_{min.}$ (see figure 12).

2.27 effective space width, E_v : For an internal spline, equal to the circular tooth thickness on the pitch circle of an imaginary perfect external spline which would fit the internal spline without looseness or interference, considering engagement of the entire axial length of the splined assembly. The minimum effective space width ($E_{v\ min.}$, always equal to E) of the internal spline is always basic, as shown in table 1.

Fit variations may be obtained by adjusting the tooth thickness of the external spline (see figure 12).

2.28 actual tooth thickness : The practically measured circular tooth thickness, on the pitch circle, of any single tooth within the limit values $S_{\max}$ and $S_{\min}$. (see figure 12).

2.29 effective tooth thickness, S_v : For an external spline, equal to the circular space width on the pitch circle of an imaginary perfect internal spline which would fit the external spline without looseness or interference, considering engagement of the entire axial length of the splined assembly. Fit variations are obtained by adjusting this value S_v (see figure 12).

2.30 effective clearance, c_v (looseness or interference) : The effective space width of the internal spline minus the effective tooth thickness of the mating external spline (see reference figure 2).

2.31 theoretical clearance, c (looseness or interference) : The actual space width of an internal spline minus the actual tooth thickness of the mating external spline. It does not define the fit between mating members, because of the effect of variations (see reference figure 2).

2.32 form clearance, c_F : The radial depth of involute profile beyond the depth of engagement with the mating part. It allows eccentricity of the minor circle (internal), of the major circle (external and of their respective pitch circle (see figure 12).

2.33 total index variation : Amount of absolute values of the two greatest actual (or practically measured) positive and negative variations from the theoretical spacing (see figure 9).

2.34 total profile variation : Amount of absolute values of the two greatest positive and negative variations, from the theoretical tooth profiles, measured normal to flanks (see figure 18).

2.35 total lead variation : Amount of absolute values of the two greatest opposite direction variations, from the theoretical direction (parallel to the datum axis), also including parallelism and alignment variations (see figure 1).

Note : Straight (non-helical) splines have an infinite lead.

2.36 parallelism variation : The variation of parallelism of a single spline tooth to any other single spline tooth (see figure 1).

2.37 alignment variation : The variation of the effective spline axis with respect to the reference axis (see figure 1).

Informative reference : The effective spline axis is the ideal axis determined by effective tooth thickness and effective space width.

2.38 out-of-roundness : The variation of the spline from a true circular configuration.

2.39 effective variation : The accumulated effect of the spline variations on the fit with the mating part.

2.40 variation allowance, λ : The permissible effective variation.

2.41 machining tolerance, T : The permissible variation in actual space width or actual tooth thickness.

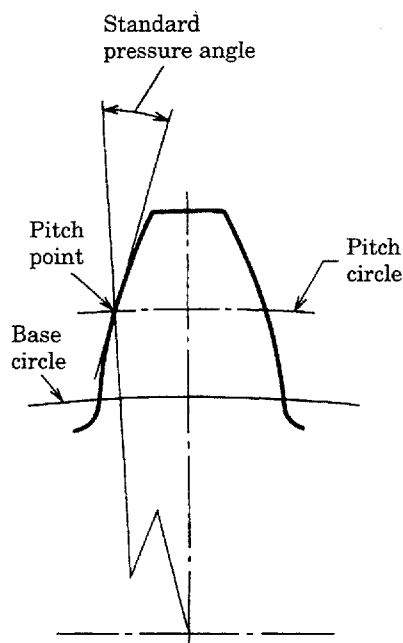
2.42 total tolerance, $(T + \lambda)$: The machining tolerance plus the variation allowance. The total tolerance on an internal spline is the difference between the minimum effective space width and the maximum actual space width; on an external spline, it is the difference between the maximum effective tooth thickness and the minimum actual tooth thickness.

2.43 length of engagement, g_γ : The axial length of contact between mating splines (see figure 17).

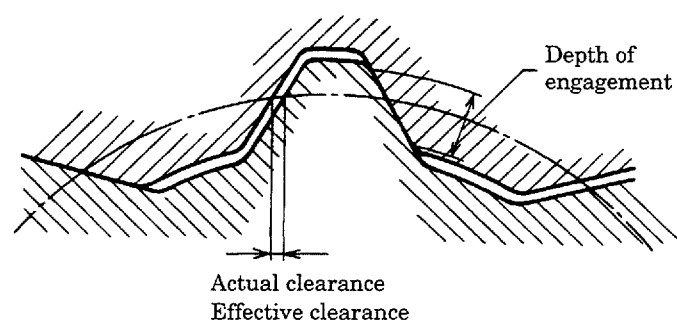
2.44 active spline length, g_w : The maximum axial spline length in contact (with working) with the mating spline. On sliding splines, the active length exceeds the length of engagement (see figure 17).

2.45 basic dimension : A numerical value to describe the theoretically exact size, shape or location of a feature. It is the basis from which permissible variations are established by tolerances.

2.46 auxiliary dimension : A dimension, without tolerance, given for information purposes only, for the determination of the useful production and control dimensions.



Informative reference figure 1



Informative reference figure 2

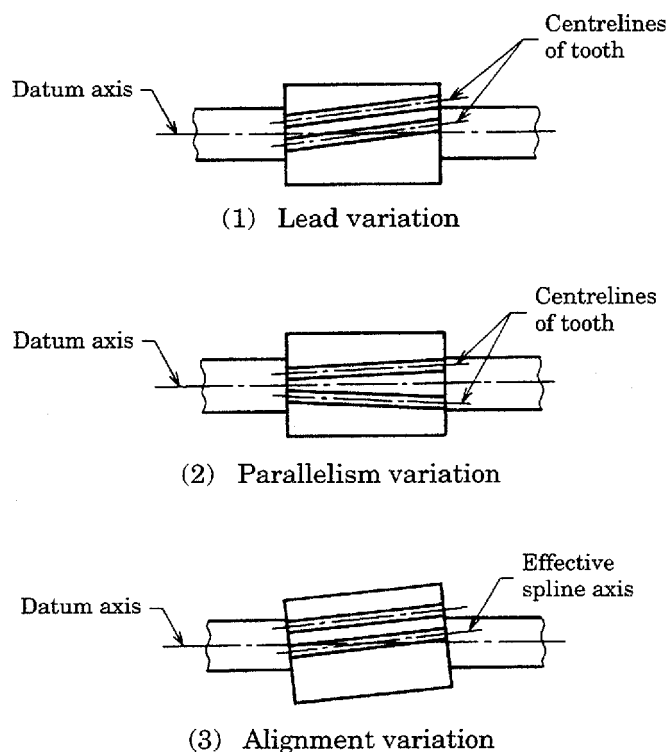


Figure 1 Total lead variation

3 Symbols

3.1 General symbols The general symbols used to designate the various spline terms and dimensions are given below (see figures 11, 12, 13, 14 and 15).

Note: In electronic data processing (EDP), it is not always possible to present symbols in their theoretically correct form because of limitations of connected printing equipment. For this reason, some alternative symbols for EDP usage are given in brackets below (for example, the symbol D_b for base diameter may be printed as DB).

c_v = effective clearance (looseness or interference)

c_F = form clearance

D = pitch diameter

D_b [DB] = base diameter

d_{ci} = pin contact diameter, internal spline

d_{ce} = pin contact diameter, external spline

D_{Fi} [DFI] = form diameter, internal spline

D_{Fe} [DFE] = form diameter, external spline

D_{ii} [DII] = minor diameter, internal spline

D_{ee} [DEE] = major diameter, external spline

D_{ei} [DEI] = major diameter, internal spline

D_{ie} [DIE] = minor diameter, external spline

D_{Ri} [DRI] = diameter of measuring pin for internal spline

D_{Re} [DRE] = diameter of measuring pin for external spline

- λ = variation allowance
- $\text{inv } \alpha$ = involute α ($= \tan \alpha - \alpha \cdot \pi/180$)
- K_i [KI] = approximation factor for internal spline K_e [KE] = approximation factor for external spline
- g = spline length
- g_w = active spline length
- g_γ = length of engagement
- T = machining tolerance
- M_{Ri} [MRI] = measurement between two pins, internal spline M_{Re} [MRE] = measurement over two pins, external spline
- W = measurement over k teeth, external spline
- z = number of teeth m = module
- P_b = base pitch
- p = circular pitch
- ρ_{Fi} = fillet radius of the basic rack, internal spline ρ_{Fe} = fillet radius of the basic rack, external spline
- E = basic space maximum space width, circular
- $E_{\max}$ = actual maximum space width, circular
- $E_{\min}$ = actual minimum space width, circular
- E_v [EV] = effective space width, circular
- S = basic tooth thickness, circular
- $S_{\max}$ = actual maximum tooth thickness, circular
- $S_{\min}$ = actual minimum tooth thickness, circular
- S_v [SV] = effective tooth thickness, circular
- α = pressure angle
- α_D = standard pressure angle
- α_{ci} = pressure angle at pin contact diameter, internal spline α_{ce} = pressure angle at pin contact diameter, external spline
- α_i = pressure angle at pin centre, internal spline α_e = pressure angle at pin centre, external spline
- α_{Fi} = pressure angle at form diameter, internal spline α_{Fe} = pressure angle at form diameter, external spline
- k, j_s, h, f, e and d = fundamental deviation of the external spline = $C_v \min$
- Informative reference : It is upper or lower deviation of dimension, whichever is close to the zero line (see **JIS B 0401**).
- H = lower deviation on the internal spline = 0

Tables 1 and 2 give the basic dimensions and fundamental formulae, a graphical presentation of which is given by figure 2.

3.2 Subscripts The following subscripts (see also the note in 3.1) are used as part of the above general symbols to designate relative conditions or locations:

- $_i[I]$ = minor or internal (in this last case, in the last position)
- $_e[E]$ = major or external (in this last case, in the last position)
- $_b[B]$ = at base
- $_c$ = at contact point
- $_F[F]$ = pertaining to form diameter
- $_v[V]$ = effective
- $_w$ = active
- $_R[R]$ = pertaining to gauges
- $_γ$ = of engagement
- $_D$ = standard

4 Pressure angle (standard) Standard pressure angles included in this Standard for involute splines are 30°, 37.5° and 45°.

5 Type of fit This Standard deals with only one type of fit, the side fit, for 30°, 37.5° and 45° pressure angle splines. Formulae for the dimensions and tolerances for these splines are shown in table 2.

5.1 Side fit In this fit, the mating members contact on the sides of the teeth only. Major and minor diameters are clearance dimensions. The tooth sides act as drivers and centralize mating splines.

5.2 Spline fit classes This Standard provides the side fit in six spline fit classes as follows:

Spline fit class	Effective interference
H/k	$c_{v \max}$ = deviation allowance $k = (T + \lambda)$
H/j _s	$c_{v \max}$ = deviation allowance $j_s = (T + \lambda)/2$
	Effective looseness
H/h	$c_{v \min}$ = deviation allowance $h = 0$
H/f	$c_{v \min}$ = deviation allowance f
H/e	$c_{v \min}$ = deviation allowance e
H/d	$c_{v \min}$ = deviation allowance d

The deviation allowances (fundamental) k , j_s , h , f , e and d are the standard deviations selected from **ISO/R286** *ISO System of limits and fits—Part 1 : General, tolerances and deviations*, which are applied to the external spine. A prescribed maximum effective interference or minimum effective looseness is obtained, allowing the fitting by adjusting from the zero line the maximum effective and minimum actual limit values of tooth thickness by the amount of the deviation allowance (see 8.7.2).

The spline dimensions in the spline tables in section two of this Standard are given for spline fit class H/h, $c_{v \min} = 0$.

Informative reference : The zero line is the straight line which shows the standard dimension and is standard against deviation allowance when illustrating dimensional limits or fit (see **JIS B 0401**).

Table 1 Theoretical dimensions for splines

Tooth $\alpha_b 30^\circ$ *	Module m	Circular pitch p	Dimensions in millimetres					
			Basic space width or tooth thickness at pitch diameter E or S			Base pitch P_b		
			$\alpha_b 30^\circ$	$\alpha_b 37.5^\circ$	$\alpha_b 45^\circ$	$\alpha_b 30^\circ$	$\alpha_b 37.5^\circ$	$\alpha_b 45^\circ$
	10	31.416	15.708	15.708	—	27.207 0	24.923 9	—
	8	25.133	12.566	12.566	—	21.765 6	19.939 2	—
	6	18.850	9.425	9.425	—	16.324 2	14.954 4	—
	5	15.708	7.854	7.854	—	13.603 5	12.462 0	—
	4	12.566	6.283	6.283	—	10.882 8	9.969 6	—
	3	9.425	4.712	4.712	—	8.162 1	7.477 2	—
	2.5	7.854	3.927	3.927	3.927	6.801 7	6.231 0	5.553 6
	2	6.283	3.142	3.142	3.142	5.441 4	4.984 8	4.442 9
	1.75	5.498	2.749	2.749	2.749	4.761 2	4.361 7	3.887 5
	1.5	4.712	2.356	2.356	2.356	4.081 0	3.738 6	3.332 2
	1.25	3.927	1.963	1.963	1.963	3.400 9	3.115 5	2.776 8
	1	3.142	1.571	1.571	1.571	2.720 7	2.492 4	2.221 4
	0.75	2.356	1.178	1.178	1.178	2.040 5	1.869 3	1.666 1
	0.5	1.571	0.785	0.785	0.785	1.360 4	1.246 2	1.110 7
	0.25	0.785	—	—	0.393	—	—	0.555 4

* For illustration purposes: relative tooth sizes for various spline modules for pressure angle $\alpha_b = 30^\circ$.

Table 2 Formulae for dimensions and tolerances for all fit classes

Term	Symbol	Formula
Pitch diameter	D	mz
Base diameter	D_b	$mz \cos \alpha_D$
Circular itch	p	πm
Base pitch	P_b	$\pi m \cos \alpha_D$
Effective upper deviation, external	es_v	resulting from deviation allowance (fundamental) k , j_s , h , f , e and d
Minimum diameter, internal		
30°, flat root	$D_{ei \min}$	$m(z+1.5)$
30°, fillet root	$D_{ei \min}$	$m(z+1.8)$
37.5°, fillet root	$D_{ei \min}$	$m(z+1.4)$
45°, fillet root	$D_{ei \min}$	$m(z+1.2)$
Maximum major diameter, internal	$D_{ei \max}$	$D_{ei \min} + (T + \lambda) / \tan \alpha_D$ (see note 1)
Minimum form diameter, internal		
30°, flat root and fillet root	$D_{Fi \min}$	$m(z+1) + 2c_F$
37.5°, fillet root	$D_{Fi \min}$	$m(z+0.9) + 2c_F$
45°, fillet root	$D_{Fi \min}$	$m(z+0.8) + 2c_F$
Minimum diameter, internal	$D_{ii \min}$	$D_{Fe \max} + 2c_F$ (see note 2)
Maximum minor diameter, internal		
$m \leq 0.75$	$D_{ii \max}$	$DD_{ii \min} + \text{tol.H10}^*$
$0.75 < m < 2$	$D_{ii \max}$	$DD_{ii \min} + \text{tol.H11}^*$
$m \geq 2$	$D_{ii \max}$	$DD_{ii \min} + \text{tol.H12}^*$
Base space width and	E and	$0.5\pi m$
Minimum effective space width	$E_{v \min}$	
Maximum actual space width		
class 4	$E_{\max}$	$E_{v \min} + (T + \lambda)$ (see note 3)
class 5	$E_{\max}$	$E_{v \min} + (T + \lambda)$ (see note 3)
class 6	$E_{\max}$	$E_{v \min} + (T + \lambda)$ (see note 3)
class 7	$E_{\max}$	$E_{v \min} + (T + \lambda)$ (see note 3)
Minimum actual space width	$E_{\min}$	$E_{v \min} + \lambda$ (see 8.2)
Maximum effective space width	$E_{v \max}$	$E_{\max} - \lambda$ (see 8.2)
Maximum major diameter, external		
30°, flat root and fillet root	$D_{ee \max}$	$m(z+1) + es_v / \tan \alpha_D$ (see note 4)
37.5°, fillet root	$D_{ee \max}$	$m(z+0.9) + es_v / \tan \alpha_D$ (see note 4)
45°, fillet root	$D_{ee \max}$	$m(z+0.8) + es_v / \tan \alpha_D$ (see note 4)
Minimum major diameter, external		
$m \leq 0.75$	$D_{ee \min}$	$D_{ee \max} - \text{tol.h10}^*$
$0.75 < m < 2$	$D_{ee \min}$	$D_{ee \max} - \text{tol.h11}^*$
$m \geq 2$	$D_{ee \min}$	$D_{ee \max} - \text{tol.h12}^*$

Table 2 (concluded)

Term	Symbol	Formula
Maximum form diameter, external	$D_{Fe\ max}$	$2 \times \sqrt{(0.5D_b)^2 + \left(0.5D \sin \alpha_b - \frac{h_s - \frac{0.5es_v}{\tan \alpha_b}}{\sin \alpha_b}\right)^2}$ (see note 6)
Maximum minor diameter, external		
30°, flat root	$D_{ie\ max}$	$m(z - 1.5) + es_v / \tan \alpha_D$
30°, fillet root	$D_{ie\ max}$	$m(z - 1.8) + es_v / \tan \alpha_D$
37.5°, fillet root	$D_{ie\ max}$	$m(z - 1.4) + es_v / \tan \alpha_D$
45°, fillet root	$D_{ie\ max}$	$m(z - 1.2) + es_v / \tan \alpha_D$
Minimum minor diameter, external	$D_{ie\ min}$	$D_{ie\ max} - (T + \lambda) / \tan \alpha_D$ (see note 1)
Basic tooth thickness	S	$0.5\pi m$
Maximum effective tooth thickness	$S_{v\ max}$	$S + es_v$
Minimum actual tooth thickness		
class 4	S_{min}	$S_{v\ max} - (T + \lambda)$ (see note 3)
class 5	S_{min}	$S_{v\ max} - (T + \lambda)$ (see note 3)
class 6	S_{min}	$S_{v\ max} - (T + \lambda)$ (see note 3)
class 7	S_{min}	$S_{v\ max} - (T + \lambda)$ (see note 3)
Maximum actual tooth thickness	S_{max}	$S_{v\ max} - \lambda$
Minimum effective tooth thickness	$S_{v\ min}$	$S_{min} + \lambda$
Total tolerance, space width or tooth thickness	$(T + \lambda)$	(see clause 6)
Form clearance	C_F	$0.1m$
Pin diameter, internal spline	D_{Ri}	(see note 5)
Pin diameter, external spline	D_{Re}	(see note 5)
Measurement between pins	M_{Ri}	(see note 5)
Measurement over pins	M_{Re}	(see note 5)
Change factor, internal	K_i	see section three, "Inspection"
Change factor, external	K_e	see section three, "Inspection"

* tol.H10, tol.h10 indicate the value of IT10, for tol. H11, tol.h11, IT11, and for tol. H12, tol. h12, IT12 (see JIS B 0401).

Notes 1 $(T + \lambda)$ for class 7 — see clause 6.

