



# SLOVENSKI STANDARD

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**Ravni utori z evolventnimi boki na valjih - Metrski modul, bočno prileganje – 3. del:  
Kontrola**

Straight cylindrical involute splines - Metric module, side fit - Part 3: Inspection

### iTeh STANDARD PREVIEW

Cannelures cylindriques droites à flancs en développante - Module métrique, à centrage sur flancs - Partie 3: Vérification

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# INTERNATIONAL STANDARD

**ISO  
4156-3**

Second edition  
2021-02

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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*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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](http://www.iso.org/iso/foreword.html).

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

This second edition ~~replaces the first edition (ISO 4156-3:2005)~~, which has been technically revised.

The main changes compared to the previous edition includes:

- ISO/R 1938-1 has been removed from [Clause 2](#);
- ISO 268-1 and ISO 1328 (all parts) have been moved from [Clause 2](#) to Bibliography;
- symbols of length and arc length between two points, according to ISO 80000-3, have been adopted and used in the formulae;
- in [Figure 9](#), ball or pin contact diameter, internal spline has been added;
- in [Figure 12](#), measurement  $W$ , indication of base pitch, circular base thickness, and base diameter have been corrected;
- Table [10](#) has been revised;
- in [Figure 16](#), measurement of value  $A$  has been corrected;
- [Formula \(A.3\)](#) has been corrected;
- calculation results  $B_1$  and  $E_r$  in [A.3](#) have been corrected;
- in [Figure A.2](#), the figure and subfigure titles have been corrected.

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](http://www.iso.org/members.html).

**ISO 4156-3:2021(E)****Introduction**

ISO 4156 (all parts) 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 (all parts) 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 (all parts) 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.

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# Straight cylindrical involute splines — Metric module, side fit —

## Part 3: Inspection

### 1 Scope

This document provides data, guidance and requirements for the inspection of straight (non-helical) side fitting cylindrical involute splines.

Limiting dimensions, tolerances, manufacturing deviations 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, *Geometrical product specifications (GPS) — Dimensional measuring equipment — Part 1: Plain limit gauges of linear size*

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, *Geometrical product specifications (GPS) — Geometrical tolerancing — Datums and datum systems*

### 3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

### 4 Symbols and abbreviated terms

**NOTE** Some of the symbols used can 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 can seem to conflict with symbols used in this document. However, it was not thought necessary to distinguish between them, since the context will always preclude any ambiguity.

## ISO 4156-3:2021(E)

|                      |  |                   |
|----------------------|--|-------------------|
| $a_{\text{allowed}}$ | Limited maximum value of distance out of the actual tolerance limit  | $\mu\text{m}$     |
| $D$                  | Pitch diameter   | mm                |
| $D_b$                | Base diameter  | mm                |
| $D_{\text{ee}}$      | 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                |
| $D_{\text{Fe max}}$  | Maximum form diameter, external spline   | mm                |
| $D_{\text{Fi min}}$  | Minimum form diameter, internal spline   | mm                |
| $D_{\text{ii}}$      | Minor diameter, internal spline  | mm                |
| $D_{\text{ii min}}$  | Minimum minor diameter, internal spline  | mm                |
| $D_{\text{Re}}$      | Diameter of measuring ball or pin for external spline  | mm                |
| $D_{\text{Ri}}$      | Diameter of measuring ball or pin for internal spline  | mm                |
| $d_{\text{ce}}$      | Ball or pin contact diameter, external spline  | mm                |
| $d_{\text{ci}}$      | Ball or pin contact diameter, internal spline  | mm                |
| $E$                  | Basic space width, circular  | mm                |
| $E_{\text{max}}$     | Maximum actual space width   | mm                |
| $E_{\text{min}}$     | Minimum actual space width   | mm                |
| $E_r$                | Eccentric radial offset  | mm                |
| $E_v$                | Effective space width, circular  | mm                |
| $E_{v \text{ max}}$  | Maximum effective space width  | mm                |
| $E_{v \text{ min}}$  | Minimum effective space width  | mm                |
| $F_p$                | Total pitch deviation  | $\mu\text{m}$     |
| $F_\alpha$           | Total profile deviation  | $\mu\text{m}$     |
| $F_\beta$            | Total helix deviation  | $\mu\text{m}$     |
| $i$                  | Integer defining the tooth considered and has values 0, 1, 2, ..., z-1 (as used in <a href="#">Annex A</a> ) | —                 |
| $\text{inv } \alpha$ | Involute $\alpha (= \tan \alpha - \pi \cdot \alpha / 180^\circ)$   | —                 |
| $K_e$                | Approximation factor for external spline   | —                 |
| $K_i$                | Approximation factor for internal spline   | —                 |
| $k$                  | Number of measured teeth   | —                 |
| $L_{\text{STA}}$     | Statistical tolerance limit actual   | $\mu\text{m}$ , % |

