INTERNATIONAL STANDARD

ISO 4156-1

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Straight cylindrical involute splines — Metric module, side fit —

Part 1: Generalities

Cannelures cylindriques droites à flancs en développante — Module métrique, à centrage sur flancs —

Partie 1: Généralités

Reference number
ISO 4156-1:2005(E)

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Foreword

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ISO 4156-1 was prepared by Technical Committee ISO/TC 14, *Shafts for machinery and accessories*.

This first edition of ISO 4156-1, together with ISO 4156-2 and ISO 4156-3, cancels and replaces ISO 4156:1981 and ISO 4156:1981/Amd 1:1992, of which it constitutes a technical revision. The values and tables are the same as in ISO 4156:1981; however, some explanations and definitions have been clarified.

ISO 4156 consists of the following parts, under the general title *Straight cylindrical involute splines — Metric module, side fit*:

— *Part 1: Generalities*

— *Part 2: Dimensions*

— *Part 3: Inspection*

Introduction

ISO 4156 provides the data and indications necessary for the design, manufacture and inspection of straight (non-helical) side-fitting cylindrical involute splines.

Straight cylindrical involute splines manufactured in accordance with ISO 4156 are used for clearance, sliding and interference connections of shafts and hubs. They contain all the necessary characteristics for the assembly, transmission of torque, and economic production.

The nominal pressure angles are 30°, 37,5° and 45°. For electronic data processing purposes, the form of expression 37,5° has been adopted instead of 37°30'. ISO 4156 establishes a specification based on the following modules:

— for pressure angles of 30° and 37,5° the module increments are

0,5; 0,75; 1; 1,25; 1,5; 1,75; 2; 2,5; 3; 4; 5; 6; 8; 10

— for pressure angle of 45° the module increments are

0,25; 0,5; 0,75; 1; 1,25; 1,5; 1,75; 2; 2,5

Straight cylindrical involute splines — Metric module, side fit —

Part 1:
Generalities

1 Scope

This part of ISO 4156 provides the data and indications necessary for the design and manufacture of straight (non-helical) side-fitting cylindrical involute splines.

Limiting dimensions, tolerances, manufacturing errors and their effects on the fit between connecting coaxial spline elements are defined in the equations and given in the tables. Unless otherwise specified, linear dimensions are expressed in millimetres and angular dimensions in degrees.

2 Normative references

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

ISO 286-1, *ISO system of limits and fits — Part 1: Bases of tolerances, deviations and fits*

ISO 1101, *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

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

ISO 4156-3:2005, *Straight cylindrical involute splines — Metric module, side fit — Part 3: Inspection*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
spline joint
connecting, coaxial 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

3.2
involute spline
member of spline joint having teeth or spaces that have involute flank profiles

3.3
internal spline
spline formed on the inner surface of a cylinder

3.4
external spline
spline formed on the outer surface of a cylinder

3.5
fillet
concave surface of the tooth or space connecting the involute flank and the root circle.

NOTE This curved surface as generated varies and cannot be properly specified by a radius of any given value.

3.6
fillet root spline
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.

3.7
flat root spline
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

3.8
module
m
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)

3.9
pitch circle
reference circle from which all normal spline dimensions are derived, and the circle on which the specified pressure angle has its nominal value

3.10
pitch diameter
D
diameter of the pitch circle, in millimetres, equal to the number of teeth multiplied by the module

3.11
pitch point
intersection of the spline tooth profile with the pitch circle

3.12
circular pitch
p
length of arc of the pitch circle between two consecutive pitch points of left- (or right-) hand flanks, which has a value of the number π multiplied by the module

3.13
pressure angle
α
acute angle between a radial line passing through any point on a tooth flank and the tangent plane to the flank at that point

3.14
standard pressure angle
α_D
pressure angle at the specified pitch point

3.15
base circle
circle from which Involute spline tooth profiles are generated

3.16
base diameter
D_b
diameter of the base circle

3.17
base pitch
p_b
arc length of the base circle between two consecutive corresponding flanks

3.18
major circle
outermost (largest) circle of the external or internal spline

3.19
major diameter
D_{ee}, D_{ei}
diameter of the major circle

3.20
minor circle
innermost (smallest) circle of the external or internal spline

3.21
minor diameter, D_{ie}, D_{ii}
diameter of the minor circle

3.22
form circle
circle used to define the depth of involute profile control

NOTE In the case of an external spline it is located near and above the minor diameter, and on an internal spline near and below the major diameter

3.23
form diameter
D_{Fe}, D_{Fi}
diameter of the form circle

3.24
depth of engagement
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

3.25
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.