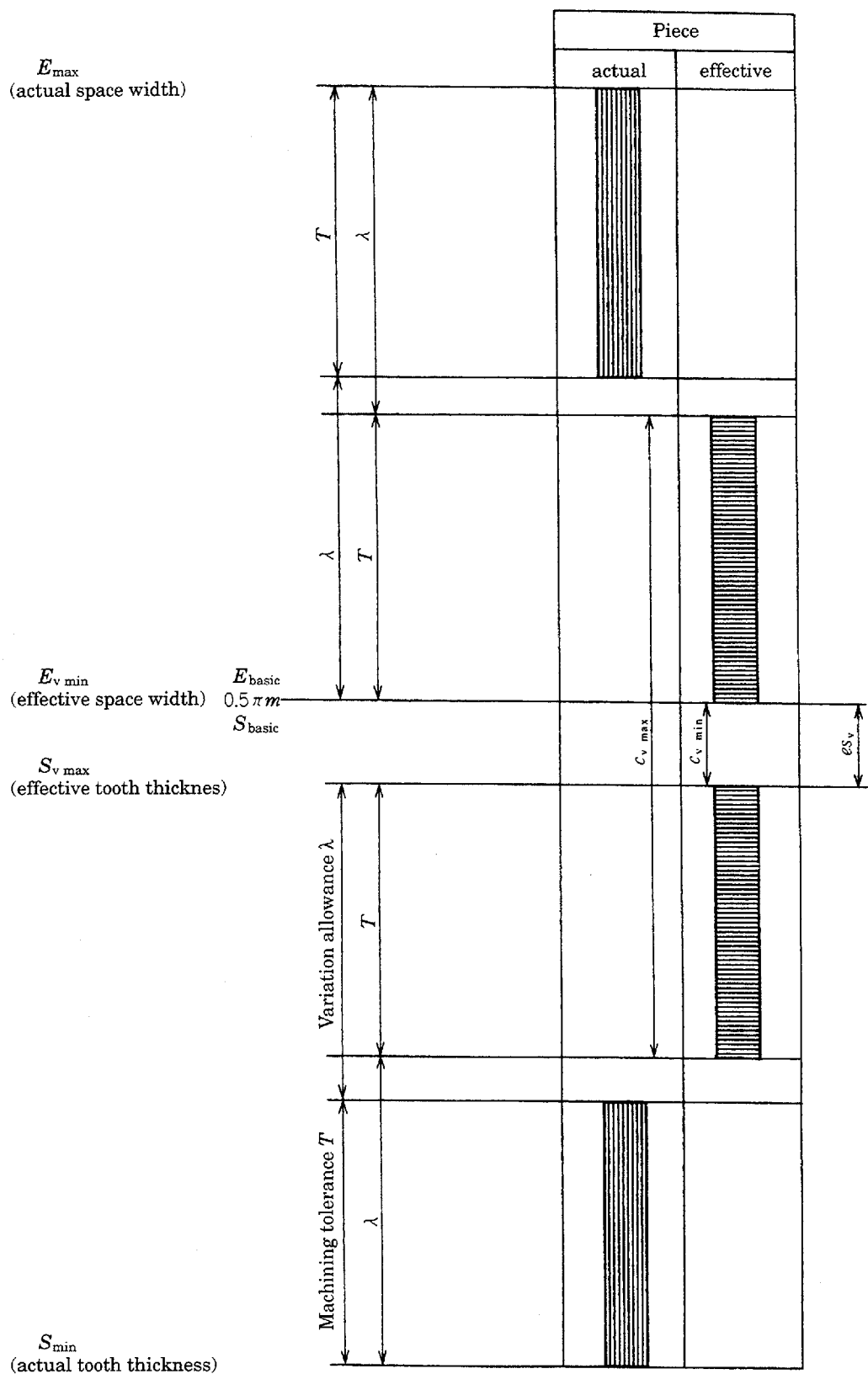
2 For all classes of fit, always take the $D_{Fe\ max}$ value corresponding to the H/h fit.

3 See clause 6 and section two — tables of dimensions.

4 Take a null upper deviation value for j_s and k fundamental deviations.

5 See section two: "Dimensions", and section three: "Inspection", concerning choice of pins.

6 For h_s see figures 3, 4, 5 and 6.



Informative reference : The values of $(T + \lambda)$ for internal and external splines are relative to on the tolerance classes considered.

Figure 2 Graphical representation of tables 1 and 2

6 Shape width and tooth thickness, total tolerance ($T+\lambda$) This Standard includes four classes of total tolerance ($T+\lambda$) on space width and tooth thickness selected from a combination of tolerance units (i) in **ISO/R 286**. The tolerance classes are indicated below, with corresponding combination of tolerance units (i). For the calculation of T and λ , see clause 8. The values of λ are given in tables 3 to 6 of clause 8.

Spline tolerance class	Tolerance unit (i)
4	$= (10i^* + 40i^{**})$
5	$= (16i^* + 64i^{**})$
6	$= (25i^* + 100i^{**})$
7	$= (40i^* + 160i^{**})$

* Tolerance based on pitch diameter

$$i = 0.45 \sqrt[3]{D} + 0.001D \quad \text{for } D \leq 500 \text{ mm}$$

$$i = 0.004D + 2.1 \quad \text{for } D > 500 \text{ mm}$$

** Tolerance based on space width or tooth thickness

$$i = 0.45 \sqrt[3]{E \text{ (or } S)} + 0.001E \text{ (or } S)$$

where

D is the pitch diameter in millimetres;

E is the basic space width in millimetres;

S is the basic tooth thickness in millimetres.

the resultant ($T+\lambda$) in micrometres. For ($T+\lambda$) in millimetres, multiply the result by 0.001.

For the calculation of tolerance units (i), only the above indicated formulae (notes *, **) are to be taken into consideration.

It should to be noted that total values ($T+\lambda$) may **always** be subtracted from the limit values of space width and tooth thickness given in section 2 and are usable even if the chosen fit class is other than H/h.

Note : Below are listed the combinations of tolerance qualities IT corresponding to the combinations of tolerance units (i) indicated above. Those combinations of tolerance qualities IT are given only to indicate the conception principle of the tolerance system regarding its eventual extension, and only to rediscover the corresponding combinations of tolerance units (i).

Spline tolerance class	Tolerance quality (IT)
4	$= (IT6^* + IT9^{**})$
5	$= (IT7^* + IT10^{**})$
6	$= (IT8^* + IT11^{**})$
7	$= (IT9^* + IT12^{**})$

Note * Tolerance based on pitch diameter.

** Tolerance based on space width and tooth thickness.

7 Basic rack profiles for spline

7.1 The basic rack is a section of the tooth surface of an involute spline of infinitely large diameter on a plane at right angles to the tooth surfaces, the profile of which is used as the basis for defining the standard tooth dimensions of a system of involute splines.

7.2 The reference line is a straight line crossing the profile of the basic rack, with reference to which the tooth dimensions are specified.

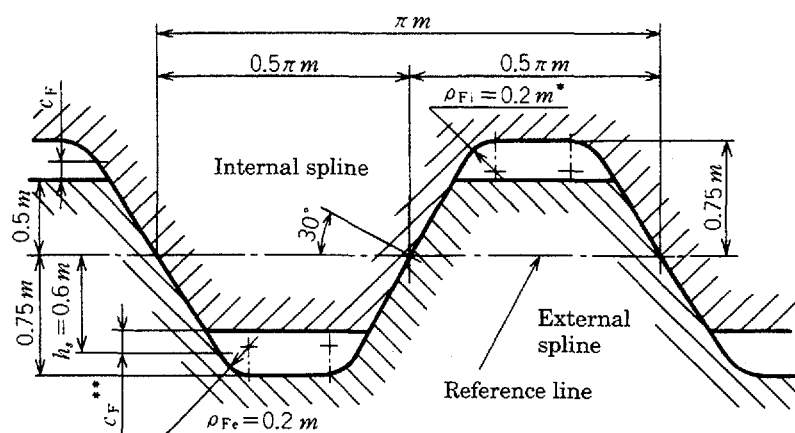
7.3 The profile of the basic rack for the standard pressure angle splines is represented in the following figures:

figure 3 : 30° flat root spline, for modules 0.5 to 10;

figure 4 : 30° fillet root spline, for modules 0.5 to 10;

figure 5 : 37.5° fillet root spline, for modules 0.5 to 10;

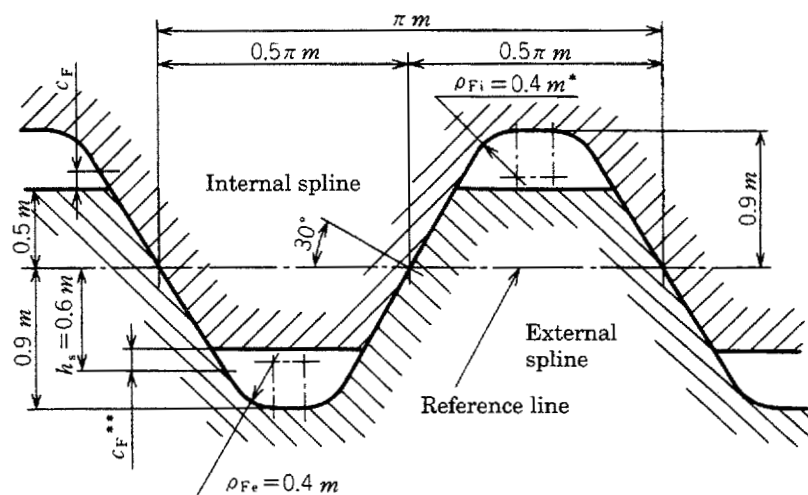
figure 6 : 45° fillet root spline, for modules 0.25 to 2.5.



* For internal splines (hub), the form diameter, obtained by generating from the basic rack, is always greater than the form diameter shown in the tables of dimensions (see section two), which corresponds in all fit cases to the major maximum diameter of the shaft (with upper deviation — es_v — zero) increased to diametral form clearance ($2c_F$) equal to 0.2 module.

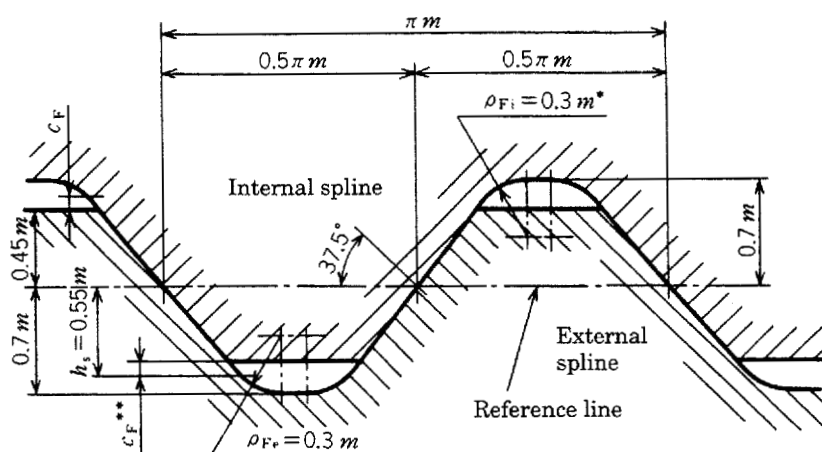
** For external splines (shafts), c_F is obtained by generation from the basic rack ($D_{Fe\max}$) and for H/h fit (see note 2 under table 2). The size c_F indicated is in fact a deviation permitting the form clearance c_F given in table 2 to be obtained and is equal to 0.1 m .

Figure 3 Profile of the basic rack for 30° flat root spline



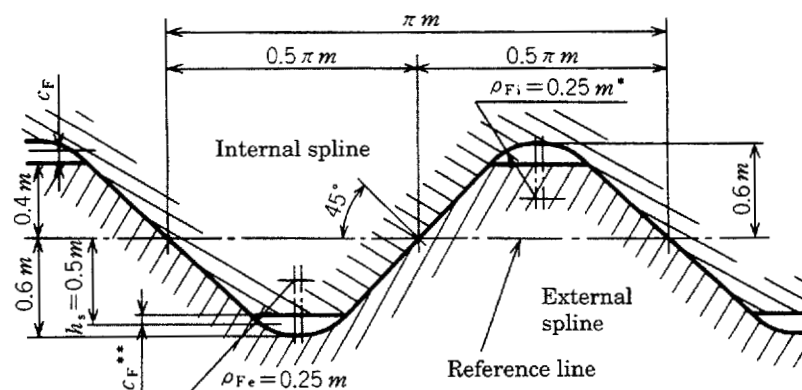
* and ** See note under figure 3.

Figure 4 Profile of the basic rack for 30° fillet root spline



* and ** See note under figure 3.

Figure 5 Profile of the basic rack for 37.5° fillet root spline



* and ** See note under figure 3.

Figure 6 Profile of the basic rack for 45° fillet root spline

7.4 The minimum radial form clearance, c_F , shown in the basic rack profiles is equal to $0.1 m$ for all pressure angle splines.

The form clearance is modified for fits other than H/h.

7.5 External splines may be produced by generating with a pinion-type shaper cutter or with a hob, or by cutting with no generating motion using a tool formed to the contour of a tooth space. External splines are also made by cold forming and in these cases are usually of the fillet root design. Internal splines are usually produced by broaching, by form cutting, or by generating with a shaper cutter. Even when full tip radius tools are used, each of these cutting methods produces a fillet contour with individual characteristics. Generated spline fillets are curves related to the prolate epicycloid for external splines and the prolate hypocycloid for internal splines. These fillets have a minimum radius of curvature at the point where the fillet is tangent to the external spline minor diameter circle or the internal spline major diameter circle, and a rapidly increasing radius of curvature up to the point where the fillet becomes tangent to the involute profile.

The values in table 10 may be used as minimum radii of curvature for stress calculations and they may be specified as the minimum fillet radius. These values are based on the fillet radius shown on the basic rack profiles. For cutting of internal and external splines by generating, with the same pinion-type shaper cutter, the tool design will have to be made according to the dimensions of the internal splines to be obtained.

8 Machining tolerances and variations

8.1 Variation allowance (λ) The variation allowance, being the addition of the total index variation, total profile variation and total lead variation, has an effect on the effective fit of an involute spline. The effect of these individual spline variations on the fit is less than their total, because areas of more than minimum clearance can have form, lead, or index errors without changing the fit. It is also unlikely that these errors would occur in their maximum amounts simultaneously on the same spline. For this reason, total index variation, profile variation and total lead variation are added together statistically and 60 % of this total is taken to determine the effect that these variations have on spline fit. On this basis, the variation allowance becomes as follows:

$$\lambda = 0.6 \sqrt{\left(\frac{\text{total index}}{\text{variation}}\right)^2 + \left(\frac{\text{total profile}}{\text{variation}}\right)^2 + \left(\frac{\text{total lead}}{\text{variation}}\right)^2}$$

The above variation allowance is based on a length of engagement equal to one-half the pitch diameter. Adjustment on the variation allowance may be required for a greater length of engagement.

8.2 Machining tolerance (T) The machining tolerance (T) is derived from the difference between the total tolerance ($T + \lambda$) and the variation allowance (λ), i.e. $(T + \lambda) - \lambda$.

The division of total class tolerance between machining tolerance and variation allowance outlined in 8.1 and 8.2 is recommended for general guidance. Design requirements or specific processes utilized for spline manufacture may require a different division.

8.3 Total index variation (F_p) The total index variation is the cumulative pitch error between the two greatest opposite pitch errors over any sector of one half circumference. The total index variation (F_p) is a standard tolerance grade selection from **ISO 1328**, *Parallel involute gears — ISO System of accuracy*. The following formulae are used in this Standard for the total index variation (F_p) expressed in micrometres:

Spline tolerance class	Total index variation (F_p) formula
4	$2.5\sqrt{L} + 6.3$
5	$3.55\sqrt{L} + 9$
6	$5\sqrt{L} + 12.5$
7	$7.1\sqrt{L} + 18$

where length of arc $L = mz\pi/2$.

8.4 Total profile variation (f_t) The total profile variation is the amount of absolute values of the two greatest opposite variations of the flank surface irregularities of the actual profile that depart from the theoretical profile. A positive variation is in the direction of the space, and a negative variation is in the direction of the tooth, as shown in figure 7. The total profile variation (f_t) is a standard tolerance grade selection from **ISO 1328**. The following formulae are used in this Standard for the total profile variation (f_t) expressed in micrometres:

Spline tolerance class	Total profile variation (f_t) formula
4	$1.6\phi_f + 10$
5	$2.5\phi_f + 16$
6	$4\phi_f + 25$
7	$6.3\phi_f + 40$

where tolerance factor $\phi_f = m + 0.012\ 5mz$.

The permissible positive variation on external splines and the negative variation on internal splines from the design profile within the central one-third of the flank depth to the form diameter shall not exceed one-third of the calculated values. See figure 7.

Note: The middle point is situated on the involute at an equal distance from the major diameter of the external spline (D_{ee}) and from the minor diameter of the internal spline (D_{ii}). This point is the reference for the computation of pin diameter (figure 7).

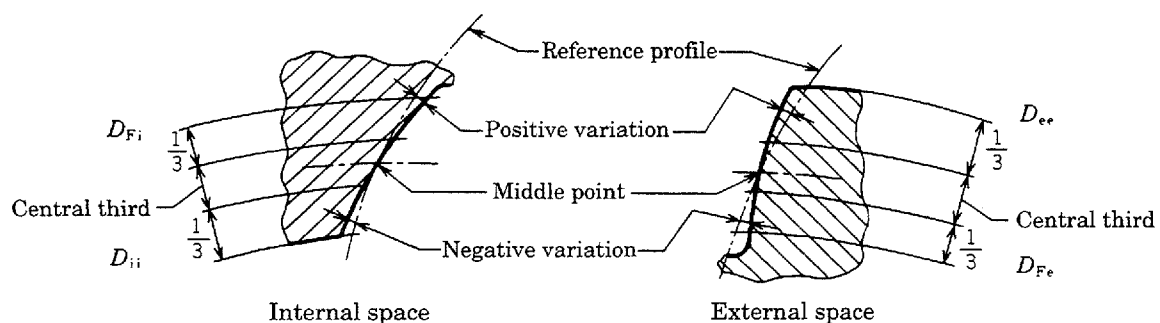


Figure 7 Profile variations

8.5 Total lead variation (F_β) The total lead variation is the amount of absolute values of the two greatest opposite misalignment variations from the theoretical position, measured normal to the flank for the full length of spline. The total lead variation (F_β) is a standard tolerance grade selection from **ISO 1328**. The following formulae are used in this Standard for the total lead variation (F_β), expressed in micrometres:

Spline tolerance class	Total lead variation (F_β) formula
4	$0.8\sqrt{g} + 4$
5	$1\sqrt{g} + 5$
6	$1.25\sqrt{g} + 6.3$
7	$2\sqrt{g} + 10$

where g is the spline length, in millimetres.

Informative reference : In the above formulas, g_w or g_f is selected by the agreement between the user and manufacturer.

8.6 Out-of-roundness This condition may appear merely as a result of total index and total profile variations described in **8.3** and **8.4**, and requires no further allowance. However, heat treatment and deflection of thin sections may cause out-of-roundness, which increases total index and total profile variations. Tolerances for such conditions depend on many variables, and are therefore not tabulated. Additional tooth and space width tolerance must allow for such conditions.

8.7 Eccentricity

8.7.1 Eccentricity of major and minor diameters, in relation to the effective reference diameter of side fit splines, should not cause contact beyond the form diameters of the mating splines, even under conditions of maximum effective clearance. This Standard does not establish specific tolerances.

8.7.2 Deviation allowance from an H/h fit (without looseness or interference) If working conditions require looseness or interference, and the alignment of mating splines is affected by eccentricity of locating surfaces relative to each other and/or the splines, it may be necessary to prescribe a minimum effective clearance by decreasing the effective and actual tooth thickness of the external spline by an amount sufficient to allow the misaligned splines to assemble.

