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Straight cylindrical involute splines — Metric module, side fit —

Part 3: **Inspection**

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

Partie 3: Vérification

ICS: 21.120.30

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 14, *Shafts for machinery and accessories*.

This second edition cancels and replaces the first edition (ISO 4156-3:2005).

The main changes compared to the previous edition includes:

— Modification of Figure 9,

— Modification of Figure 12,

— Revision of Table 10,

— Modification of Figure 16,

— Correction of example calculation A.3.

A list of all parts in the ISO 4156 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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 cylinderical involute splines — Metric module, side fit — Part 3: Inspection

1 Scope

This part of ISO 4156 provides data and guidance for the inspection 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 and tabulated. Linear dimensions are expressed in millimetres and angular dimensions in degrees.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 3, *Preferred numbers — Series of preferred numbers*

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

ISO 1938-1, *ISO system of limits and fits — Part 1: Inspection of plain workpieces*

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

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

ISO 5459, *Technical drawings — Geometrical tolerancing — Datums and datum-systems for geometrical tolerances*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in 4156-1 apply.

4 Symbols and abbreviated terms

NOTE Some of the symbols used might have a meaning other than the one intended here. The symbols H, Z, Y and W are common for gauge tolerances in other ISO standards and could seem to conflict with symbols used in this part of ISO 4156. However, it was not thought necessary to distinguish between them, since the context will always preclude any ambiguity.

$a_{allowed}$	Limited max. value of distance out of the actual tolerance limit	µm
D	Pitch diameter	mm
D_b	Base diameter	mm

D_{ee}	Major diameter, external spline	mm
$D_{ee\ max}$	Maximum major diameter, external spline	mm
$D_{ee\ min}$	Minimum major diameter, external spline	mm
$D_{Fe\ max}$	Maximum form diameter, external spline	mm
$D_{Fi\ min}$	Minimum form diameter, internal spline	mm
D_{ii}	Minor diameter, internal spline	mm
$D_{ii\ min}$	Minimum minor 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_{ci}	Ball or pin contact diameter, internal spline	mm
E	Basic space width	mm
E_{max}	Maximum actual space width	mm
E_{min}	Minimum actual space width	mm
E_{r}	Eccentric radial offset	mm
E_{v}	Effective space width	mm
$E_{v\ max}$	Maximum effective space width	mm
$E_{v\ min}$	Minimum effective space width	mm
F_{p}	Total cumulative pitch deviation	µm
F_{α}	Total profile deviation	µm
F_{β}	Total helix deviation	µm
i	Integer defining the tooth considered and has values 0, 1, 2, ..., z-1 (as used in Annex A)	
inv α	Involute $\alpha (= \tan \alpha - \pi \cdot \alpha / 180°)$	—
K_{e}	Approximation factor for external spline	—
K_{i}	Approximation factor for internal spline	—
k	Number of measured teeth	
M_{Re}	Measurement over two balls or pins, external splines	mm
M_{Ri}	Measurement between two balls or pins, internal	mm
m	Module	mm
$n_{allowed}$	Max. allowed number of measured sizes outside tolerance limit	—
p_{b}	Base pitch	mm
S	Basic tooth thickness	mm
S_{max}	Maximum actual tooth thickness	mm
S_{min}	Minimum actual tooth thickness	mm
S_{b}	Circular base thickness	mm
$S_{v\ max}$	Maximum effective tooth thickness	mm

$S_{v\,min}$	Minimum effective tooth thickness	mm
STA	Statistical tolerance limit actual	µm, %
$STA_{absolute}$	Statistical tolerance limit actual absolute	µm, %
$STA_{relative}$	Statistical tolerance limit actual relative	%
T	Machining tolerance	µm
T_v	Effective clearance tolerance	µm
W	Measurement over k teeth, external spline	mm
z	Number of teeth	—
α	Pressure angle	°
α_{ce}	Pressure angle at ball or pin diameter, external 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
τ	Angular pitch	°
ψ	Phase angle	°

5 Reference conditions

The standard reference temperature for industrial length measurements is 20 °C. The dimensional requirements for parts and gauges are defined at that temperature and inspection shall also normally be carried out at that same temperature.

If measurements are taken at another temperature, the results shall be corrected using the expansion coefficients of parts and gauges respectively.

Unless otherwise specified, all measurements shall be made under zero measuring load.

If measurements are made under a non-zero load, the results shall be corrected accordingly. However, such correction is not required for comparison measurements made with the same comparison means and under the same measuring load, between similar components of the same material and with the same surface condition.

6 Quality features

6.1 General

The inspection of splines is divided into three quality features, as shown in Figure 1. To specify the location ISO 1101 and ISO 5459 shall be used. For profile and size ISO 4156-1 and -2 apply.