3.26
actual space width
practically measured circular space width, on the pitch circle, of any single space width within the limit values E_{max} and E_{min}

3.27
effective space width
E_v
space width where an imaginary perfect external spline would fit without clearance or interference, given by the size of the tooth thickness of this external spline, considering engagement of the entire axial length of the splined assembly

NOTE The minimum effective space width ($E_{v\ min}$, always equal to E) of the internal spline is always basic, as shown in Table 3.

3.28
actual tooth thickness
practically measured circular tooth thickness, on the pitch circle, of any single tooth within the limit values S_{max} and S_{min}

3.29
effective tooth thickness
S_v
tooth thickness where an imaginary perfect internal spline would fit without clearance or interference, given by the size of the space width of this internal spline, considering engagement of the entire axial length of the splined assembly

3.30
effective clearance
c_v
⟨looseness or interference⟩ effective space width of the internal spline minus the effective tooth thickness of the external spline

NOTE For looseness, c_v is positive; for interference, c_v is negative.

3.31
theoretical clearance
c
⟨looseness or interference⟩ actual space width of the internal spline minus the actual tooth thickness of the external spline

NOTE It does not define the effective fit between internal and external spline, because of the effect of deviations.

3.32
form clearance
c_F
radial clearance between the form diameter of the internal spline and the major diameter of the external spline, or between the minor diameter of the internal spline and the form diameter of the external spline

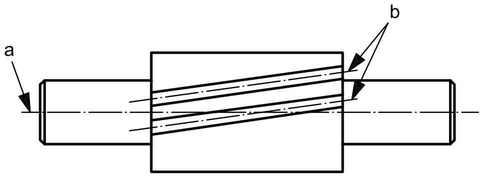
NOTE It allows eccentricity of their respective pitch circles.

3.33
total pitch deviation
F_p
absolute value of the difference between the greatest positive and negative deviations from the theoretical spacing

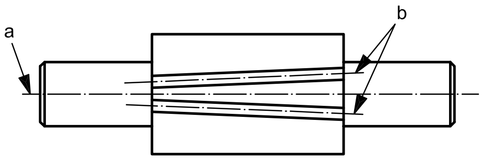
3.34
total profile deviation
F_α
absolute value of the difference between the greatest positive and negative deviations from the theoretical tooth profile, measured normal to the flanks

3.35
total helix deviation
F_β
absolute value of the difference between the two extreme deviations from the theoretical direction parallel to the reference axis

NOTE This includes parallelism and alignment deviations, see Figure 1.



a) Helix deviation



b) Parallelism deviation

c) Alignment deviation

a Reference axis.
b Centreline of teeth.
c Effective spline axis.

Figure 1 — Helix deviations

3.36
parallelism deviation
deviation of parallelism of a single spline tooth to any other single spline tooth

See Figure 1 b).

3.37
alignment deviation
deviation of the effective spline axis with respect to the reference axis

See Figure 1 c).

3.38
out-of-roundness
deviation of the spline from a true circular configuration

3.39
effective deviation
accumulated effect of the spline deviations on the fit with the mating part

3.40
deviation allowance
λ
permissible deviation between minimum actual and minimum effective space width or maximum effective and maximum actual tooth thickness

3.41
machining tolerance
T
permissible deviation between maximum actual and minimum actual space width or tooth thickness

3.42
effective clearance tolerance
T_{v}
permissible deviation between maximum effective and minimum effective space width or tooth thickness

3.43
total tolerance
$T + \lambda$
machining tolerance plus the deviation allowance

3.43.1
total tolerance
⟨internal spline⟩ difference between the minimum effective space width and the maximum actual space width

3.43.2
total tolerance
⟨external spline⟩ difference between the maximum effective tooth thickness and the minimum actual tooth thickness

3.44
basic dimension
numerical value to describe the theoretically exact size, shape or location of a feature

NOTE It is the basis from which permissible deviations are established by tolerances.

3.45
auxiliary dimension
dimension, without tolerance, given for information purposes only, for the determination of the useful production and control dimensions.

4 Symbols, subscripts and abbreviated terms

4.1 General symbols

The general symbols used to designate the various spline terms and dimensions are given below.