8.7.2.1 This Standard provides standard deviation allowance k , j_s , h , f , e and d for application to the circular tooth thickness at the pitch diameter (S) of the external spline in order to establish the spline fit classes without looseness or having maximum effective interferences or minimum effective clearances (see table 7) and thus standardizing on composite GO gauges. Figure 8 represents in graphical form the deviation allowances and spline class tolerance zones for the six spline fit classes as outlined in **5.2**.

8.7.2.2 Application of deviation allowance The spline tables 5 to 116 in section two of this Standard are based on spline fit class H/h, which has a minimum effective clearance equal to zero. Selection of a spline fit class having a different deviation allowance requires adjustment to the external spline dimensions as follows:

- a) For the deviation allowance selected (k , j_s , h , f , e , and d), determine the upper deviation value (es_v) from table 7.
- b) Adjust the maximum effective tooth thickness, $S_{v\max}$, and the minimum actual tooth thickness, $S_{\min}$, specified in the spline tables, by the amount of the upper deviation value (es_v) shown in section two.
- c) Adjust major diameter and minor minimum and maximum diameters (D_{ee} , $D_{ie\min}$ and $D_{ie\max}$) from the value given in table 8 for each deviation allowance and each pressure angle.

For fit classes H/k and H/ j_s , a nut value of upper deviation (es_v) for the major diameter of the external spline (D_{ee}) will have to be taken.

- d) Calculate minimum and maximum dimensions over two pins, external spline ($M_{Re\min}$ and $M_{Re\max}$):

$$M_{Re\min} = M_{Re\min}^* + (es_v) K_e$$

$$M_{Re\max}^{**} = M_{Re\min}^* + (es_v + T) K_e$$

* $M_{Re\min}$ values corresponding to values of fit class H/h (see section three).

** $M_{Re\max}$ values corresponding to the maximum actual limits (machining).

Values of the factor K_e are given in section three. These formulae are approximate (see section three; clause 23.3.4.2.2, approximation factor). In case of dispute, only calculated values according to the formulae stated in section three, (concerning dimensions between or over pins) shall be taken into consideration.

Upper deviation (es_v) values are given in table 7.

- e) Calculate the minimum and maximum dimensions over k teeth, external spline ($W_{\min}$ and $W_{\max}$).

Values of minimum and maximum dimensions over k teeth are given for the fit class H/h in section three — Inspection — clause 23.4. For other fit classes, apply the corresponding formulae in section three, clause 23.4.1.

8.7.2.3 In the manufacture of external splines with a standard deviation allowance, standard cutters conforming to the basic rack can be used by shifting the basic rack reference line radially from its position touching the spline pitch circle. The spline tooth profiles remain as involutes; merely different parts of the same involutes, lying further inward or outward with respect to the pitch circle, are used. The amount of this radial displacement is equivalent to $\frac{0.5 es_v}{\tan \alpha_D}$.

8.7.2.4 The effect of the various magnitudes of upper deviation (es_v) on the tooth form have an effect on the circular tip thickness, at the major diameter of the external spline, which varies when the upper deviation (es_v) varies. The following checks should be made when applying deviation allowances:

- a) Check for tip thickness at major maximum diameter of external spline

Tip thickness S_{ee} less than $0.25 m$ should be avoided. Tip thickness is computed as follows, considering $D_{ee \max}$

$$S_{ee} = D_{ee \max} \left(\frac{S_{\min}}{D} + \text{inv} \alpha_D - \text{inv} \alpha_{Dee} \right)$$

where

S_{ee} is the tip thickness;

$S_{\min}$ is the minimum actual tooth thickness resulting from the deviation allowance

α_D is the pressure angle at the pitch diameter;

α_{Dee} is the pressure angle at the maximum major diameter

$$\left(\cos \alpha_{Dee} = \frac{D_b}{D_{ee \max}} \right)$$

$$\text{inv} \alpha_D = \tan \alpha_D - \alpha_D$$

$$\text{inv} \alpha_{Dee} = \tan \alpha_{Dee} - \alpha_{Dee}$$

- b) Undercut fillet at the root circle (interference) When a fit with looseness is selected, generating tools may produce undercut fillets on the external spline. Calculation using the appropriate tool data should be made to establish the presence or absence of undercutting and, if it exists, further calculations or a layout are then required to determine whether the degree of undercutting is acceptable.

Low tooth numbers and pressure angles introduce the risk of undercutting which occurs with basic rack generation when:

$$(h_s - 0.5 \Delta D_{ie}) > 0.5 D \sin^2 \alpha_D$$

Informative reference : where, h_s is effective depth of addendum of rack

$$\left(= D - \frac{D_{Fe \min}}{2} \right)$$

$0.5 \Delta D_{ie}$ is negative displacement

Table 3 Variation allowance, λ — Modules 0.25 to 1

Values in micrometres

Number of teeth z	$m=0.25$				$m=0.50$				$m=0.75$				$m=1$				Number of teeth z
	Tolerance class				Tolerance class				Tolerance class				Tolerance class				
	4	5	6	7	4	5	6	7	4	5	6	7	4	5	6	7	
6	9	14	20	31	10	15	22	34	11	16	23	36	11	17	25	38	6
7			21	32							24		12				7
8							23	35		17		37		18	26	39	8
9	10				11	16					25	38				40	9
10								36	12				13		27		10
11				33			24				26	39		19		41	11
12		15	22							18					28	42	12
13						17		37				40					13
14							25		13		27			20	29	43	14
15				34	12							41	14				15
16								38		19						44	16
17											28	42			30	45	17
18			23				26	39					21				18
19	11	16		35		18									31	46	19
20									14	20	29	43	15				20
21								40								47	21
22					13		27					44	22	32			22
23																48	23
24			24	36		19					30						24
25								41		21		45	16		33		25
26													23			49	26
27							28		15		31	46					27
28								42							34	50	28
29		17		37													29
30										22		47	24			51	30
31	12		25		14	20		43			32		17				31
32							29								35	52	32
33												48					33
34				38					16								34
35								44		23	33			25	36	53	35
36												49					36
37							30						18			54	37
38						21									37		38
39		18	26					45			34	50					39
40				39									26			55	40
41					15					24							41
42							31		17			51			38		42
43								46			35					56	43
44																	44
45												52	19	27		57	45
46	13			40		22									39		46
47								47		25							47
48			27				32				36	53				58	48
49																	49
50													28	40			50
51		19						48	18			54				59	51
52					16						37		20				52
53				41													53
54						23	33			26					41	60	54
55								49				55					55

Table 3 (concluded)

Values in micrometres

Number of teeth <i>z</i>	<i>m</i> = 0.25				<i>m</i> = 0.50				<i>m</i> = 0.75				<i>m</i> = 1				Number of teeth <i>z</i>
	Tolerance class				Tolerance class				Tolerance class				Tolerance class				
	4	5	6	7	4	5	6	7	4	5	6	7	4	5	6	7	
56	13	19	27	41	16	23	33	49	18	26	37	55	20	29	41	60	56
57			28								38					61	57
58												56			42		58
59				42													59
60							34	50	19				21			62	60
61										27							61
62											39	57		30	43		62
63						24										63	63
64	14	20			17												64
65								51									65
66			29	43								58				64	66
67							35								44		67
68										28	40						68
69								52				59	22	31		65	69
70									20								70
71															45		71
72						25										66	72
73							36				41	60					73
74				44				53									74
75														32			75
76										29					46	67	76
77			30		18							61					77
78		21											23				78
79								54			42					68	79
80																	80
81							37		21			62			47		81
82				45		26								33			82
83																69	83
84	15							55		30	43						84
85												63					85
86															48	70	86
87																	87
88			31				38						24				88
89				46										34			89
90								56			44	64				71	90
91					19										49		91
92										31							92
93						27			22							72	93
94		22										65					94
95							39	57									95
96											45			35	50		96
97																73	97
98				47								66	25				98
99			32														99
100																	100

Table 4 Variation allowance, λ — Modules 1.25 to 2

Values in micrometres

Num- ber of teeth z	$m=1.25$				$m=1.5$				$m=1.75$				$m=2$				Num- ber of teeth z
	Tolerance class				Tolerance class				Tolerance class				Tolerance class				
	4	5	6	7	4	5	6	7	4	5	6	7	4	5	6	7	
6	12	18	26	40	13	18	27	41	13	19	28	43	14	20	29	44	6
7			27			19	28	42		20	29	44			30	45	7
8	13	19		41			29	43	14		30	45		21	31	47	8
9			28	42	14	20		44		21		46	15	22	32	48	9
10				43			30	45	15		31	47				49	10
11	14	20	29			21		46		22	32	48	16	23	33		11
12				44	15		31								34	50	12
13			30	45		22		47	16	23	33	49				51	13
14		21					32	48				50	17	24	35	52	14
15	15		31	46							34	51			36	53	15
16				47	16	23	33	49		24	35	52		25		54	16
17		22	32					50	17						37	55	17
18				48			34	51			36	53	18	26			18
19			33			24				25		54			38	56	19
20	16	23		49	17		35	52	18		37					57	20
21				50						26		55	19	27	39	58	21
22			34			25	36	53			38	56					22
23		24		51				54						28	40	59	23
24	17		35		18		37		19	27	39	57				60	24
25				52		26		55				58	20		41		25
26														29		61	26
27		25	36	53			38	56		28	40	59			42	62	27
28								57				60					28
29				54	19	27	39		20		41		21	30	43	63	29
30	18		37					58				61				64	30
31		26		55						29	42				44		31
32						28	40	59				62		31		65	32
33			38	56					21				22		45	66	33
34					20		41	60		30	43	63					34
35	19	27		57								64				67	35
36			39			29		61			44			32	46		36
37				58			42					65				68	37
38								62	22	31			23		47	69	38
39			40		21						45	66		33			39
40		28		59		30	43	63							48	70	40
41	20							64		32	46	67					41
42			41	60												71	42
43							44					68	24	34	49		43
44		29		61				65	23		47					72	44
45					22	31				33		69					45
46			42				45	66						35	50	73	46
47				62							48	70				74	47
48	21												25		51		48
49		30	43	63		32	46	67	24	34		71				75	49
50											49			36			50
51					23			68				72			52	76	51
52			44	64			47										52
53						33		69		35	50	73	26			77	53
54		31		65										37	53		54
55	22							70	25			74				78	55

Table 4 (concluded)

Values in micrometres

Number of teeth z	$m=1.25$				$m=1.5$				$m=1.75$				$m=2$				Number of teeth z																																			
	Tolerance class				Tolerance class				Tolerance class				Tolerance class																																							
	4	5	6	7	4	5	6	7	4	5	6	7	4	5	6	7																																				
56	22	31	45	65	23	33	48	70	25	35	51	74	26	37	53	78	56																																			
57				66																	75		54	79	57																											
58																				24	34		71		36			38		55	80	58																				
59																		32					49			52	76	27				59																				
60																			46					72									60																			
61																									26							81	61																			
62	23			68						37	53	77		39	56		62																																			
63																				35		73				82	63																									
64																			47						78			64																								
65																		33		69	25		74		54		28		57		65																					
66																						51				79				83	66																					
67																									38				40			67																				
68			48	70		36		75	27							84	68																																			
69																										58		69																								
70				24																			52	76			81	29	41	59	86	72																				
71																																		34		71		26									73					
72																																			49			37	53	77								74				
73																																									28							75				
74															60		76																																			
75					72																												77																			
76		35	50					78		40		57	83	30	42		88	77																																		
77																					73			54																												
78																			25							79				84			61		78																	
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82							55	80	29						62	90	81																																			
83										41								82																																		
84		36		75								59	86	31			91	84																																		
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97																																																				
98																																																				
99																																																				
100																																																				

Table 5 Variation allowance, λ — Modules 2.5 to 5

Values in micrometres

Number of teeth z	$m=2.5$				$m=3$				$m=4$				$m=5$				Number of teeth z
	Tolerance class				Tolerance class				Tolerance class				Tolerance class				
	4	5	6	7	4	5	6	7	4	5	6	7	4	5	6	7	
6	14	21	31	47	15	22	33	50	17	25	37	56	18	27	40	61	6
7		22	32	49	16	23	34	52	18	26	38	57	19	28	41	62	7
8		23	33	50		24	35	53		27	39	59		20	29	43	
9	15		34	51	17	25	36	54	19		40	60		30	44	66	9
10	24		35	52		37	55	28			41	62		21	31	45	
11	16			53	18	26	38	57	20	29	42	63	22		46	69	11
12	25			36		54	39	58		43	64	32			47	70	
13			37	55	19	27		59	21	30	44	66	23	33	48	72	13
14			26	38		56		28		40	60	31		45	67	34	
15	18			57		41	61	22		46	68	24		50	75	15	
16	27			39		58	20			29	42			62	32	47	69
17			40	59				63	23	33	48	70	25	36	52	77	17
18			28	60				21		30	43	64		72	53	79	
19	20		41	61			44	65		34	49	73	26	37	54	80	19
20			29	42			62	31		66	24	50		74	38	55	
21					22		45	67		35	51	75	27		56	82	21
22							21	43		63	32	46			68	25	
23		30		64				69		36	52	77	28			85	23
24		44		65				23		47	53	78				40	
25		31		66		33	48	70	26	37	54	79		41	59	87	25
26		22		45			71			80	29	60		88	26		
27			67	24	34		49		72	27	38	55	81		42	61	89
28			32	46	68	73	56	82	30		90	28					
29			47	69		35	50	74		39		83		43	62	92	29
30			23	33			51			28		57		84	63	93	
31			48	70	25				52	76		40	58	85	31	44	64
32			71	36		77		29	41	59		87	45	65		96	33
33	24	34	49		26	37	53	78			60	88	32		66	97	34
34			72			54	79	61			89	33			67	98	
35				50	73				80	30		62	90		47	68	100
36	35			51	74				38	55		81	43		63	92	34
37	25			75	27		39	56	82	31	44		93		49	71	
38							57	84	32		65		95		50	72	
39			36			52	76		40	58	85		66	96		73	106
40		77							46		97		36	51			107
41																	67
42	26		37	53	28								33			47	
43			78	42				60	88		68	99		52	75	110	
44				39	56	82					100	37		76	111	49	
45															69	101	
46			27				38	55	80	29		41	59		86	34	
47																	
48																	
49	39	56	82														
50																	
51				28	57	83											
52																	
53							40										
54		58	85														
55																	
	31			44													

Table 5 (concluded)

Values in micrometres

Number of teeth <i>z</i>	<i>m</i> = 2,5				<i>m</i> = 3				<i>m</i> = 4				<i>m</i> = 5				Number of teeth <i>z</i>															
	Tolerance class				Tolerance class				Tolerance class				Tolerance class																			
	4	5	6	7	4	5	6	7	4	5	6	7	4	5	6	7																
56	29	41	59	86	31	44	63	93	35	50	72	105	39	55	80	117	56															
57											64							73	106		56			57								
58								87				45							94	36	51		107			81	118	58				
59							42	60				32							65			74		40		82	119	59				
60	30	42	60	88	32	44	65	95	35	50	74	108	39	55	80	117	60															
61																																
62																		61				66	96		52	75	109		57		120	60
63																			89		46			37				41	58			62
64	31	43	62	90	33	44	67	98	35	50	76	111	39	55	80	117	64															
65																																
66																						68	99	38		77	112	42				66
67																		44	63	92					54		113			86	125	67
68	32	45	64	93	34	48	69	100	35	50	78	114	39	55	80	117	68															
69																																
70																							101		55	79	115	43	61		128	70
71																			94			70		39						88		71
72	33	46	65		35	49	102	103	35	50	80	116	39	55	80	117	72															
73																																
74																						71	103			81		44		90		74
75																							104	40			118				131	75
76	34	47	66	96	36	50	72	105	36	51	73	106	41	57	82	119	76															
77																																
78																																
79																																
80	35	48	67	97	37	52	73	106	42	58	74	107	43	60	86	125	81															
81																																
82																																
83																																
84	36	49	68	99	38	53	74	108	44	61	88	122	47	63	91	132	77															
85																																
86																																
87																																
88	37	50	69	100	39	54	75	109	45	62	89	129	49	66	94	134	78															
89																																
90																																
91																																
92	38	51	68	101	40	55	76	110	46	63	90	130	50	68	98	136	82															
93																																
94																																
95																																
96	39	52	69	102	41	56	77	111	47	64	91	131	51	69	99	138	83															
97																																
98																																
99																																
100	40	53	70	103	42	57	78	112	48	65	92	132	52	70	100	139	84															

Table 6 Variation allowance, λ — Modules 6 to 10

Values in micrometres

Number of teeth z	$m=6$				$m=8$				$m=10$				Number of teeth z
	Tolerance class				Tolerance class				Tolerance class				
	4	5	6	7	4	5	6	7	4	5	6	7	
6	20	29	43	66	23	33	50	75	25	37	55	84	6
7	21	30	45	68		34	51	77	26	38	57	87	7
8		31	46	69	24	36	53	79	27	40	59	89	8
9	22	32	47	71	25	37	54	82	28	41	61	91	9
10	23	33	49	73	26	38	56	84	29	42	62	94	10
11		34	50	75	27	39	57	86	30	43	64	96	11
12	24	35	51	76		40	58	87		44	65	98	12
13	25	36	52	78	28	41	60	89	31	45	67	100	13
14			53	80	29	42	61	91	32	46	68	102	14
15	26	37	55	81			62	93	33	47	70	104	15
16		38	56	83	30	43	64	95		48	71	106	16
17	27	39	57	84	31	44	65	96	34	49	72	108	17
18			58	85		45	66	98	35	50	74	110	18
19	28	40	59	87	32	46	67	100		51	75	112	19
20		41	60	88		47	68	101	36	52	76	113	20
21	29		61	90	33		69	103	37	53	78	115	21
22		42		91		48	70	104		54	79	117	22
23	30	43	62	92	34	49	72	106	38	55	80	119	23
24			63	93	35	50	73	107	39		81	120	24
25	31	44	64	95			74	109		56	82	122	25
26		45	65	96	36	51	75	110	40	57	84	124	26
27	32		66	97		52	76	112		58	85	125	27
28		46	67	98	37	53	77	113	41	59	86	127	28
29			68	100			78	114			87	128	29
30	33	47		101	38	54	79	116	42	60	88	130	30
31		48	69	102		55	80	117		61	89	131	31
32	34		70	103	39		81	119	43	62	90	133	32
33		49	71	104		56		120	44		91	134	33
34	35		72	105	40	57	82	121		63	92	136	34
35		50		106			83	122	45	64	93	137	35
36			73	107		58	84	124		65	94	139	36
37	36	51	74	109	41		85	125	46		95	140	37
38			75	110		59	86	126		66	96	142	38
39		52		111	42	60	87	127	47	67	97	143	39
40	37	53	76	112			88	129			98	144	40
41			77	113	43	61	89	130	48	68	99	146	41
42	38	54	78	114				131		69	100	147	42
43				115		62	90	132			101	149	43
44		55	79	116	44	63	91	133	49	70	102	150	44
45	39		80	117			92	135		71	103	151	45
46				118	45	64	93	136	50		104	153	46
47		56	81	119				137		72	105	154	47
48	40		82	120		65	94	138	51	73	106	155	48
49		57		121	46		95	139			107	156	49
50			83	122		66	96	140	52	74		158	50
51	41	58	84	123	47		97	141			108	159	51
52				124		67		143		75	109	160	52
53		59	85			68	98	144	53	76	110	161	53
54	42		86	125	48		99	145			111	163	54
55		60		126		69	100	146	54	77	112	164	55