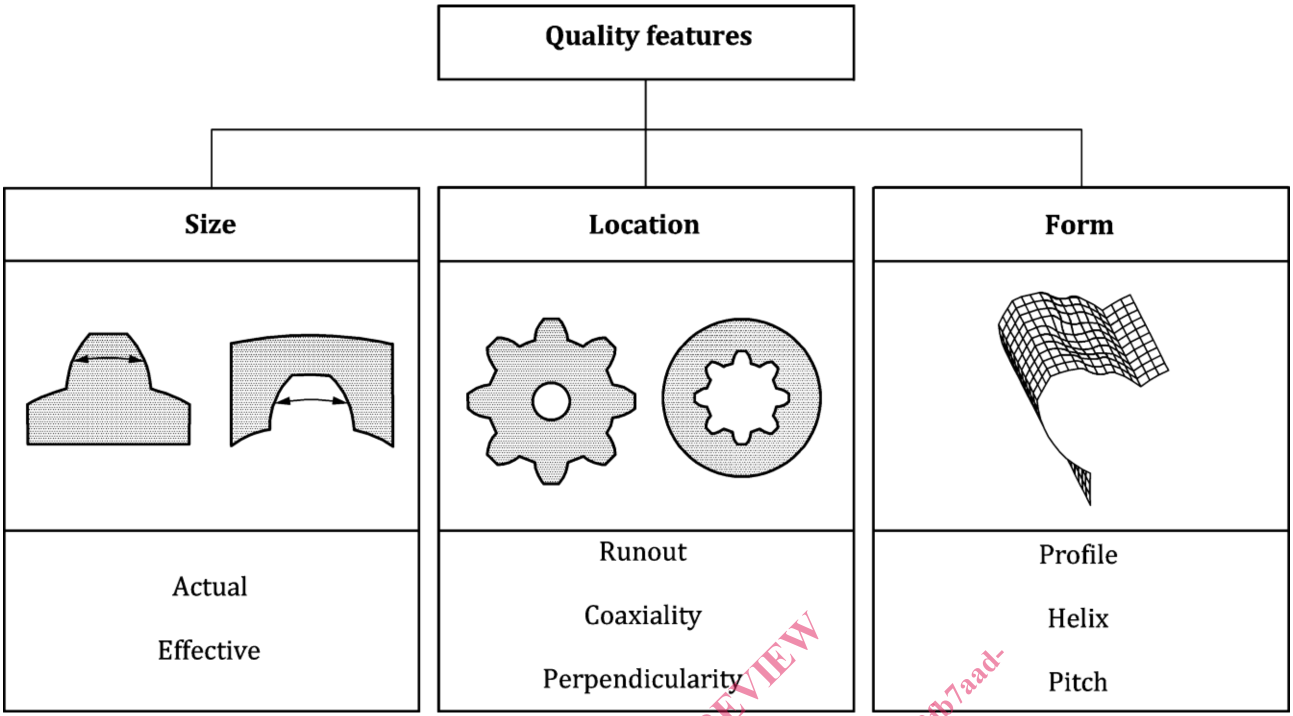


Figure 1 — Quality features

6.2 Size

6.2.1 Actual size

The actual size is

a) for external splines, the circular tooth thickness at the pitch diameter, and

b) for internal splines, the circular space width at the pitch diameter.

6.2.2 Effective size

The effective tooth thickness or space width is the maximum material condition resulting from the actual size and the accumulation of form deviations.

6.3 Location

The location of a spline is the location of the central axis in relation to any other geometrical element found by actual or effective inspection methods.

6.4 Form

The form deviations of a spline are the deviations to the true geometrical form of profile, helix and pitch.

7 Methods of inspection

7.1 Size

7.1.1 General methods

Three general methods of inspection are provided in Table 1. If not otherwise specified, the standard method shall be used. If the alternative methods A or B are required, this shall be stated in the part data table. For the consequence of general methods, see Table 2.

Table 1 — Relationship between parameters and control method

	Minimum material	**Minimum effective clearance**	**Maximum effective clearance**
Parameter	S_{min}/E_{max}	$S_{v\ max}/E_{v\ min}$	$S_{v\ min}/E_{v\ max}$
Standard method	X	X	—
Method A	X	X	X
Method B	—	X	X

Table 2 — Consequence of general methods

Inspection method	**Theoretical maximum clearance between mating parts (zero form deviation)**	**Maximum deviation of form in each part (zero clearance)**
Standard	$2\ (T + \lambda)$	$T + \lambda$
Alternative A	$2T_v$	$T + \lambda$
Alternative B	$2T_v$	Undetermined
NOTE The theoretical maximum clearance between mating parts in this table is for parts in their new condition. The clearance will increase when wear occurs.		