D	Pitch diameter	mm
D_{Fe}	Form diameter, external spline	mm
$D_{\text{Fe max}}$	Maximum form diameter, external spline	mm
D_{Fi}	Form diameter, internal spline	mm
$D_{\text{Fi min}}$	Minimum form diameter, internal spline	mm
D_{Re}	Diameter of measuring ball or pin for external spline	mm
D_{Ri}	Diameter of measuring ball or pin for internal spline	mm
D_{b}	Base diameter	mm
D_{ee}	Major diameter, external spline	mm
$D_{\text{ee max}}$	Maximum major diameter, external spline	mm
$D_{\text{ee min}}$	Minimum major diameter, external spline	mm
D_{ei}	Major diameter, internal spline	mm
$D_{\text{ei max}}$	Maximum major diameter, internal spline	mm
$D_{\text{ei min}}$	Minimum major diameter, internal spline	mm
D_{ie}	Minor diameter, external spline	mm
$D_{\text{ie max}}$	Maximum minor diameter, external spline	mm
$D_{\text{ie min}}$	Minimum minor diameter, external spline	mm
D_{ii}	Minor diameter, internal spline	mm
$D_{\text{ii max}}$	Maximum minor diameter, internal spline	mm
$D_{\text{ii min}}$	Minimum minor diameter, internal spline	mm
E	Basic space width, circular	mm
E_{max}	Maximum actual space width	mm
E_{min}	Minimum actual space width	mm
E_{v}	Effective space width, circular	mm
$E_{\text{v max}}$	Maximum effective space width	mm
$E_{\text{v min}}$	Minimum effective space width	mm
F_p	Total cumulative pitch deviation	µm
F_α	Total profile deviation	µm
F_β	Total helix deviation	µm
K_{e}	Approximation factor for external spline	—
K_{i}	Approximation factor for internal spline	—
M_{Re}	Measurement over two balls or pins, external splines	mm
M_{Ri}	Measurement between two balls or pins, internal	mm
S	Basic tooth thickness, circular	mm

$S_{\max}$	Maximum actual tooth thickness	mm
$S_{\min}$	Minimum actual tooth thickness	mm
S_{v}	Effective tooth thickness, circular	mm
$S_{\mathrm{v\,max}}$	Maximum effective tooth thickness	mm
$S_{\mathrm{v\,min}}$	Minimum effective tooth thickness	mm
T	Machining tolerance	µm
T_{v}	Effective clearance tolerance	µm
W	Measurement over k teeth, external spline	mm
b	Spline length	mm
c_{F}	Form clearance	mm
c_{v}	Effective clearance (looseness or interference)	µm
$c_{\mathrm{v\,max}}$	Maximum effective clearance	µm
$c_{\mathrm{v\,min}}$	Minimum effective clearance	µm
d_{ce}	Ball or pin contact diameter, external spline	mm
d_{ci}	Ball or pin contact diameter, internal spline	mm
es_{v}	Fundamental deviation, external	µm
h_{s}	Form tooth height	mm
inv α	Involute α $(= \tan\alpha - \pi \cdot \alpha / 180°)$	—
k	Number of measured teeth	—
m	Module	mm
p	Circular pitch	mm
p_{b}	Base pitch	mm
z	Number of teeth	—
α	Pressure angle	°
α_{Fe}	Pressure angle at form diameter, external spline	°
α_{Fi}	Pressure angle at form diameter, internal spline	°
α_{ce}	Pressure angle at ball or pin diameter, external spline	°
α_{ci}	Pressure angle at ball or pin diameter, internal spline	°
α_D	Standard pressure angle at pitch diameter	°
α_{e}	Pressure angle at ball or pin centre, external spline	°
α_{i}	Pressure angle at ball or pin centre, internal spline	°
λ	Deviation allowance	µm
ρ_{Fa}	Fillet radius of the basic rack, external spline	mm
ρ_{Fi}	Fillet radius of the basic rack, internal spline	mm
k; js; h; f; e; d	Fundamental deviation of the external spline	µm

4.2 Subscripts

The following subscripts are used as part of the above general symbols to designate relative conditions or locations:

i minor or internal (in the last case in the last position)

e major or external (in the last case in the last position)

b at the base

c at contact point

d tolerance based on pitch diameter (D)

E tolerance based on space width (E) or tooth thickness (S)

F pertaining to form diameter

v effective

R pertaining to gauges

D standard

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 Table 1 (for example, the symbol for D_b for base diameter may be printed as DB).

4.3 Formulae for dimensions and tolerances for all fit classes

The formulae for dimensions and tolerances for all fit classes are given in Table 1.