Table 6 (concluded)

Values in micrometres

Number of teeth <i>z</i>	<i>m</i> = 6				<i>m</i> = 8				<i>m</i> = 10				Number of teeth <i>z</i>												
	Tolerance class				Tolerance class				Tolerance class																
	4	5	6	7	4	5	6	7	4	5	6	7													
56	42	60	87	127	49	69	100	147	54	77	113	165	56												
57	43	61	88	128		70	101	148		55	78		166	57											
58				129				102			149	79	114	168	58										
59				89			130	50			71		103	150		115	169	59							
60			44	62	90		131						151	56		80	116	170	60						
61		132			51	72	104			152						117	171	61							
62							73			105		153	57			81	118	172	62						
63	63	91						133		51					154			173	63						
64			45	64					92					134	52		74	106	155	58	82	119	175	64	
65						93			135		75			107				156				120	176	65	
66							136						108	157				59			83	121	177	66	
67	46	65			94	137	53	76		110		158	60	84		122					178	67			
68				138		54						77		111	162	61				179	68				
69											76						110		160	85	123	180	69		
70				96														161			60		124	181	70
71	47	67	97	140	54		77	111		162			86									125	183	71	
72												141			112	163						61		184	72
73											142						164		87	126			185	73	
74						48			68		98							143		55	78		113	165	88
75			56	80	116		169	63					128												
76		99								144			79		167										
77		69								100		145					81		117			171			
78	49	70				101			147	57	82	118						172		64	130		190	78	
79					58		83	119													174		90	131	191
80													120	65		192								80	
81			50	71											102	148	82					173		92	132
82		149							174	93	133	194						82							
83		103			150		58	84			122	178						94		134	196		83		
84					151									121						176	66				197
85	51	72	104		83											175			135			198	85		
86									152	59									85			123	179	67	95
87							73	105	153		86							182							68
88								154					124	181											
89	52		106		85	123	179	67							95	137	202				89				
90															74		155		60			180		138	
91												107			156	87	126							184	69
92											108	157		127	185										
93	53	75			61		125	183	97	139	206	93													
94											109	158							88			186	70		
95												159					128	187							
96											76	110	160	62						129					188
97	54		111	161		89	129	188		143	210	97													
98												112							63						
99																									
100																									

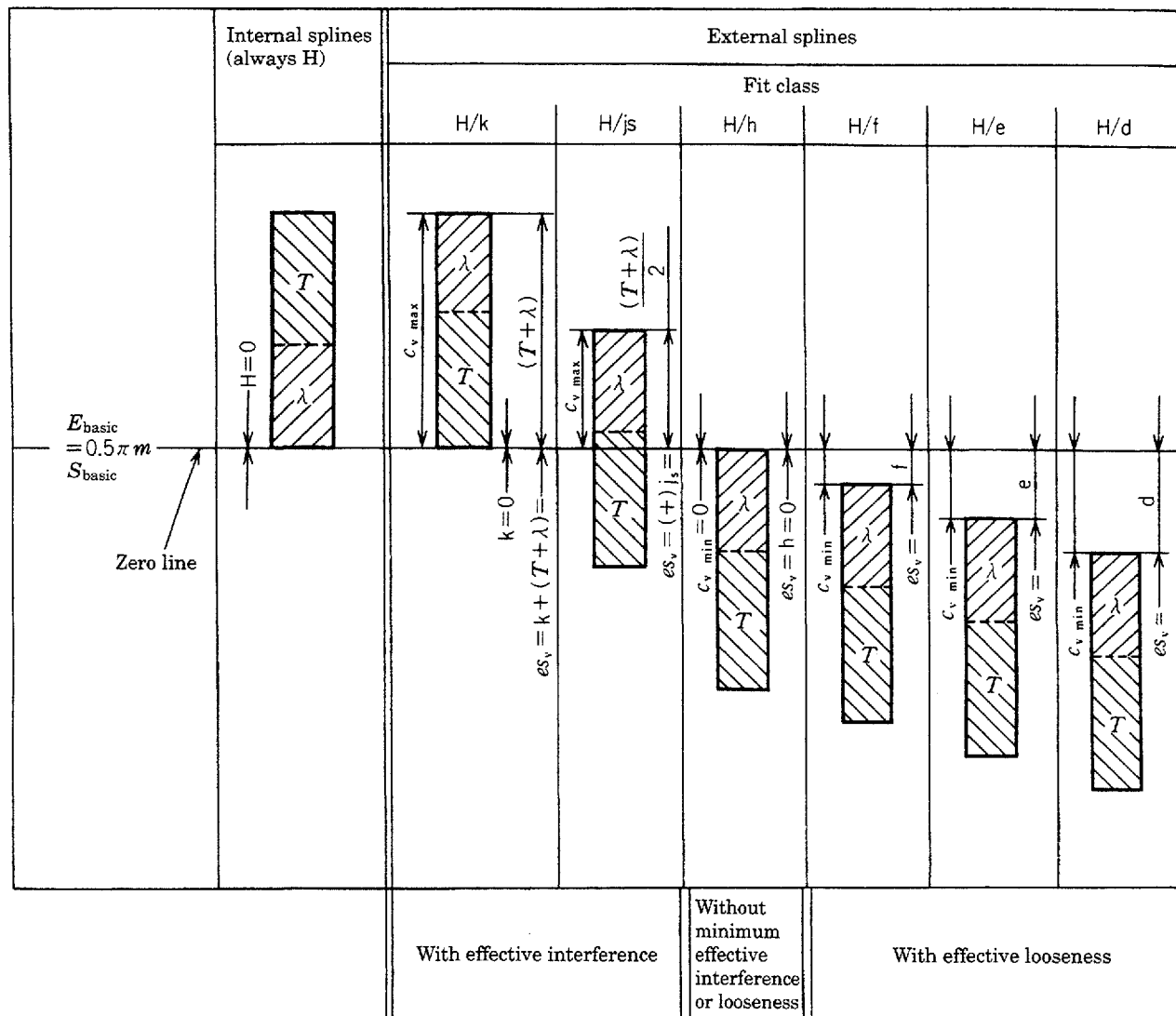


Figure 8 Graphical representation of deviation allowances for the spline fit classes

Table 7 Limit deviations (es_v) resulting from fundamental deviations

1 μm = 0.001 mm

Pitch diameter D (mm)	External splines						Internal splines
	Upper deviation relative to basic tooth thickness, S , at pitch diameter, μm						Lower deviation relative to basic space width at pitch diameter, μm
	For fundamental deviations						H
	d	e	f	h	j_s	k	
≤ 3	-20	-14	-6	0			0
> 3 to 6	-30	-20	-10	0			0
> 6 to 10	-40	-25	-13	0			0
> 10 to 18	-50	-32	-16	0			0
> 18 to 30	-65	-40	-20	0			0
> 30 to 50	-80	-50	-25	0			0
> 50 to 80	-100	-60	-30	0			0
> 80 to 120	-120	-72	-36	0			0
> 120 to 180	-145	-85	-43	0			0
> 180 to 250	-170	-100	-50	0			0
> 250 to 315	-190	-110	-56	0			0
> 315 to 400	-210	-125	-62	0			0
> 400 to 500	-230	-135	-68	0			0
> 500 to 630	-260	-145	-76	0			0
> 630 to 800	-290	-160	-80	0			0
> 800 to 1 000	-320	-170	-86	0			0

* For $S_{v \max}$ and $S_{\min}$, see section two — tables 15 to 116 of dimensions (relative to tolerance class considered).

Basic tooth thickness, S , and basic space width E at pitch diameter, mm							
m	S, E (mm)	m	S, E (mm)	m	S, E (mm)	m	S, E (mm)
0.25	0.393	1.25	1.963	2.5	3.927	6	9.425
0.5	0.785	1.5	2.356	3	4.712	8	12.566
0.75	1.178	1.75	2.749	4	6.283	10	15.708
1	1.571	2	3.142	5	7.854		

**Table 8 Reduction for minor and major diameters (D_{ie} and D_{ee})
of external splines resulting from fundamental deviations**

1 μm = 0.001 mm

Pitch diameter D (mm)	$\frac{eS_v}{\tan \alpha_D}$, μm , for											
	d			e			f			h	j_s	k
	30°	37.5°	45°	30°	37.5°	45°	30°	37.5°	45°	α_D	α_D	α_D
≤ 3	-35	-26	-20	-24	-18	-14	-10	-8	-6	0		
> 3 to 6	-52	-39	-30	-35	-26	-20	-17	-13	-10	0		
> 6 to 10	-69	-52	-40	-43	-33	-25	-23	-17	-13	0		
> 10 to 18	-87	-65	-50	-55	-42	-32	-28	-21	-16	0		
> 18 to 30	-113	-85	-65	-69	-52	-40	-35	-26	-20	0		
> 30 to 50	-139	-104	-80	-87	-65	-50	-43	-33	-25	0		
> 50 to 80	-173	-130	-100	-104	-78	-60	-52	-39	-30	0		
> 80 to 120	-208	-156	-120	-125	-94	-72	-62	-47	-36	0		
> 120 to 180	-251	-189	-145	-147	-111	-85	-74	-56	-43	0		
> 180 to 250	-294	-222	-170	-173	-130	-100	-87	-65	-50	0		
> 250 to 315	-329	-248	-190	-191	-143	-110	-97	-73	-56	0		
> 315 to 400	-364	-274	-210	-217	-163	-125	-107	-81	-62	0		
> 400 to 500	-398	-300	-230	-234	-176	-135	-118	-89	-68	0		
> 500 to 630	-450	-339	-260	-251	-189	-145	-132	-99	-76	0		
> 630 to 800	-502	-378	-290	-277	-209	-160	-139	-104	-80	0		
> 800 to 1 000	-554	-417	-320	-294	-222	-170	-149	-112	-86	0		

* For $S_{v \max}$ and $S_{v \min}$ see section two — tables 15 and 116 of dimensions.

$$\tan 30^\circ = 0.577\ 35$$

$$\tan 37.5^\circ = 0.767\ 33$$

$$\tan 45^\circ = 1$$

Table 9 Tolerances for minor diameter — internal spline (D_{ii})
Tolerances for major diameter — external spline (D_{ee})

1 μm = 0.001 mm

Diameter $D_{ii \text{ min}}$ or $D_{ee \text{ max}}$ (mm)	Tolerances for D_{ii} , μm			Tolerances for D_{ee} , μm		
	for modules m			for modules m		
	0.25 to 0.75	1 to 1.75	2 to 10	0.25 to 0.75	1 to 1.75	2 to 10
	H10	H11	H12	h10	h11	h12
≤ 3	+40 0			0 -40		
> 3 to 6	+48 0	+75 0		0 -48	0 -75	
> 6 to 10	+58 0	+90 0		0 -58	0 -90	
> 10 to 18	+70 0	+110 0	+180 0	0 -70	0 -110	0 -180
> 18 to 30	+84 0	+130 0	+210 0	0 -84	0 -130	0 -210
> 30 to 50	+100 0	+160 0	+250 0	0 -100	0 -160	0 -250
> 50 to 80	+120 0	+190 0	+300 0	0 -120	0 -190	0 -300
> 80 to 120		+220 0	+350 0		0 -220	0 -350
> 120 to 180		+250 0	+400 0		0 -250	0 -400
> 180 to 250			+460 0			0 -460
> 250 to 315			+520 0			0 -520
> 315 to 400			+570 0			0 -570
> 400 to 500			+630 0			0 -630
> 500 to 630			+700 0			0 -700
> 630 to 800			+800 0			0 -800
> 800 to 1 000			+900 0			0 -900

Table 10 Minimum fillet radius of internal or external splines resulting from fillet radius of basic racks (see 7.5)

Module	Minimum radius, mm, for			
	$\alpha_D = 30^\circ$ (fig. 3)	$\alpha_D = 30^\circ$ (fig. 4)	$\alpha_D = 37.5^\circ$ (fig. 5)	$\alpha_D = 45^\circ$ (fig. 6)
m	$0.2m$	$0.4m$	$0.3m$	$0.25m$
10	2.00	4.00	3.00	
8	1.60	3.20	2.40	
6	1.20	2.40	1.80	
5	1.00	2.00	1.50	
4	0.80	1.60	1.20	
3	0.60	1.20	0.90	
2.5	0.50	1.00	0.75	0.62
2	0.40	0.80	0.60	0.50
1.75	0.35	0.70	0.52	0.44
1.5	0.30	0.60	0.45	0.38
1.25	0.25	0.50	0.38	0.31
1	0.20	0.40	0.30	0.25
0.75	0.15	0.30	0.22	0.19
0.5	0.10	0.20	0.15	0.12
0.25				0.06

9 Effect of spline variations

9.1 Index variations These variations cause looseness or interference from one set of mating tooth sides to another. Since the fit depends on the areas with minimum looseness or interference, index variations reduce the effective looseness or increase the effective interference.

9.2 Profile variations (see figure 7) Profile variations reduce contact area. Positive profile variations affect the fit by reducing effective looseness. Negative profile variations do not affect the effective looseness.

9.3 Lead variations The variations cause clearance variations and therefore reduce the effective looseness.

10 Effective and actual dimensions for splines

10.1 Effective and actual space width Figure 9 a) illustrates an internal spline with variations of index and profile. Figure 9 b) shows that a perfect external spline contour (without variations) does not fit, even though each tooth has the same width as the mating space. To allow the perfect external spline to fit in any position, all spaces of the internal spline must be widened by the amount of interference. This width, as shown in figure 9 c), is the actual space width of the internal spline. The effective space width is the tooth thickness of the perfect mating spline.

10.2 Effective and actual tooth thickness The same reasoning applied to the external spline leads to the concept of effective tooth thickness which exceeds the actual tooth thickness by the effective variation (see figure 10).

10.3 Effective clearance (looseness or interference) The effective space width of the internal spline minus the effective tooth thickness of the external spline is the effective clearance (looseness or interference), which defines the fit of mating parts. (This is strictly true only if high points — crests — of mating parts come into contact.) Positive effective clearance represents looseness or backlash; negative effective clearance represents tightness or interference.

10.4 Space width and tooth thickness limits The variations of the actual space width and actual tooth thickness within the machining tolerance cause corresponding variations of their effective dimensions. Thus, there are four limit dimensions for space width (minimum effective, maximum effective, minimum actual and maximum actual) and four limit dimensions for tooth thickness (maximum effective, minimum effective, maximum actual and minimum actual), as illustrated in figure 11.

10.4.1 The minimum effective space width ($E_{v \min}$), maximum effective tooth thickness ($S_{v \max}$), and minimum effective clearance ($c_{v \min}$) for the spline fit class H/h are as follows:

$$E_{v \min} = S_{v \max} = 0.5 \pi m (E_{\text{basic}} \text{ or } S_{\text{basic}})$$

$$c_{v \min} = 0 \text{ (no backlash).}$$

10.4.2 The maximum effective space width ($E_{v \max}$), minimum effective tooth thickness ($S_{v \min}$), and maximum effective clearance ($c_{v \max}$) for the spline fit class H/h are as follows:

$$E_{v \max} = 0.5 \pi m + T$$

$$S_{v \min} = 0.5 \pi m - T$$

$$c_{v \max} = 2 T$$

10.4.3 The minimum actual space width ($E_{\min}$), maximum actual tooth thickness ($S_{\max}$), and minimum theoretical clearance ($c_{\min}$) for spline fit class H/h are as follows:

$$E_{\min} = 0.5 \pi m + \lambda$$

$$S_{\max} = 0.5 \pi m - \lambda$$

$$c_{\min} = 2 \lambda$$

10.4.4 The maximum actual space width ($E_{\max}$), minimum actual tooth thickness ($S_{\min}$), and maximum theoretical clearance ($c_{\max}$) for spline fit class H/h are as follows:

$$E_{\max} = 0.5 \pi m + (T + \lambda)$$

$$S_{\min} = 0.5 \pi m - (T + \lambda)$$

$$c_{\max} = 2 (T + \lambda)$$

10.4.5 Where the external spline has a deviation allowance other than h, the above effective and theoretical values, c_v and c (in 10.4.1 to 10.4.4) must be modified by the amount of the quantity result from these deviation allowance (see table 7).

11 Use of effective and actual dimensions for space width and tooth thickness

11.1 Minimum effective space width and maximum effective tooth thickness These dimensions define the maximum material condition which ensures that the

splines will assemble. These dimensions shall be specified for all splines inspected by composite spline GO gauges controlling the minimum effective clearance ($c_{v \min}$).

11.2 Minimum actual space width and maximum actual tooth thickness These dimensions should be specified as auxiliary dimensions (AUX) and are not used for acceptance or rejection of parts inspected by composite spline GO gauges controlling the maximum material limit. If the measured actual space width is less than the auxiliary minimum actual space width, and the internal spline accepts the composite plug GO gauge, or if the measured actual tooth thickness is more than the auxiliary maximum actual tooth thickness, and the external spline accepts the composite ring GO gauge, the cumulative effect of the individual spline variation errors is less than the variation allowance λ ; such parts are acceptable because the maximum material condition has not been exceeded. The specification of these actual dimensions as auxiliary dimensions is desirable in order to control space width size and tooth thickness size.

The machining tolerance includes all variations of section. Any variation of section will affect tooth thickness and flank parallelism measurements.

11.3 Maximum actual space width and minimum actual tooth thickness These dimensions define the minimum material condition and shall be specified for all splines for acceptance or rejection of parts.

11.4 Maximum effective space width and minimum effective tooth thickness These dimensions define the maximum effective clearance for spline fit class H/h, but they do not limit the effective variation.

11.4.1 They may be used, in addition to the limits of 11.3, in order to prevent the increase of maximum effective clearance, due to reduction of effective variations. See figure 11, alternative method A. This method requires inspection by NOT GO composite gauges as well as GO composite gauges, which increases the gauging requirements. The notation "inspection optional" may be added where maximum effective clearance is an assembly requirement, but does not need absolute control. It will indicate, without necessarily adding inspection time and equipment, that in this case the actual space width of the internal spline must be held below the maximum, or the actual tooth thickness of the external spline above the minimum, if matching methods result in less than allowance variations.

11.4.2 Where spline variations require no control, alternative method B shown in figure 11 and shall be used. When alternative method B is used and it is necessary to control the spline variations by laboratory inspection, the following data shall be added to the spline specifications:

- a) total involute profile variation 0.0xx
positive variation within central
one-third of flank depth +0.0xx
- b) total index variation over any
sector of one-half circumference 0.0xx_{max}
- c) total lead variation,
 $g_\gamma = \text{xx.xx}$ 0.0xx

These values result from the formulae given in 8.3, 8.4 and 8.5

12 Drawing data It is important that uniform specifications be used to show complete information on detail drawings of splines. Much misunderstanding will be avoided by following the suggested arrangement of dimensions and data, as shown on data sheets (see Tables 11 to 14). The number of xs indicates the number of decimal places normally used. With this charted type of spline specifications, it is usually not necessary to give a graphical illustration of the spline teeth.

12.1 Spline data and basic dimensions Spline data are used for engineering and manufacturing purposes. Pitch and pressure angle are not subject to individual inspection. Basic dimensions are defined in 2.45.

12.2 Combinations of types

12.2.1 Flat root side fit internal splines may be used with fillet root external splines where the larger radius is desired on the external spline for control of stress concentrations. This combination of spline roots may also be permitted as a design option by specifying, for the minimum root diameter of the external spline, the value of the minimum root diameter of the fillet root external spline, and noting this as "optional root".