7.1.2 Choice of measuring instrument

The choice of measuring instrument shall be made according to the design requirements (see ISO 4156-1). See Table 3 and Figure 2.

7.1.3 Actual size

7.1.3.1 Dimensions over and between balls

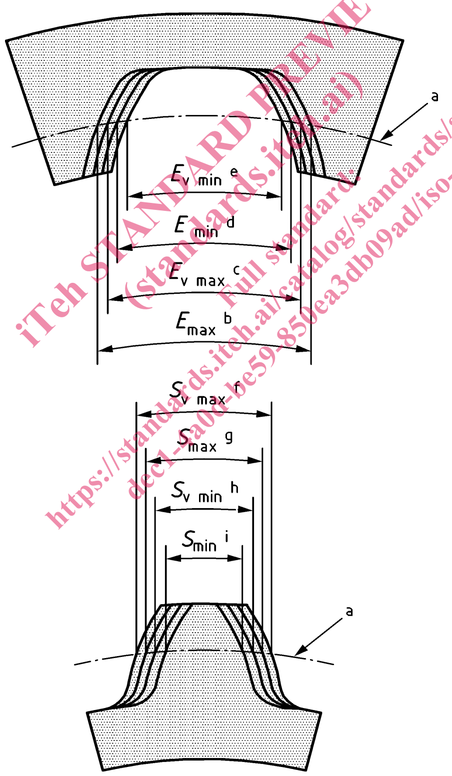
The dimension over or between balls facilitates the calculation of the theoretical actual circular tooth thickness or space width at the pitch circle diameter based on the actual tooth thickness or space width where the balls contact through one normal plane. The size measured over or between balls is a true size at 2 particular gaps and in one particular plane.

7.1.3.2 Dimensions over and between pins

The dimension over or between pins facilitates the calculation of the theoretical actual circular tooth thickness or space width at the pitch circle diameter based on the actual tooth thickness or space width where the pins have a line contact.

Table 3 — Size Inspection measuring instruments, methods and priorities

Priority	Parameter			
	S_{min}/E_{max}	$S_{v\ max}/E_{v\ min}$	$S_{v\ min}/E_{v\ max}$	S_{max}/E_{min}
	Method			
Highest	Measurement over and between balls	GO composite gauge	NO GO composite gauge	Measurement over and between balls
Lower ↓	Measurement over and between pins NO GO sector gauge Variable sector gauge Span size	Variable composite gauge Analysis calculations using size and form deviations	Variable composite gauge	Measurement over and between pins Variable sector gauge



Key

a Pitch circle.

b NO GO sector plug gauge or max. measurement between balls or pins.

c NO GO composite plug gauge.

d Min. measurement between balls or pins, aux.

e GO composite plug gauge.

f GO composite ring gauge.

g Max. measurement over balls or pins, aux.

h NO GO composite ring gauge.

i NO GO sector ring gauge or min. measurement over balls or pins.

Figure 2 — Elementary inspection methods for space widths and tooth thicknesses

7.1.3.3 NO GO sector gauge

The NO GO sector gauge is used to inspect the specified actual tolerance limit of the circular tooth thickness or space width at the minimum material condition of the part, where the gauge contacts only at the ends.

7.1.3.4 Span size over *k* teeth

The span measurement facilitates the calculation of the theoretical actual circular tooth thickness of external splines at the pitch circle diameter based on the measurement over a block of teeth. Before using this method, suitability should be checked.

7.1.3.5 Variable sector gauge

The variable sector gauge measures the actual circular tooth thickness or space width. The actual measurement is achieved using radially locking left and right hand flanks and comparison to a master having a known tooth thickness or space width.

7.1.4 Effective size

7.1.4.1 GO composite gauge

GO composite gauges are used to check

a) that the specified effective limits of tooth thickness or space width are not exceeded at the maximum material condition of the part,

b) the specified form diameter of the part, thus ensuring that the required tolerances are controlled for the full involute depth, and

c) the specified length of engagement, thus ensuring that the spline maximum material limit has not been exceeded.

7.1.4.2 Variable composite gauge

The variable composite gauge measures the effective size of tooth thickness or space width. The actual measurement is achieved using the radially locking left and right hand flanks and comparison to a master having a known tooth thickness or space width.

7.1.4.3 NO GO composite gauge

The NO GO composite gauge is used to check the specified effective limit of minimum tooth thickness or maximum space width, where the gauge contacts only at the ends.

7.1.4.4 Inspection of diameter at tooth tip (D_{ii} or D_{ee})

All these inspection methods require measuring the tooth tip (internal minor diameter, D_{ii}, or external major diameter, D_{ee}) using GO and NO GO plain (plug or ring) gauges or other acceptable measuring devices.