12.2.2 A design option may also be permitted to provide either flat root internal or fillet root internal by specifying, for the maximum major diameter, the value of the maximum major diameter of the fillet root internal spline and noting this as "optional root".

Note (concerning 12.2.1 and 12.2.2): The major diameter of a flat root internal spline and, if needed, the diameter at the tangence point of radius, should be placed between the form diameter and the maximum major diameter of the fillet root internal spline.

In all cases, the GO gauge should be accepted by the piece.

12.3 Designation The mating parts of straight cylindrical involute splines (metric module, side fit) are designated in the following order:

- a) Internal spline = INT
External spline = EXT
Mating splines = INT/EXT
- b) Number of teeth = z (preceded by the number)
- c) Module = m (preceded by the value)
- d) Pressure angle = 30° flat root = 30 P
Pressure angle = 30° fillet root = 30 R
Pressure angle = 37.5° = 37.5
Pressure angle 45° = 45
- e) Tolerance classes = 4, 5, 6 or 7
- f) Fit class, internal spline = H
Fit classes, external spline = k, js, h, f, e or d
- g) **JIS B 1603**

Example : Mating splines, 24 teeth, module 2.5, pressure angle 30° fillet root, tolerance class 5, fit H/f

Mating: INT/EXT 24z × 2.5 m × 30R × 5H/5f **JIS B 1603**

Internal spline: INT 24z × 2.5 m × 30R × 5H **JIS B 1603**

External spline: EXT 24z × 2.5 m × 30R × 5f **JIS B 1603**

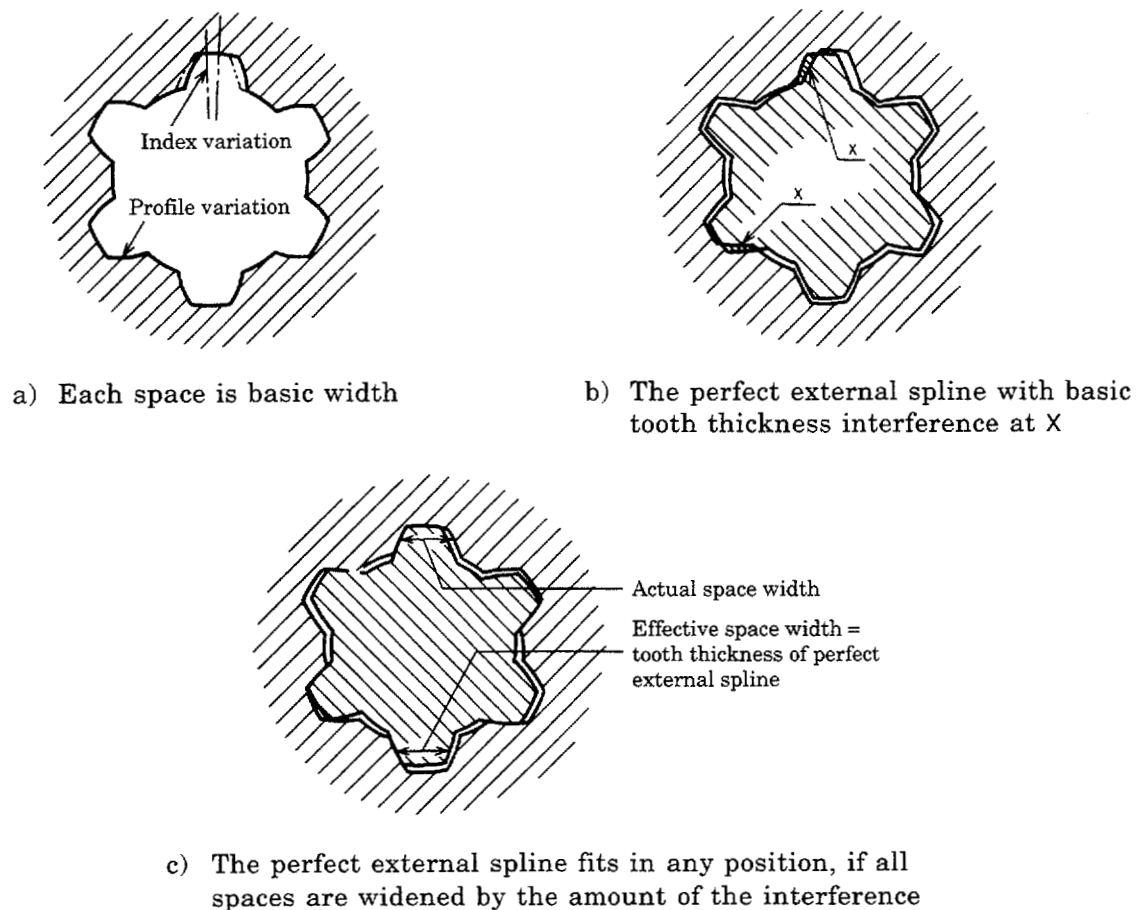
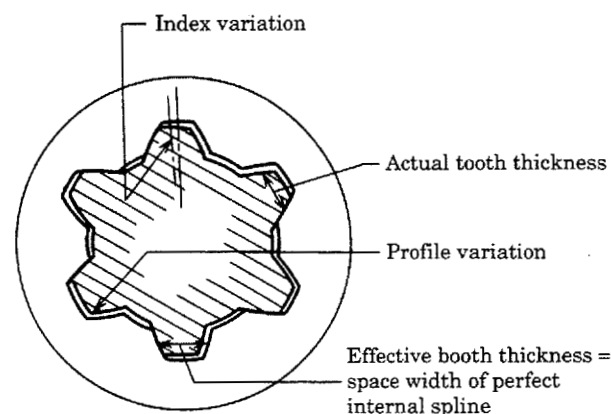
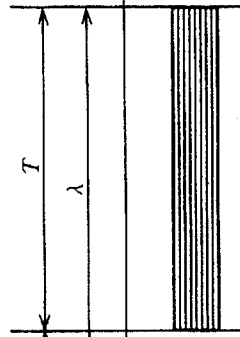
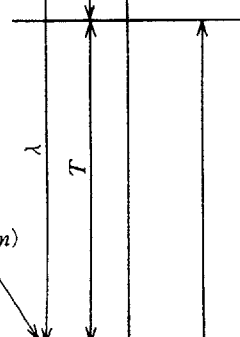
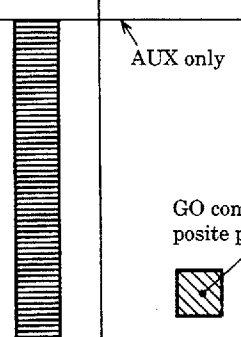
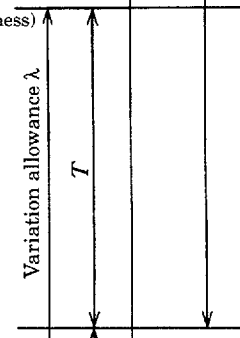
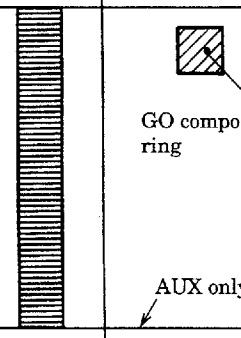
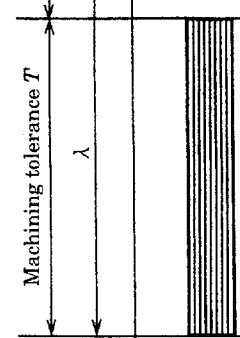
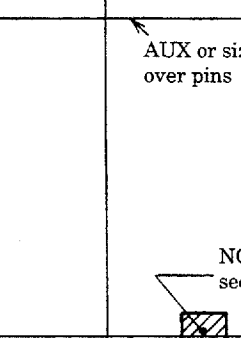


Figure 9 Effect of variations on internal spline



The perfect internal spline fits in any position, if all teeth of the external spline are narrowed by the amount of the interference

Figure 10 Effect of variations on external spline

	Piece		Inspection		
	actual	effective	Standard method	Alternative A	Alternative B
$E_{\max}$ (actual space width)			Size between pins 		AUX only
$E_{\min}$			AUX or size between pins	AUX only	AUX only
$E_{v \max}$			AUX only	NOT GO composite plug 	NOT GO composite plug 
$E_{\text{basic}} (0.5 \pi m)$ or S_{basic}			GO composite plug 	GO composite plug 	GO composite plug 
$E_{v \min}$ (effective space width)					
$S_{v \max}$ (effective tooth thickness)					
Variation allowance λ			GO composite ring 	GO composite ring 	GO composite ring 
$S_{v \min}$			AUX only	NOT GO composite ring 	NOT GO composite ring 
$S_{\max}$			AUX or sizes over pins	AUX only	AUX only
Machining tolerance T					
$S_{\min}$ (actual tooth thickness)			NOT GO sector ring 		AUX only
			Size over pins		

Informative reference : E , S , T and λ are dependent on their tolerance classes.

Figure 11 Specification guide for space width and tooth thickness for splines

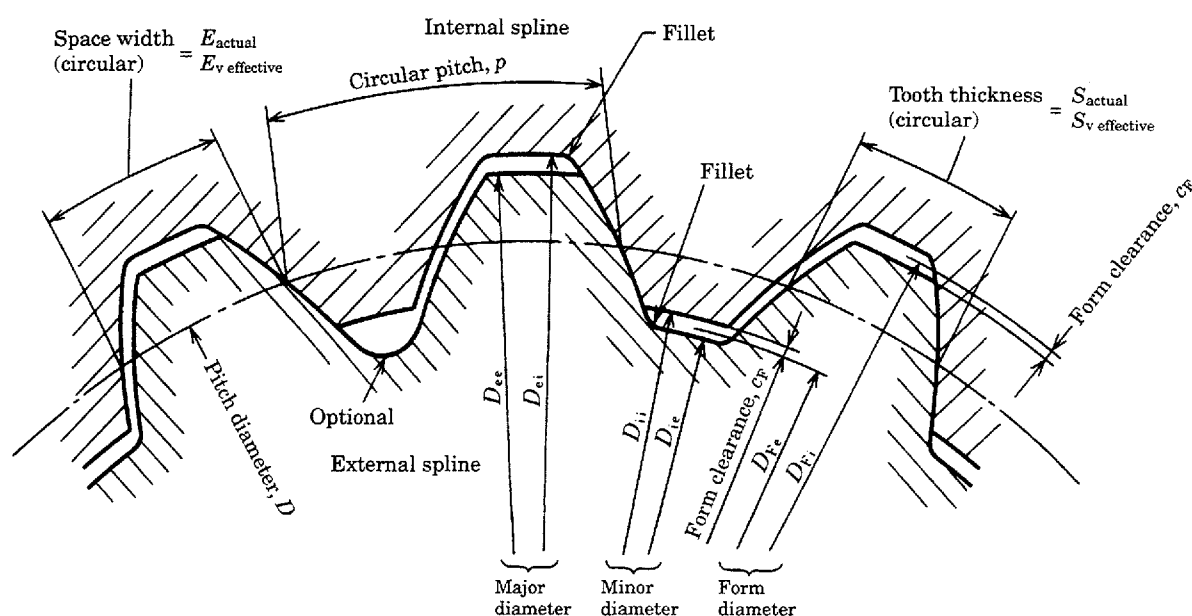


Figure 12 Flat root spline — Pressure angle $\alpha_D = 30^\circ$ — Modules 0.5 to 10

Table 11 Spline terms, symbols and drawing data, 30° pressure angle, flat root side fit

Internal spline			External spline		
Number of teeth	z	...	Number of teeth	z	...
Module	m	...	Module	m	...
Pressure angle	α_D	30°	Pressure angle	α_D	30°
Base diameter	D_b	xx.xxxx (Ref)*	Base diameter	D_b	xx.xxxx (Ref)*
Pitch diameter	D	xx.xxxx (Ref)*	Pitch diameter	D	xx.xxxx (Ref)*
Major diameter	D_{ei}	$\begin{cases} \text{xx.xx}_{\max} \\ \text{xx.xx}_{\min} \end{cases}$	Major diameter	D_{ee}	xx.xx - tol. h...
Form diameter	D_{Fi}	$\text{xx.xx}_{\min}$	Form diameter	D_{Fe}	$\text{xx.xx}_{\max}$
Minor diameter	D_{ii}	$\text{xx.xx} + \text{tol. H}...$	Minor diameter	D_{ie}	$\begin{cases} \text{xx.xx}_{\min} \\ \text{xx.xx}_{\max} \end{cases}$
Base pitch	P_b	xx.xxxx	Base pitch	P_b	xx.xxxx
Circular space width			Circular tooth thickness		
max. actual	$E_{\max}$	xx.xxx	max. effective	$S_{v \max}$	xx.xxx
min. actual	$E_{\min}$	xx.xxx (Ref)*	min. effective	$S_{v \min}$	xx.xxx
max. effective	$E_{v \max}$	xx.xxx	max. actual	$S_{\max}$	xx.xxx (Ref)*
min. effective	$E_{v \min}$	xx.xxx	min. actual	$S_{\min}$	xx.xxx
Measurement between pins	M_{Ri}	xx.xxx - xx.xxx	Measurement over pins	M_{Re}	xx.xxx - xx.xxx
Pin diameter	D_{Ri}	x.xxx	Pin diameter	D_{Re}	xx.xxx
Fillet radius	see table 10		Fillet radius	see table 10	

* Non measurable or values measurable with difficulty used for determination of dimensions to be controlled.

Remarks : The above drawing data are required for the spline specifications. The standard system is shown; for control alternatives and combinations of types, see 11.4 and 12.2. This fit is used in restricted areas (as with tubular parts with wall thickness too small to permit use of fillet roots, and to allow hobbing closer to shoulders, etc.) and for economy (when hobbing, shaping, etc. and shorter broaches for the internal member). See section two, tables 16 to 43.

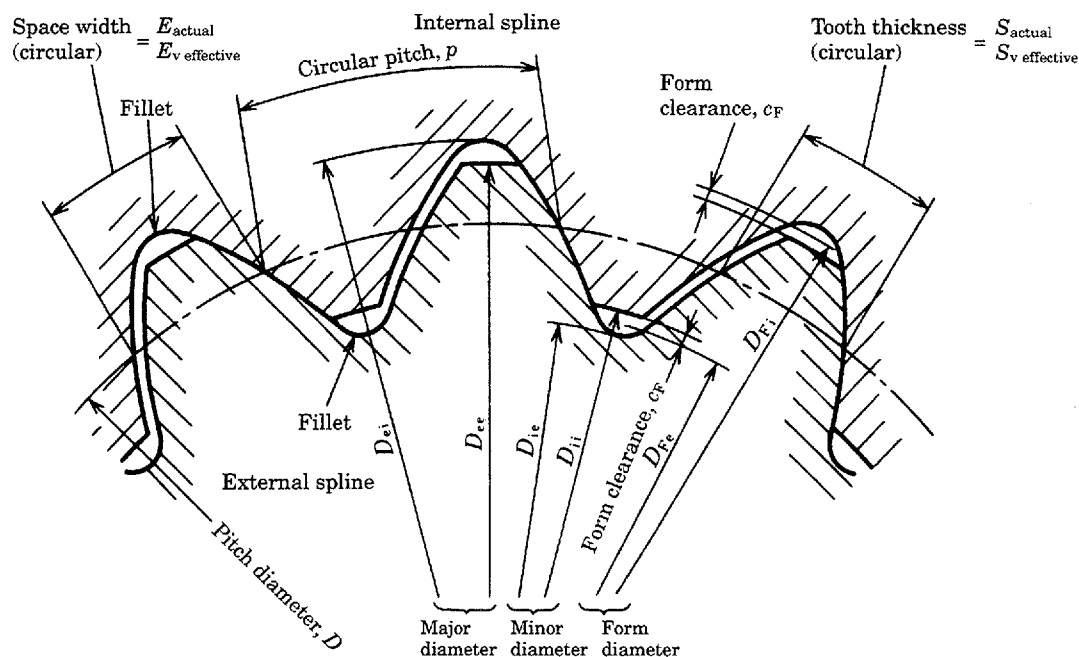


Figure 13 Fillet root spline — Pressure angle $\alpha_D = 30^\circ$ — Modules 0.5 to 10

Table 12 Spline terms, symbols and drawing data, 30° pressure angle, fillet root side fit

Internal spline			External spline		
Number of teeth	z	...	Number of teeth	z	...
Module	m	...	Module	m	...
Pressure angle	α_D	30°	Pressure angle	α_D	30°
Base diameter	D_b	xx.xxxx (Ref)*	Base diameter	D_b	xx.xxxx (Ref)*
Pitch diameter	D	xx.xxxx (Ref)*	Pitch diameter	D	xx.xxxx (Ref)*
Major diameter	D_{ei}	$\begin{cases} \text{xx.xx}_{\text{max}} \\ \text{xx.xx}_{\text{min}} \end{cases}$	Major diameter	D_{ee}	xx.xx - tol. h...
Form diameter	D_{Fi}	xx.xx _{min}	Form diameter	D_{Fe}	xx.xx _{max}
Minor diameter	D_{ii}	xx.xx + tol. H...	Minor diameter	D_{ie}	$\begin{cases} \text{xx.xx}_{\text{min}} \\ \text{xx.xx}_{\text{max}} \end{cases}$
Base pitch	P_b	xx.xxxx	Base pitch	P_b	xx.xxxx
Circular space width			Circular tooth thickness		
max. actual	E_{max}	xx.xxx	max. effective	$S_{v \text{ max}}$	xx.xxx
min. actual	E_{min}	xx.xxx (Ref)*	min. effective	$S_{v \text{ min}}$	xx.xxx
max. effective	$E_{v \text{ max}}$	xx.xxx	max. actual	S_{max}	xx.xxx (Ref)*
min. effective	$E_{v \text{ min}}$	xx.xxx	min. actual	S_{min}	xx.xxx
Measurement between pins	M_{Ri}	xx.xxx - xx.xxx	Measurement over pins	M_{Re}	xx.xxx - xx.xxx
Pin diameter	D_{Ri}	x.xxx	Pin diameter	D_{Re}	xx.xxx
Fillet radius	see table 10		Fillet radius	see table 10	

* Non measurable or values measurable with difficulty used for determination of dimensions to be controlled.

Remarks : The above drawing data are required for the spline specifications. The standard system is shown; for control alternatives and combinations of types, see 11.4 and 12.2. The fillet radius permits heavier loading and effects greater fatigue resistance than flat roots, through absence of stress raisers. See section two, tables 44 to 71.

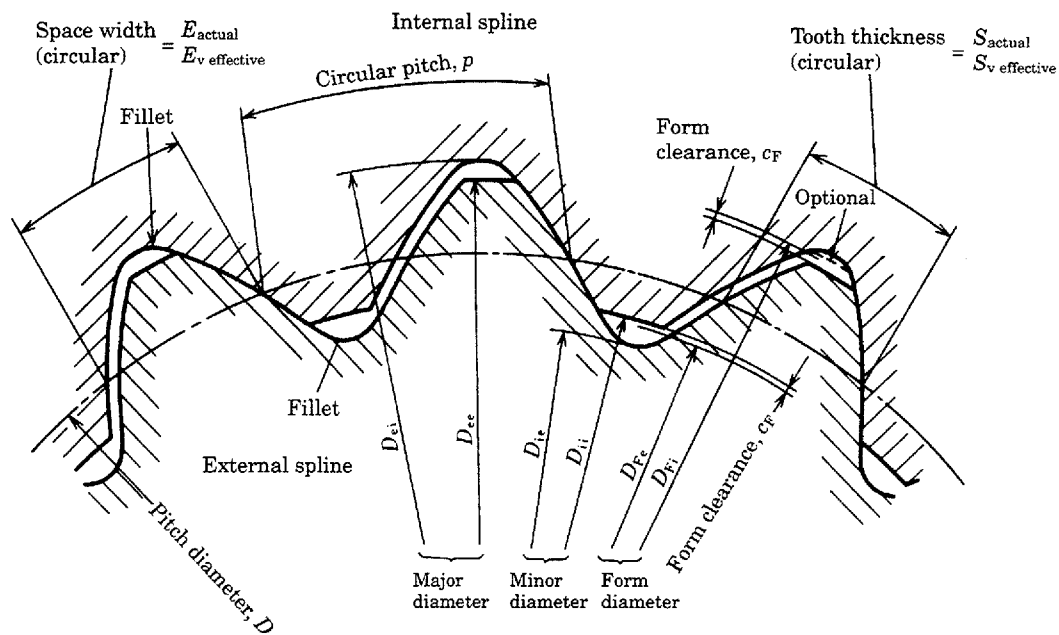


Figure 14 Fillet root spline — Pressure angle $\alpha_D = 37.5^\circ$ — Modules 0.5 to 10

Table 13 Spline terms, symbols and drawing data, 37.5° pressure angle, fillet root side fit

Internal spline			External spline		
Number of teeth	z	...	Number of teeth	z	...
Module	m	...	Module	m	...
Pressure angle	α_D	37.5°	Pressure angle	α_D	37.5°
Base diameter	D_b	xx.xxxx (Ref)*	Base diameter	D_b	xx.xxxx (Ref)*
Pitch diameter	D	xx.xxxx (Ref)*	Pitch diameter	D	xx.xxxx (Ref)*
Major diameter	D_{ei}	$\begin{cases} \text{xx.xx}_{\text{max}} \\ \text{xx.xx}_{\text{min}} \end{cases}$	Major diameter	D_{ee}	xx.xx - tol. h...
Form diameter	D_{Fi}	$\text{xx.xx}_{\text{min}}$	Form diameter	D_{Fe}	$\text{xx.xx}_{\text{max}}$
Minor diameter	D_{ii}	$\text{xx.xx} + \text{tol. H}...$	Minor diameter	D_{ie}	$\begin{cases} \text{xx.xx}_{\text{min}} \\ \text{xx.xx}_{\text{max}} \end{cases}$
Base pitch	P_b	xx.xxxx	Base pitch	P_b	xx.xxxx
Circular space width			Circular tooth thickness		
max. actual	E_{max}	xx.xxx	max. effective	$S_{v \text{ max}}$	xx.xxx
min. actual	E_{min}	xx.xxx (Ref)*	min. effective	$S_{v \text{ min}}$	xx.xxx
max. effective	$E_{v \text{ max}}$	xx.xxx	max. actual	S_{max}	xx.xxx (Ref)*
min. effective	$E_{v \text{ min}}$	xx.xxx	min. actual	S_{min}	xx.xxx
Measurement between pins	M_{Ri}	xx.xxx - xx.xxx	Measurement over pins	M_{Re}	xx.xxx - xx.xxx
Pin diameter	D_{Ri}	x.xxx	Pin diameter	D_{Re}	xx.xxx
Fillet radius	see table 10		Fillet radius	see table 10	

* Non measurable or values measurable with difficulty used for determination of dimensions to be controlled.

Remarks : The above drawing data are required for the spline specifications. The standard system is shown; for control alternatives and combinations of types, see 11.4 and 12.2. The pressure angle proportions of this spline are a direct compromise of the 30° and 45° pressure angle splines. It is often used on couplings where the external spline is to be cold formed, especially where a 45° pressure angle spline will not satisfy functional requirements and the shaft material is above the hardness limitation of 30° pressure angle cold-forming tools. See section two, tables 72 and 73.

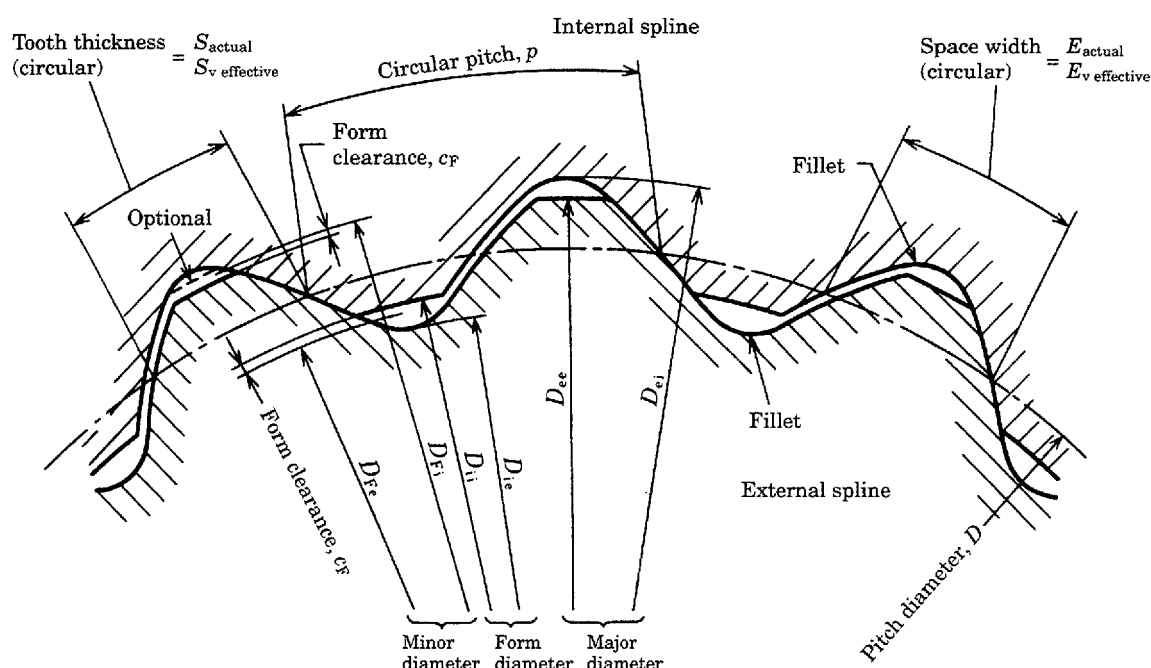


Figure 15 Fillet root spline — Pressure angle $\alpha_D = 45^\circ$ — Modules 0.25 to 2.5

Table 14 Spline terms, symbols and drawing data, 45° pressure angle, fillet root side fit

Internal spline			External spline		
Number of teeth	z	...	Number of teeth	z	...
Module	m	...	Module	m	...
Pressure angle	α_D	45°	Pressure angle	α_D	45°
Base diameter	D_b	xx.xxxx (Ref)*	Base diameter	D_b	xx.xxxx (Ref)*
Pitch diameter	D	xx.xxxx (Ref)*	Pitch diameter	D	xx.xxxx (Ref)*
Major diameter	D_{ei}	$\begin{cases} \text{xx.xx}_{\text{max}} \\ \text{xx.xx}_{\text{min}} \end{cases}$	Major diameter	D_{ee}	xx.xx - tol. h...
Form diameter	D_{Fi}	xx.xx _{min}	Form diameter	D_{Fe}	xx.xx _{max}
Minor diameter	D_{ii}	xx.xx + tol. H...	Minor diameter	D_{ie}	$\begin{cases} \text{xx.xx}_{\text{min}} \\ \text{xx.xx}_{\text{max}} \end{cases}$
Base pitch	P_b	xx.xxxx	Base pitch	P_b	xx.xxxx
Circular space width			Circular tooth thickness		
max. actual	E_{max}	xx.xxx	max. effective	$S_{v \text{ max}}$	xx.xxx
min. actual	E_{min}	xx.xxx (Ref)*	min. effective	$S_{v \text{ min}}$	xx.xxx
max. effective	$E_{v \text{ max}}$	xx.xxx	max. actual	S_{max}	xx.xxx (Ref)*
min. effective	$E_{v \text{ min}}$	xx.xxx	min. actual	S_{min}	xx.xxx
Measurement between pins	M_{Ri}	xx.xxx - xx.xxx	Measurement over pins	M_{Re}	xx.xxx - xx.xxx
Pin diameter	D_{Ri}	x.xxx	Pin diameter	D_{Re}	xx.xxx
Fillet radius	see table 10		Fillet radius	see table 10	

* Non measurable or values measurable with difficulty used for determination of dimensions to be controlled.

Remarks : The above drawing data are required for the spline specifications. The standard system is shown; for control alternatives and combinations of types, see 11.4 and 12.2. Involute splines with 45° pressure angle are used where the toothed member delivers torque only (does not slide under load) and where wall thicknesses are great enough to resist bursting tendencies. The 45° pressure angle spline is highly suitable for cold forming. See section two, tables 100 to 117.

Section two : Dimensions

13 Introduction The spline tables in this section are based on spline fit class H/h, which gives a minimum effective clearance equal to zero. Selection of a spline fit class having a different deviation allowance requires adjustment to the external spline dimensions (see section one, sub-clause 8.7.2.2).

Tables 15 to 70 give dimensions for 30° pressure angle flat root side fit and fillet root side fit splines for tolerance classes 4, 5, 6 and 7 for spline fit class H/h. Tables 71 to 98 give dimensions for 37.5° pressure angle fillet root side fit splines for tolerance classes 4, 5, 6 and 7 for spline fit class H/h. Tables 99 to 116 give dimensions for 45° pressure angle fillet root side fit splines for tolerance classes 4, 5, 6 and 7 for spline fit class H/h.

14 Dimensions and tolerances The dimensions and tolerances listed in the tables in this section are derived from the formulae listed in table 2 of section one. Space width and tooth thickness tolerances are based on formulae given in clause 6 and sub-clauses 8.1 and 8.2 of section one.

Table 15 Internal spline

30 degree pressure angle — Side fit — Flat root — Module = 10.00

$E_{v \min}$ = minimum effective space width, circular = 5.708

Number of teeth z	Pitch diameter D	Base diameter D_b	Major diameter (max.) D_{e1}	Form diameter (min.) D_{F1}	Minor diameter (min.) D_{i1}	Actual max. space width, circular $E_{\max} = E_{v \min} + (T + \lambda)$			
						4H	5H	6H	7H
6	60.0000	51.5615	75.44	72.00	54.31	15.772	15.810	15.868	15.964
7	70.0000	60.6218	85.45	82.00	63.61	15.773	15.812	15.870	15.968
8	80.0000	69.2820	95.46	92.00	73.11	15.774	15.813	15.873	15.972
9	90.0000	77.9423	105.46	102.00	82.72	15.775	15.815	15.875	15.975
10	100.0000	86.6025	115.47	112.00	92.42	15.776	15.816	15.877	15.978
11	110.0000	95.2628	125.47	122.00	102.18	15.776	15.817	15.879	15.981
12	120.0000	103.9231	135.48	132.00	111.99	15.777	15.819	15.881	15.984
13	130.0000	112.5833	145.48	142.00	121.82	15.778	15.820	15.882	15.987
14	140.0000	121.2436	155.49	152.00	131.68	15.778	15.821	15.884	15.990
15	150.0000	129.9038	165.49	162.00	141.56	15.779	15.822	15.886	15.992
16	160.0000	138.5641	175.50	172.00	151.45	15.780	15.823	15.887	15.995
17	170.0000	147.2243	185.50	182.00	161.36	15.780	15.824	15.889	15.997
18	180.0000	155.8846	195.51	192.00	171.28	15.781	15.825	15.890	16.000
19	190.0000	164.5448	205.51	202.00	181.21	15.781	15.826	15.892	16.002
20	200.0000	173.2051	215.51	212.00	191.15	15.782	15.826	15.893	16.004
21	210.0000	181.8653	225.52	222.00	201.09	15.783	15.827	15.894	16.006
22	220.0000	190.5256	235.52	232.00	211.04	15.783	15.828	15.896	16.008
23	230.0000	199.1859	245.52	242.00	220.99	15.784	15.829	15.897	16.010
24	240.0000	207.8461	255.53	252.00	230.95	15.784	15.830	15.898	16.012
25	250.0000	216.5064	265.53	262.00	240.91	15.785	15.830	15.899	16.014
26	260.0000	225.1666	275.53	272.00	250.87	15.785	15.831	15.901	16.016
27	270.0000	233.8269	285.54	282.00	260.84	15.785	15.832	15.902	16.018
28	280.0000	242.4871	295.54	292.00	270.80	15.786	15.833	15.903	16.020
29	290.0000	251.1474	305.54	302.00	280.78	15.786	15.833	15.904	16.022
30	300.0000	259.8076	315.55	312.00	290.75	15.787	15.834	15.905	16.023
31	310.0000	268.4679	325.55	322.00	300.72	15.787	15.835	15.906	16.025
32	320.0000	277.1281	335.55	332.00	310.70	15.788	15.835	15.907	16.027
33	330.0000	285.7884	345.55	342.00	320.68	15.788	15.836	15.908	16.028
34	340.0000	294.4487	355.56	352.00	330.66	15.788	15.837	15.909	16.030
35	350.0000	303.1089	365.56	362.00	340.64	15.789	15.837	15.910	16.032
36	360.0000	311.7692	375.56	372.00	350.62	15.789	15.838	15.911	16.033
37	370.0000	320.4294	385.57	382.00	360.60	15.790	15.839	15.912	16.035
38	380.0000	329.0897	395.57	392.00	370.59	15.790	15.839	15.913	16.036
39	390.0000	337.7499	405.57	402.00	380.57	15.791	15.840	15.914	16.038
40	400.0000	346.4102	415.57	412.00	390.56	15.791	15.841	15.915	16.039
41	410.0000	355.0704	425.58	422.00	400.54	15.791	15.841	15.916	16.041
42	420.0000	363.7307	435.58	432.00	410.53	15.792	15.842	15.917	16.042
43	430.0000	372.3909	445.58	442.00	420.52	15.792	15.842	15.918	16.044
44	440.0000	381.0512	455.58	452.00	430.50	15.792	15.843	15.919	16.045
45	450.0000	389.7115	465.59	462.00	440.49	15.793	15.843	15.920	16.047
46	460.0000	398.3717	475.59	472.00	450.48	15.793	15.844	15.921	16.048
47	470.0000	407.0320	485.59	482.00	460.47	15.793	15.845	15.921	16.050
48	480.0000	415.6922	495.59	492.00	470.46	15.794	15.845	15.922	16.051
49	490.0000	424.3525	505.60	502.00	480.45	15.794	15.846	15.923	16.052
50	500.0000	433.0127	515.60	512.00	490.44	15.794	15.846	15.924	16.054
51	510.0000	441.6730	525.60	522.00	500.43	15.795	15.847	15.926	16.056
52	520.0000	450.3332	535.61	532.00	510.43	15.795	15.848	15.927	16.058
53	530.0000	458.9935	545.61	542.00	520.42	15.796	15.849	15.928	16.060
54	540.0000	467.6537	555.61	552.00	530.41	15.796	15.849	15.929	16.061
55	550.0000	476.3140	565.61	562.00	540.40	15.797	15.850	15.930	16.063
56	560.0000	484.9743	575.62	572.00	550.39	15.797	15.851	15.931	16.064
57	570.0000	493.6345	585.62	582.00	560.39	15.797	15.851	15.932	16.066
58	580.0000	502.2948	595.62	592.00	570.38	15.798	15.852	15.933	16.068
59	590.0000	510.9550	605.63	602.00	580.37	15.798	15.852	15.934	16.069
60	600.0000	519.6153	615.63	612.00	590.37	15.799	15.853	15.935	16.071
61	610.0000	528.2755	625.63	622.00	600.36	15.799	15.854	15.936	16.072
62	620.0000	536.9358	635.63	632.00	610.36	15.799	15.854	15.937	16.074
63	630.0000	545.5960	645.64	642.00	620.35	15.800	15.855	15.938	16.076
64	640.0000	554.2563	655.64	652.00	630.34	15.800	15.856	15.939	16.077
65	650.0000	562.9165	665.64	662.00	640.34	15.801	15.856	15.940	16.079
66	660.0000	571.5768	675.65	672.00	650.33	15.801	15.857	15.941	16.080
67	670.0000	580.2371	685.65	682.00	660.33	15.801	15.858	15.942	16.082
68	680.0000	588.8973	695.65	692.00	670.32	15.802	15.858	15.943	16.084
69	690.0000	597.5576	705.65	702.00	680.32	15.802	15.859	15.944	16.085
70	700.0000	606.2178	715.66	712.00	690.31	15.803	15.859	15.945	16.087
71	710.0000	614.8781	725.66	722.00	700.31	15.803	15.860	15.946	16.088
72	720.0000	623.5383	735.66	732.00	710.31	15.803	15.861	15.947	16.090
73	730.0000	632.1986	745.66	742.00	720.30	15.804	15.861	15.948	16.092
74	740.0000	640.8588	755.67	752.00	730.30	15.804	15.862	15.949	16.093
75	750.0000	649.5191	765.67	762.00	740.29	15.805	15.863	15.950	16.095
76	760.0000	658.1793	775.67	772.00	750.29	15.805	15.863	15.951	16.096
77	770.0000	666.8396	785.68	782.00	760.28	15.805	15.864	15.952	16.098
78	780.0000	675.4999	795.68	792.00	770.28	15.806	15.865	15.953	16.100
79	790.0000	684.1601	805.68	802.00	780.28	15.806	15.866	15.954	16.101
80	800.0000	692.8204	815.68	812.00	790.27	15.807	15.866	15.955	16.103
81	810.0000	701.4806	825.69	822.00	800.27	15.807	15.867	15.956	16.104
82	820.0000	710.1409	835.69	832.00	810.27	15.807	15.867	15.957	16.106
83	830.0000	718.8011	845.69	842.00	820.26	15.808	15.868	15.958	16.108
84	840.0000	727.4614	855.69	852.00	830.26	15.808	15.868	15.959	16.109
85	850.0000	736.1216	865.70	862.00	840.26	15.809	15.869	15.960	16.111
86	860.0000	744.7819	875.70	872.00	850.25	15.809	15.870	15.961	16.112
87	870.0000	753.4421	885.70	882.00	860.25	15.809	15.870	15.962	16.114
88	880.0000	762.1024	895.71	892.00	870.25	15.810	15.871	15.963	16.116
89	890.0000	770.7627	905.71	902.00	880.25	15.810	15.872	15.964	16.117
90	900.0000	779.4229	915.71	912.00	890.24	15.811	15.872	15.965	16.119
91	910.0000	788.0832	925.71	922.00	900.24	15.811	15.873	15.966	16.120
92	920.0000	796.7434	935.72	932.00	910.24	15.811	15.874	15.967	16.122
93	930.0000	805.4037	945.72	942.00	920.24	15.812	15.874	15.968	16.124
94	940.0000	814.0639	955.72	952.00	930.23	15.812	15.875	15.969	16.125
95	950.0000	822.7242	965.73	962.00	940.23	15.813	15.875	15.970	16.127
96	960.0000	831.3844	975.73	972.00	950.23	15.813	15.876	15.971	16.128
97	970.0000	840.0447	985.73	982.00	960.23	15.813	15.877	15.972	16.130
98	980.0000	848.7049	995.73	992.00	970.22	15.814	15.877	15.973	16.132
99	990.0000	857.3652	1005.74	1002.00	980.22	15.814	15.878	15.974	16.133
100	1000.0000	866.0255	1015.74	1012.00	990.22	15.815	15.879	15.975	16.135

Table 16 External spline

30 degree pressure angle — Side fit — Flat root — Module = 10.00

 $S_{v \max}$ = maximum effective tooth thickness, circular = 15.708

Number of teeth z	Pitch diameter D	Base diameter D_b	Major diameter (max.) D_{ee}	Form diameter (max.) D_{Fe}	Minor diameter (min.) D_{ie}	Actual min. tooth thickness, circular $S_{\min} = S_{v \max} - (T + \lambda)$			
						$5h$	$6h$	$7h$	
6	60.0000	51.9615	70.00	52.31	44.56	15.644	15.666	15.548	15.452
7	70.0000	60.6218	80.00	61.61	54.22	15.643	15.666	15.548	15.448
8	80.0000	69.2820	90.00	71.11	64.54	15.642	15.666	15.548	15.444
9	90.0000	77.9423	100.00	80.42	74.54	15.641	15.666	15.548	15.441
10	100.0000	86.6025	110.00	90.42	84.53	15.640	15.666	15.548	15.438
11	110.0000	95.2628	120.00	100.18	94.53	15.640	15.599	15.537	15.434
12	120.0000	103.9231	130.00	109.98	104.52	15.639	15.597	15.535	15.432
13	130.0000	112.5833	140.00	119.82	114.49	15.639	15.596	15.533	15.429
14	140.0000	121.2436	150.00	129.68	124.51	15.637	15.595	15.532	15.426
15	150.0000	129.9038	160.00	139.56	134.51	15.637	15.594	15.530	15.423
16	160.0000	138.5641	170.00	149.45	144.50	15.636	15.593	15.529	15.421
17	170.0000	147.2243	180.00	159.36	154.50	15.636	15.592	15.527	15.419
18	180.0000	155.8844	190.00	169.28	164.49	15.635	15.591	15.526	15.416
19	190.0000	164.5448	200.00	179.21	174.49	15.634	15.590	15.524	15.414
20	200.0000	173.2051	210.00	189.15	184.49	15.634	15.590	15.523	15.412
21	210.0000	181.8653	220.00	199.09	194.48	15.633	15.589	15.522	15.410
22	220.0000	190.5256	230.00	209.04	204.48	15.632	15.588	15.521	15.408
23	230.0000	199.1859	240.00	218.99	214.48	15.632	15.587	15.519	15.406
24	240.0000	207.8461	250.00	228.95	224.47	15.632	15.586	15.518	15.404
25	250.0000	216.5064	260.00	238.91	234.47	15.631	15.585	15.517	15.402
26	260.0000	225.1666	270.00	248.87	244.47	15.631	15.585	15.515	15.400
27	270.0000	233.8269	280.00	258.84	254.46	15.630	15.584	15.513	15.398
28	280.0000	242.4871	290.00	268.81	264.46	15.630	15.583	15.512	15.396
29	290.0000	251.1474	300.00	278.78	274.46	15.629	15.583	15.511	15.394
30	300.0000	259.8076	310.00	288.75	284.45	15.629	15.582	15.510	15.393
31	310.0000	268.4679	320.00	298.72	294.45	15.629	15.581	15.509	15.391
32	320.0000	277.1281	330.00	308.70	304.45	15.628	15.580	15.508	15.389
33	330.0000	285.7884	340.00	318.68	314.44	15.627	15.579	15.507	15.388
34	340.0000	294.4487	350.00	328.66	324.44	15.627	15.578	15.506	15.386
35	350.0000	303.1089	360.00	338.64	334.44	15.627	15.578	15.505	15.384
36	360.0000	311.7692	370.00	348.62	344.44	15.627	15.578	15.504	15.383
37	370.0000	320.4294	380.00	358.60	354.43	15.626	15.577	15.503	15.381
38	380.0000	329.0897	390.00	368.58	364.43	15.626	15.576	15.502	15.380
39	390.0000	337.7499	400.00	378.57	374.43	15.625	15.576	15.501	15.378
40	400.0000	346.4102	410.00	388.56	384.43	15.625	15.575	15.500	15.377
41	410.0000	355.0704	420.00	398.54	394.42	15.625	15.575	15.499	15.375
42	420.0000	363.7307	430.00	408.53	404.42	15.624	15.574	15.498	15.374
43	430.0000	372.3909	440.00	418.52	414.42	15.624	15.574	15.497	15.372
44	440.0000	381.0512	450.00	428.50	424.42	15.624	15.573	15.496	15.371
45	450.0000	389.7115	460.00	438.49	434.41	15.623	15.572	15.495	15.369
46	460.0000	398.3717	470.00	448.48	444.41	15.623	15.572	15.494	15.368
47	470.0000	407.0320	480.00	458.47	454.41	15.622	15.571	15.493	15.366
48	480.0000	415.6922	490.00	468.46	464.41	15.622	15.571	15.492	15.365
49	490.0000	424.3525	500.00	478.45	474.40	15.622	15.570	15.491	15.364
50	500.0000	433.0127	510.00	488.44	484.40	15.622	15.570	15.490	15.362
51	510.0000	441.6730	520.00	498.43	494.40	15.621	15.569	15.489	15.360
52	520.0000	450.3332	530.00	508.42	504.39	15.621	15.568	15.488	15.358
53	530.0000	458.9935	540.00	518.41	514.39	15.620	15.567	15.487	15.356
54	540.0000	467.6537	550.00	528.40	524.39	15.619	15.566	15.486	15.355
55	550.0000	476.3140	560.00	538.40	534.39	15.619	15.566	15.485	15.353
56	560.0000	484.9743	570.00	548.39	544.38	15.619	15.565	15.484	15.352
57	570.0000	493.6345	580.00	558.38	554.38	15.618	15.564	15.483	15.350
58	580.0000	502.2948	590.00	568.37	564.37	15.618	15.563	15.482	15.348
59	590.0000	510.9550	600.00	578.37	574.37	15.617	15.563	15.481	15.347
60	600.0000	519.6153	610.00	588.37	584.37	15.617	15.563	15.481	15.345
61	610.0000	528.2755	620.00	598.36	594.37	15.617	15.562	15.480	15.344
62	620.0000	536.9358	630.00	608.36	604.37	15.616	15.562	15.479	15.342
63	630.0000	545.5960	640.00	618.35	614.36	15.616	15.561	15.478	15.340
64	640.0000	554.2563	650.00	628.34	624.36	15.616	15.560	15.477	15.339
65	650.0000	562.9165	660.00	638.34	634.36	15.615	15.560	15.476	15.337
66	660.0000	571.5768	670.00	648.33	644.35	15.615	15.559	15.475	15.336
67	670.0000	580.2371	680.00	658.33	654.35	15.614	15.558	15.474	15.334
68	680.0000	588.8973	690.00	668.32	664.35	15.614	15.558	15.473	15.332
69	690.0000	597.5576	700.00	678.32	674.35	15.613	15.557	15.472	15.331
70	700.0000	606.2178	710.00	688.31	684.34	15.613	15.556	15.471	15.329
71	710.0000	614.8781	720.00	698.31	694.34	15.612	15.556	15.470	15.328
72	720.0000	623.5383	730.00	708.31	704.34	15.612	15.555	15.469	15.326
73	730.0000	632.1986	740.00	718.30	714.34	15.612	15.555	15.468	15.324
74	740.0000	640.8588	750.00	728.30	724.33	15.612	15.554	15.467	15.323
75	750.0000	649.5191	760.00	738.29	734.33	15.611	15.553	15.466	15.321
76	760.0000	658.1793	770.00	748.29	744.33	15.611	15.553	15.465	15.320
77	770.0000	666.8396	780.00	758.28	754.32	15.610	15.552	15.464	15.318
78	780.0000	675.4999	790.00	768.28	764.32	15.610	15.551	15.463	15.316
79	790.0000	684.1601	800.00	778.28	774.32	15.610	15.551	15.462	15.315
80	800.0000	692.8204	810.00	788.27	784.32	15.609	15.550	15.461	15.313
81	810.0000	701.4806	820.00	798.27	794.31	15.609	15.549	15.460	15.312
82	820.0000	710.1409	830.00	808.27	804.31	15.608	15.549	15.459	15.310
83	830.0000	718.8011	840.00	818.26	814.31	15.608	15.548	15.458	15.308
84	840.0000	727.4614	850.00	828.26	824.31	15.608	15.547	15.457	15.307
85	850.0000	736.1216	860.00	838.26	834.30	15.607	15.547	15.456	15.305
86	860.0000	744.7819	870.00	848.25	844.30	15.607	15.546	15.455	15.304
87	870.0000	753.4421	880.00	858.25	854.30	15.606	15.546	15.454	15.302
88	880.0000	762.1024	890.00	868.25	864.29	15.606	15.545	15.453	15.300
89	890.0000	770.7627	900.00	878.25	874.29	15.605	15.544	15.452	15.299
90	900.0000	779.4229	910.00	888.24	884.29	15.605	15.544	15.451	15.297
91	910.0000	788.0832	920.00	898.24	894.29	15.605	15.543	15.450	15.296
92	920.0000	796.7434	930.00	908.24	904.28	15.604	15.542	15.449	15.294
93	930.0000	805.4037	940.00	918.24	914.28	15.604	15.542	15.448	15.292
94	940.0000	814.0639	950.00	928.23	924.28	15.604	15.541	15.447	15.291
95	950.0000	822.7242	960.00	938.23	934.27	15.603	15.540	15.446	15.289
96	960.0000	831.3844	970.00	948.23	944.27	15.603	15.540	15.445	15.288
97	970.0000	840.0447	980.00	958.23	954.27	15.602	15.539	15.444	15.286
98	980.0000	848.7049	990.00	968.22	964.27	15.602	15.539	15.443	15.284
99	990.0000	857.3652	1000.00	978.22	974.26	15.602	15.538	15.442	15.283
100	1000.0000	866.0255	1010.00	988.22	984.26	15.601	15.537	15.441	15.281

Table 17 Internal spline

30 degree pressure angle — Side fit — Flat root — Module = 8.00

 $E_{v \min}$ = minimum effective space width, circular = 12.566

Number of teeth	Pitch diameter	Base diameter	Major diameter (max.)	Form diameter (min.)	Minor diameter (min.)	Actual max. space width, circular $E_{\max} = E_{v \min} + (T + \lambda)$			
z	D	D_b	D_{e1}	D_{F1}	D_{11}	4H	5H	6H	7H
6	48.0000	41.5692	60.41	57.60	43.45	12.626	12.661	12.714	12.803
7	56.0000	48.4974	68.42	65.60	50.89	12.626	12.663	12.717	12.807
8	64.0000	55.4256	76.42	73.60	58.48	12.627	12.664	12.719	12.810
9	72.0000	62.3538	84.43	81.60	66.18	12.628	12.665	12.721	12.814
10	80.0000	69.2820	92.43	89.60	73.94	12.629	12.666	12.723	12.817
11	88.0000	76.2102	100.44	97.60	81.74	12.630	12.668	12.724	12.819
12	96.0000	83.1384	108.44	105.60	89.59	12.630	12.669	12.725	12.822
13	104.0000	90.0666	116.45	113.60	97.48	12.631	12.670	12.726	12.825
14	112.0000	96.9948	124.45	121.60	105.34	12.632	12.671	12.729	12.827
15	120.0000	103.9231	132.46	129.60	113.25	12.632	12.672	12.731	12.829
16	128.0000	110.8513	140.46	137.60	121.16	12.633	12.672	12.732	12.832
17	136.0000	117.7795	148.46	145.60	129.07	12.634	12.673	12.733	12.834
18	144.0000	124.7077	156.47	153.60	136.97	12.634	12.674	12.735	12.836
19	152.0000	131.6359	164.47	161.60	144.97	12.634	12.675	12.736	12.838
20	160.0000	138.5641	172.47	169.60	152.97	12.635	12.676	12.737	12.840
21	168.0000	145.4923	180.48	177.60	160.87	12.635	12.677	12.739	12.842
22	176.0000	152.4205	188.48	185.60	168.83	12.636	12.677	12.740	12.844
23	184.0000	159.3487	196.48	193.60	176.79	12.636	12.678	12.741	12.846
24	192.0000	166.2769	204.49	201.60	184.76	12.637	12.679	12.742	12.847
25	200.0000	173.2051	212.49	209.60	192.72	12.637	12.679	12.743	12.849
26	208.0000	180.1333	220.49	217.60	200.70	12.637	12.680	12.744	12.851
27	216.0000	187.0615	228.50	225.60	208.67	12.638	12.681	12.745	12.854
28	224.0000	193.9897	236.50	233.60	216.64	12.638	12.681	12.746	12.856
29	232.0000	200.9179	244.51	241.60	224.63	12.639	12.682	12.747	12.857
30	240.0000	207.8461	252.50	249.60	232.60	12.639	12.683	12.748	12.857
31	248.0000	214.7743	260.51	257.60	240.58	12.639	12.683	12.749	12.859
32	256.0000	221.7025	268.51	265.60	248.56	12.640	12.684	12.750	12.860
33	264.0000	228.6307	276.51	273.60	256.54	12.641	12.684	12.751	12.862
34	272.0000	235.5589	284.52	281.60	264.53	12.641	12.685	12.752	12.863
35	280.0000	242.4871	292.52	289.60	272.51	12.641	12.686	12.753	12.865
36	288.0000	249.4153	300.52	297.60	280.50	12.641	12.686	12.754	12.866
37	296.0000	256.3435	308.52	305.60	288.48	12.642	12.687	12.755	12.868
38	304.0000	263.2717	316.53	313.60	296.47	12.642	12.687	12.756	12.869
39	312.0000	270.1999	324.53	321.60	304.46	12.642	12.688	12.757	12.870
40	320.0000	277.1281	332.53	329.60	312.45	12.643	12.688	12.757	12.872
41	328.0000	284.0563	340.53	337.60	320.43	12.643	12.689	12.758	12.873
42	336.0000	290.9845	348.53	345.60	328.42	12.643	12.690	12.759	12.874
43	344.0000	297.9127	356.54	353.60	336.40	12.644	12.690	12.760	12.876
44	352.0000	304.8409	364.54	361.60	344.40	12.644	12.691	12.761	12.877
45	360.0000	311.7692	372.54	369.60	352.39	12.644	12.691	12.761	12.878
46	368.0000	318.6974	380.54	377.60	360.39	12.645	12.692	12.762	12.879
47	376.0000	325.6256	388.54	385.60	368.38	12.645	12.692	12.763	12.881
48	384.0000	332.5538	396.55	393.60	376.37	12.645	12.693	12.764	12.882
49	392.0000	339.4820	404.55	401.60	384.36	12.646	12.693	12.764	12.883
50	400.0000	346.4102	412.55	409.60	392.35	12.646	12.694	12.765	12.884
51	408.0000	353.3384	420.55	417.60	400.35	12.646	12.694	12.766	12.886
52	416.0000	360.2666	428.55	425.60	408.34	12.647	12.695	12.767	12.887
53	424.0000	367.1948	436.56	433.60	416.33	12.647	12.695	12.768	12.888
54	432.0000	374.1230	444.56	441.60	424.33	12.647	12.695	12.769	12.889
55	440.0000	381.0512	452.56	449.60	432.32	12.647	12.696	12.769	12.890
56	448.0000	387.9794	460.56	457.60	440.32	12.648	12.696	12.770	12.891
57	456.0000	394.9076	468.56	465.60	448.31	12.648	12.697	12.771	12.893
58	464.0000	401.8358	476.57	473.60	456.30	12.648	12.697	12.771	12.894
59	472.0000	408.7640	484.57	481.60	464.30	12.648	12.698	12.772	12.895
60	480.0000	415.6922	492.57	489.60	472.29	12.649	12.698	12.772	12.896
61	488.0000	422.6204	500.57	497.60	480.29	12.649	12.699	12.773	12.897
62	496.0000	429.5486	508.57	505.60	488.28	12.649	12.699	12.774	12.898
63	504.0000	436.4768	516.58	513.60	496.28	12.650	12.700	12.775	12.900
64	512.0000	443.4050	524.58	521.60	504.28	12.650	12.700	12.776	12.902
65	520.0000	450.3332	532.58	529.60	512.27	12.651	12.701	12.777	12.903
66	528.0000	457.2614	540.59	537.60	520.27	12.651	12.702	12.778	12.904
67	536.0000	464.1896	548.59	545.60	528.26	12.651	12.702	12.779	12.906
68	544.0000	471.1178	556.59	553.60	536.26	12.652	12.703	12.780	12.907
69	552.0000	478.0461	564.59	561.60	544.25	12.652	12.703	12.781	12.908
70	560.0000	484.9743	572.59	569.60	552.25	12.652	12.704	12.781	12.909
71	568.0000	491.9025	580.60	577.60	560.25	12.652	12.704	12.782	12.911
72	576.0000	498.8307	588.60	585.60	568.24	12.653	12.705	12.782	12.912
73	584.0000	505.7589	596.60	593.60	576.24	12.653	12.705	12.783	12.913
74	592.0000	512.6871	604.60	601.60	584.24	12.653	12.706	12.784	12.914
75	600.0000	519.6153	612.61	609.60	592.23	12.654	12.706	12.785	12.916
76	608.0000	526.5435	620.61	617.60	600.23	12.654	12.707	12.786	12.917
77	616.0000	533.4717	628.61	625.60	608.22	12.655	12.707	12.787	12.918
78	624.0000	540.3999	636.61	633.60	616.22	12.655	12.708	12.787	12.920
79	632.0000	547.3281	644.61	641.60	624.22	12.655	12.708	12.788	12.921
80	640.0000	554.2563	652.62	649.60	632.22	12.655	12.709	12.789	12.922
81	648.0000	561.1845	660.62	657.60	640.22	12.656	12.709	12.790	12.923
82	656.0000	568.1127	668.62	665.60	648.21	12.656	12.710	12.791	12.925
83	664.0000	575.0409	676.62	673.60	656.21	12.656	12.710	12.791	12.926
84	672.0000	581.9691	684.63	681.60	664.21	12.657	12.711	12.792	12.927
85	680.0000	588.8973	692.63	689.60	672.21	12.657	12.711	12.793	12.929
86	688.0000	595.8255	700.63	697.60	680.20	12.657	12.712	12.794	12.930
87	696.0000	602.7537	708.63	705.60	688.20	12.658	12.712	12.794	12.931
88	704.0000	609.6819	716.63	713.60	696.20	12.658	12.713	12.795	12.932
89	712.0000	616.6101	724.64	721.60	704.20	12.658	12.713	12.796	12.934
90	720.0000	623.5383	732.64	729.60	712.19	12.659	12.714	12.797	12.935
91	728.0000	630.4665	740.64	737.60	720.19	12.659	12.714	12.798	12.936
92	736.0000	637.3947	748.64	745.60	728.19	12.659	12.715	12.798	12.938
93	744.0000	644.3229	756.65	753.60	736.19	12.659	12.715	12.799	12.939
94	752.0000	651.2511	764.65	761.60	744.19	12.660	12.716	12.800	12.940
95	760.0000	658.1793	772.65	769.60	752.18	12.660	12.716	12.801	12.941
96	768.0000	665.1075	780.65	777.60	760.18	12.660	12.717	12.802	12.943
97	776.0000	672.0357	788.65	785.60	768.18	12.661	12.717	12.802	12.944
98	784.0000	678.9639	796.66	793.60	776.18	12.661	12.718	12.803	12.945
99	792.0000	685.8921	804.66	801.60	784.18	12.661	12.718	12.804	12.946
100	800.0000	692.8203	812.66	809.60	792.17	12.662	12.719	12.805	12.948

Table 18 External spline

30 degree pressure angle — Side fit — Flat root — Module = 8.00

 $S_{v \max}$ = maximum effective tooth thickness, circular = 12.566

Number of teeth	Pitch diameter	Base diameter	Major diameter (max.)	Form diameter (max.)	Minor diameter (min.)	Actual min. tooth thickness, circular $S_{\min} = S_{v \max} - (T + \lambda)$			
z	D	D_b	D_{ee}	D_{Fe}	D_e	4h	5h	6h	7h
6	48.0000	41.5692	56.00	41.85	35.59	12.507	12.412	12.418	12.330
7	56.0000	48.4974	64.00	49.29	43.58	12.507	12.410	12.416	12.326
8	64.0000	55.4256	72.00	56.88	51.58	12.505	12.409	12.414	12.322
9	72.0000	62.3538	80.00	64.58	59.57	12.505	12.408	12.412	12.316
10	80.0000	69.2820	88.00	72.34	67.57	12.504	12.406	12.410	12.316
11	88.0000	76.2102	96.00	80.14	75.56	12.503	12.405	12.408	12.313
12	96.0000	83.1384	104.00	87.99	83.56	12.502	12.404	12.407	12.311
13	104.0000	90.0666	112.00	95.85	91.55	12.502	12.403	12.405	12.308
14	112.0000	96.9949	120.00	103.74	99.55	12.501	12.402	12.403	12.306
15	120.0000	103.9231	128.00	111.65	107.54	12.501	12.401	12.402	12.303
16	128.0000	110.8513	136.00	119.56	115.54	12.500	12.400	12.401	12.301
17	136.0000	117.7795	144.00	127.49	123.54	12.499	12.400	12.399	12.299
18	144.0000	124.7077	152.00	135.42	131.53	12.499	12.400	12.398	12.297
19	152.0000	131.6359	160.00	143.37	139.53	12.498	12.400	12.397	12.295
20	160.0000	138.5641	168.00	151.32	147.53	12.499	12.400	12.395	12.293
21	168.0000	145.4923	176.00	159.27	155.52	12.498	12.400	12.394	12.291
22	176.0000	152.4205	184.00	167.23	163.52	12.497	12.400	12.393	12.289
23	184.0000	159.3487	192.00	175.19	171.52	12.497	12.400	12.392	12.287
24	192.0000	166.2769	200.00	183.16	179.51	12.496	12.400	12.391	12.285
25	200.0000	173.2051	208.00	191.12	187.51	12.496	12.400	12.390	12.284
26	208.0000	180.1333	216.00	199.10	195.51	12.495	12.400	12.389	12.282
27	216.0000	187.0615	224.00	207.07	203.50	12.495	12.400	12.388	12.280
28	224.0000	193.9897	232.00	215.04	211.50	12.494	12.400	12.387	12.279
29	232.0000	200.9179	240.00	223.02	219.50	12.494	12.400	12.386	12.277
30	240.0000	207.8461	248.00	231.00	227.50	12.494	12.400	12.385	12.276
31	248.0000	214.7743	256.00	238.98	235.49	12.493	12.400	12.384	12.274
32	256.0000	221.7025	264.00	246.96	243.49	12.493	12.400	12.383	12.272
33	264.0000	228.6307	272.00	254.94	251.49	12.493	12.400	12.382	12.271
34	272.0000	235.5589	280.00	262.93	259.49	12.492	12.400	12.381	12.269
35	280.0000	242.4871	288.00	270.91	267.48	12.492	12.400	12.380	12.268
36	288.0000	249.4153	296.00	278.90	275.48	12.491	12.400	12.379	12.267
37	296.0000	256.3435	304.00	286.88	283.48	12.491	12.400	12.378	12.265
38	304.0000	263.2717	312.00	294.87	291.48	12.491	12.400	12.377	12.264
39	312.0000	270.1999	320.00	302.86	299.47	12.490	12.400	12.376	12.262
40	320.0000	277.1281	328.00	310.85	307.47	12.490	12.400	12.376	12.261
41	328.0000	284.0563	336.00	318.83	315.47	12.490	12.400	12.375	12.260
42	336.0000	290.9845	344.00	326.82	323.47	12.489	12.400	12.374	12.258
43	344.0000	297.9127	352.00	334.81	331.46	12.489	12.400	12.373	12.257
44	352.0000	304.8409	360.00	342.80	339.46	12.489	12.400	12.372	12.256
45	360.0000	311.7692	368.00	350.79	347.46	12.488	12.400	12.371	12.255
46	368.0000	318.6974	376.00	358.79	355.46	12.488	12.400	12.370	12.253
47	376.0000	325.6256	384.00	366.78	363.46	12.488	12.400	12.369	12.252
48	384.0000	332.5538	392.00	374.77	371.45	12.487	12.400	12.368	12.251
49	392.0000	339.4820	400.00	382.76	379.45	12.487	12.400	12.368	12.250
50	400.0000	346.4102	408.00	390.75	387.45	12.487	12.400	12.368	12.248
51	408.0000	353.3384	416.00	398.75	395.45	12.487	12.400	12.367	12.247
52	416.0000	360.2666	424.00	406.74	403.45	12.487	12.400	12.366	12.246
53	424.0000	367.1948	432.00	414.73	411.44	12.486	12.400	12.365	12.245
54	432.0000	374.1230	440.00	422.73	419.44	12.486	12.400	12.365	12.244
55	440.0000	381.0512	448.00	430.72	427.44	12.485	12.400	12.364	12.242
56	448.0000	387.9794	456.00	438.72	435.44	12.485	12.400	12.363	12.241
57	456.0000	394.9076	464.00	446.71	443.44	12.485	12.400	12.362	12.240
58	464.0000	401.8358	472.00	454.70	451.43	12.485	12.400	12.362	12.239
59	472.0000	408.7640	480.00	462.70	459.43	12.484	12.400	12.361	12.238
60	480.0000	415.6922	488.00	470.69	467.43	12.484	12.400	12.360	12.237
61	488.0000	422.6204	496.00	478.69	475.43	12.484	12.400	12.360	12.236
62	496.0000	429.5486	504.00	486.68	483.43	12.483	12.400	12.359	12.235
63	504.0000	436.4768	512.00	494.68	491.42	12.483	12.400	12.358	12.232
64	512.0000	443.4050	520.00	502.68	499.42	12.483	12.400	12.357	12.231
65	520.0000	450.3332	528.00	510.67	507.42	12.482	12.400	12.356	12.230
66	528.0000	457.2614	536.00	518.67	515.41	12.482	12.400	12.355	12.228
67	536.0000	464.1896	544.00	526.66	523.41	12.482	12.400	12.354	12.227
68	544.0000	471.1178	552.00	534.66	531.41	12.481	12.400	12.354	12.226
69	552.0000	478.0461	560.00	542.65	539.41	12.481	12.400	12.353	12.225
70	560.0000	484.9743	568.00	550.65	547.41	12.481	12.400	12.352	12.223
71	568.0000	491.9025	576.00	558.65	555.40	12.480	12.400	12.351	12.222
72	576.0000	498.8307	584.00	566.64	563.40	12.480	12.400	12.350	12.221
73	584.0000	505.7589	592.00	574.64	571.40	12.480	12.400	12.350	12.220
74	592.0000	512.6871	600.00	582.64	579.40	12.479	12.400	12.349	12.218
75	600.0000	519.6153	608.00	590.63	587.39	12.479	12.400	12.348	12.217
76	608.0000	526.5435	616.00	598.63	595.39	12.479	12.400	12.347	12.216
77	616.0000	533.4717	624.00	606.63	603.39	12.478	12.400	12.346	12.214
78	624.0000	540.3999	632.00	614.62	611.39	12.478	12.400	12.346	12.213
79	632.0000	547.3281	640.00	622.62	619.39	12.478	12.400	12.345	12.212
80	640.0000	554.2563	648.00	630.62	627.38	12.477	12.400	12.344	12.211
81	648.0000	561.1845	656.00	638.62	635.38	12.477	12.400	12.343	12.209
82	656.0000	568.1127	664.00	646.61	643.38	12.477	12.400	12.342	12.208
83	664.0000	575.0409	672.00	654.61	651.38	12.476	12.400	12.342	12.207
84	672.0000	581.9691	680.00	662.61	659.37	12.476	12.400	12.341	12.205
85	680.0000	588.8973	688.00	670.61	667.37	12.476	12.400	12.340	12.204
86	688.0000	595.8255	696.00	678.60	675.37	12.475	12.400	12.339	12.203
87	696.0000	602.7537	704.00	686.60	683.37	12.475	12.400	12.338	12.202
88	704.0000	609.6819	712.00	694.60	691.37	12.475	12.400	12.338	12.200
89	712.0000	616.6101	720.00	702.60	699.36	12.475	12.400	12.337	12.199
90	720.0000	623.5383	728.00	710.59	707.36	12.475	12.400	12.336	12.198
91	728.0000	630.4665	736.00	718.59	715.36	12.474	12.400	12.335	12.196
92	736.0000	637.3947	744.00	726.59	723.36	12.474	12.400	12.334	12.195
93	744.0000	644.3229	752.00	734.59	731.35	12.473	12.400	12.334	12.194
94	752.0000	651.2511	760.00	742.59	739.35	12.473	12.400	12.333	12.193
95	760.0000	658.1793	768.00	750.58	747.35	12.473	12.400	12.332	12.191
96	768.0000	665.1076	776.00	758.58	755.35	12.472	12.400	12.331	12.190
97	776.0000	672.0358	784.00	766.58	763.35	12.472	12.400	12.330	12.189
98	784.0000	678.9640	792.00	774.58	771.34	12.472	12.400	12.330	12.188
99	792.0000	685.8922	800.00	782.58	779.34	12.471	12.400	12.329	12.186
100	800.0000	692.8204	808.00	790.57	787.34	12.471	12.400	12.328	12.185

Table 19 Internal spline

30 degree pressure angle — Side fit — Flat root — Module = 6.00

$E_{v \min}$ = minimum effective space width, circular = 9.425

Number of teeth	Pitch diameter	Base diameter	Major diameter (max.)	Form diameter (min.)	Minor diameter (min.)	Actual max. space width, circular $E_{\max} = E_{v \min} + (T + \lambda)$			
z	D	D_b	D_{e1}	D_{F1}	D_{I1}	4H	5H	6H	7H
6	36.0000	31.1769	45.37	43.20	32.58	9.478	9.511	9.559	9.639
7	42.0000	36.3731	51.38	49.20	38.17	9.479	9.513	9.561	9.643
8	48.0000	41.5692	57.38	55.20	43.86	9.480	9.514	9.563	9.646
9	54.0000	46.7654	63.39	61.20	49.55	9.481	9.519	9.565	9.649
10	60.0000	51.9615	69.39	67.20	55.24	9.481	9.515	9.566	9.651
11	66.0000	57.1577	75.40	73.20	61.31	9.482	9.516	9.568	9.654
12	72.0000	62.3538	81.40	79.20	67.19	9.483	9.517	9.569	9.656
13	78.0000	67.5499	87.40	85.20	73.07	9.483	9.518	9.570	9.658
14	84.0000	72.7461	93.41	91.20	79.01	9.484	9.519	9.572	9.661
15	90.0000	77.9423	99.41	97.20	84.93	9.484	9.520	9.573	9.663
16	96.0000	83.1384	105.42	103.20	90.87	9.485	9.521	9.575	9.665
17	102.0000	88.3346	111.42	109.20	96.84	9.485	9.521	9.576	9.667
18	108.0000	93.5307	117.43	115.20	102.79	9.486	9.522	9.577	9.668
19	114.0000	98.7269	123.43	121.20	108.73	9.486	9.523	9.578	9.670
20	120.0000	103.9231	129.43	127.20	114.69	9.487	9.524	9.579	9.672
21	126.0000	109.1192	135.43	133.20	120.65	9.487	9.524	9.580	9.674
22	132.0000	114.3154	141.43	139.20	126.62	9.487	9.525	9.581	9.675
23	138.0000	119.5115	147.44	145.20	132.58	9.488	9.526	9.582	9.677
24	144.0000	124.7077	153.44	151.20	138.57	9.488	9.526	9.583	9.678
25	150.0000	129.9038	159.44	157.20	144.54	9.489	9.527	9.584	9.680
26	156.0000	135.1000	165.44	163.20	150.52	9.489	9.527	9.585	9.682
27	162.0000	140.2961	171.45	169.20	156.50	9.489	9.528	9.586	9.683
28	168.0000	145.4923	177.45	175.20	162.49	9.490	9.529	9.587	9.684
29	174.0000	150.6884	183.45	181.20	168.47	9.490	9.530	9.589	9.686
30	180.0000	155.8846	189.45	187.20	174.45	9.490	9.530	9.589	9.687
31	186.0000	161.0807	195.46	193.20	180.43	9.491	9.530	9.590	9.689
32	192.0000	166.2769	201.46	199.20	186.42	9.491	9.531	9.591	9.690
33	198.0000	171.4730	207.46	205.20	192.41	9.491	9.531	9.591	9.691
34	204.0000	176.6692	213.46	211.20	198.39	9.492	9.532	9.592	9.692
35	210.0000	181.8653	219.47	217.20	204.38	9.492	9.532	9.593	9.694
36	216.0000	187.0615	225.47	223.20	210.37	9.492	9.533	9.594	9.695
37	222.0000	192.2577	231.47	229.20	216.36	9.493	9.533	9.594	9.696
38	228.0000	197.4538	237.48	235.20	222.35	9.493	9.534	9.595	9.697
39	234.0000	202.6500	243.48	241.20	228.34	9.493	9.534	9.595	9.698
40	240.0000	207.8461	249.48	247.20	234.33	9.494	9.535	9.597	9.700
41	246.0000	213.0423	255.48	253.20	240.33	9.494	9.535	9.597	9.701
42	252.0000	218.2384	261.48	259.20	246.32	9.494	9.536	9.598	9.702
43	258.0000	223.4346	267.48	265.20	252.31	9.494	9.536	9.599	9.703
44	264.0000	228.6307	273.49	271.20	258.30	9.495	9.537	9.600	9.704
45	270.0000	233.8269	279.49	277.20	264.30	9.495	9.537	9.600	9.706
46	276.0000	239.0230	285.49	283.20	270.29	9.495	9.538	9.601	9.707
47	282.0000	244.2192	291.49	289.20	276.28	9.496	9.538	9.602	9.708
48	288.0000	249.4154	297.49	295.20	282.27	9.496	9.539	9.602	9.709
49	294.0000	254.6115	303.49	301.20	288.27	9.496	9.539	9.603	9.710
50	300.0000	259.8076	309.50	307.20	294.27	9.496	9.539	9.604	9.711
51	306.0000	265.0038	315.50	313.20	300.26	9.497	9.540	9.604	9.712
52	312.0000	270.1999	321.50	319.20	306.26	9.497	9.540	9.605	9.713
53	318.0000	275.3961	327.50	325.20	312.25	9.497	9.541	9.606	9.714
54	324.0000	280.5923	333.50	331.20	318.25	9.498	9.541	9.607	9.715
55	330.0000	285.7884	339.50	337.20	324.24	9.498	9.541	9.607	9.716
56	336.0000	290.9846	345.51	343.20	330.24	9.498	9.542	9.607	9.717
57	342.0000	296.1807	351.51	349.20	336.23	9.498	9.542	9.608	9.718
58	348.0000	301.3769	357.51	355.20	342.23	9.499	9.543	9.609	9.719
59	354.0000	306.5730	363.51	361.20	348.22	9.499	9.543	9.609	9.720
60	360.0000	311.7692	369.51	367.20	354.22	9.499	9.543	9.610	9.721
61	366.0000	316.9653	375.51	373.20	360.22	9.499	9.544	9.610	9.722
62	372.0000	322.1615	381.52	379.20	366.21	9.499	9.544	9.611	9.723
63	378.0000	327.3576	387.52	385.20	372.21	9.500	9.544	9.612	9.724
64	384.0000	332.5538	393.52	391.20	378.21	9.500	9.545	9.613	9.725
65	390.0000	337.7499	399.52	397.20	384.20	9.500	9.545	9.613	9.725
66	396.0000	342.9461	405.52	403.20	390.20	9.500	9.545	9.613	9.726
67	402.0000	348.1422	411.52	409.20	396.20	9.500	9.546	9.614	9.727
68	408.0000	353.3384	417.53	415.20	402.19	9.501	9.546	9.615	9.728
69	414.0000	358.5345	423.53	421.20	408.19	9.501	9.547	9.616	9.729
70	420.0000	363.7307	429.53	427.20	414.19	9.501	9.547	9.616	9.730
71	426.0000	368.9268	435.53	433.20	420.19	9.501	9.547	9.616	9.731
72	432.0000	374.1230	441.53	439.20	426.18	9.502	9.548	9.617	9.732
73	438.0000	379.3191	447.53	445.20	432.18	9.502	9.548	9.617	9.733
74	444.0000	384.5153	453.54	451.20	438.18	9.502	9.549	9.618	9.734
75	450.0000	389.7115	459.54	457.20	444.18	9.502	9.549	9.618	9.734
76	456.0000	394.9076	465.54	463.20	450.17	9.502	9.549	9.619	9.735
77	462.0000	400.1038	471.54	469.20	456.17	9.503	9.550	9.620	9.736
78	468.0000	405.2999	477.54	475.20	462.17	9.503	9.550	9.620	9.737
79	474.0000	410.4961	483.54	481.20	468.17	9.503	9.550	9.621	9.738
80	480.0000	415.6922	489.54	487.20	474.16	9.503	9.550	9.621	9.739
81	486.0000	420.8884	495.54	493.20	480.16	9.503	9.551	9.621	9.739
82	492.0000	426.0845	501.55	499.20	486.16	9.504	9.551	9.622	9.740
83	498.0000	431.2807	507.55	505.20	492.16	9.504	9.551	9.622	9.741
84	504.0000	436.4768	513.55	511.20	498.16	9.504	9.552	9.624	9.743
85	510.0000	441.6730	519.55	517.20	504.15	9.505	9.552	9.624	9.744
86	516.0000	446.8691	525.55	523.20	510.15	9.505	9.553	9.625	9.745
87	522.0000	452.0653	531.56	529.20	516.15	9.505	9.553	9.625	9.746
88	528.0000	457.2614	537.56	535.20	522.15	9.505	9.554	9.626	9.747
89	534.0000	462.4576	543.56	541.20	528.15	9.506	9.554	9.627	9.748
90	540.0000	467.6537	549.56	547.20	534.15	9.506	9.554	9.627	9.749
91	546.0000	472.8499	555.56	553.20	540.14	9.506	9.555	9.628	9.750
92	552.0000	478.0461	561.56	559.20	546.14	9.506	9.555	9.628	9.751
93	558.0000	483.2422	567.57	565.20	552.14	9.506	9.556	9.629	9.752
94	564.0000	488.4384	573.57	571.20	558.14	9.507	9.556	9.630	9.753
95	570.0000	493.6345	579.57	577.20	564.14	9.507	9.556	9.630	9.754
96	576.0000	498.8307	585.57	583.20	570.14	9.507	9.557	9.631	9.755
97	582.0000	504.0268	591.57	589.20	576.14	9.507	9.557	9.631	9.755
98	588.0000	509.2230	597.57	595.20	582.13	9.508	9.558	9.632	9.756
99	594.0000	514.4191	603.58	601.20	588.13	9.508	9.558	9.633	9.757
100	600.0000	519.6153	609.58	607.20	594.13	9.508	9.558	9.633	9.758