|                            |  |                   |
|----------------------------|--|-------------------|
| $L_{STA \text{ absolute}}$ | Statistical tolerance limit actual absolute                      | $\mu\text{m}, \%$ |
| $L_{STA \text{ relative}}$ | Statistical tolerance limit actual relative                      | $\%$              |
| $l_{BA}$                   | Length between two points (e.g. point B and point A)             | mm                |
| $M_{Re}$                   | Measurement over two balls or pins, external splines             | mm                |
| $M_{Ri}$                   | Measurement between two balls or pins, internal                  | mm                |
| $m$                        | Module   | mm                |
| $n_{\text{allowed}}$       | Maximum allowed number of measured sizes outside tolerance limit | —                 |
| $p_b$                      | Base pitch   | mm                |
| $S$                        | Basic tooth thickness, circular                                  | mm                |
| $S_{\text{max}}$           | Maximum actual tooth thickness                                   | mm                |
| $S_{\text{min}}$           | Minimum actual tooth thickness                                   | mm                |
| $S_b$                      | Circular base thickness  | mm                |
| $S_{v \text{ max}}$        | Maximum effective tooth thickness                                | mm                |
| $S_{v \text{ min}}$        | Minimum effective tooth thickness                                | mm                |
| $s_{DE}$                   | Arc length between two points (e.g. point D and point E)         | mm                |
| $T$                        | Machining tolerance  | $\mu\text{m}$     |
| $T_v$                      | Effective clearance tolerance                                    | $\mu\text{m}$     |
| $W$                        | Measurement over $k$ teeth, external spline                      | mm                |
| $z$                        | Number of teeth  | —                 |
| $\alpha$                   | Pressure angle   | $^\circ$          |
| $\alpha_{ce}$              | Pressure angle at ball or pin diameter, external spline          | $^\circ$          |
| $\alpha_{ci}$              | Pressure angle at ball or pin diameter, internal spline          | $^\circ$          |
| $\alpha_D$                 | Standard pressure angle at pitch diameter                        | $^\circ$          |
| $\alpha_e$                 | Pressure angle at ball or pin centre, external spline            | $^\circ$          |
| $\alpha_i$                 | Pressure angle at ball or pin centre, internal spline            | $^\circ$          |
| $\Delta_{\text{safety}}$   | Safety recommendation value                                      | mm                |
| $\lambda$                  | Deviation allowance  | $\mu\text{m}$     |
| $\tau$                     | Angular pitch  | $^\circ$          |
| $\psi$                     | Phase angle  | $^\circ$          |

## 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.

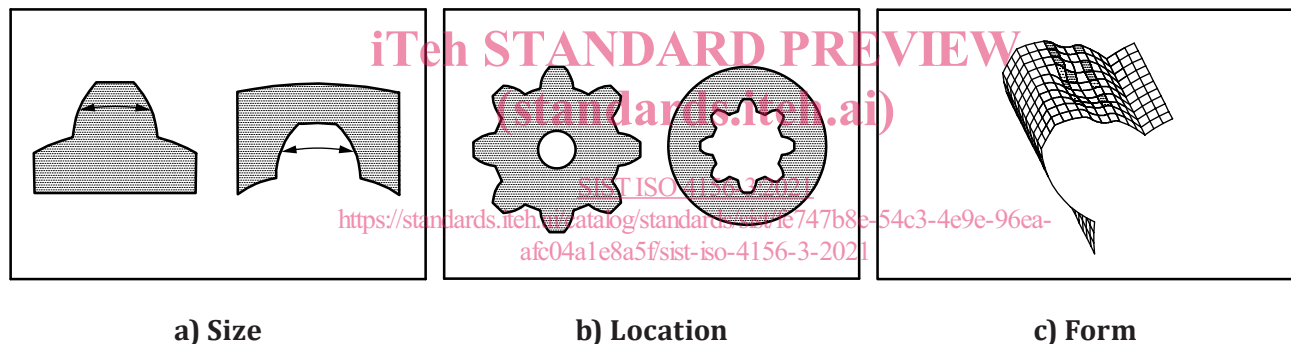
Unless otherwise specified, all measurements shall be made under zero measuring load.

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 form and size ISO 4156-1 and ISO 4156-2 apply.



NOTE 1 Size can be a quality feature (actual, effective).

NOTE 2 Location can be a quality feature (runout, coaxiality, perpendicularity).

NOTE 3 Form can be a quality feature (profile, helix, pitch).

**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<br>$S_{\min}/E_{\max}$ | Minimum effective clearance<br>$S_{v\max}/E_{v\min}$ | Maximum effective clearance<br>$S_{v\min}/E_{v\max}$ |
|-----------------|---|--|--|
| Parameter       |   |  |  |
| Standard method | X                                       | X  | —  |
| Method A        | X                                       | X  | X  |
| Method B        | —                                       | X  | X  |

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**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 increases 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.

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## 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.

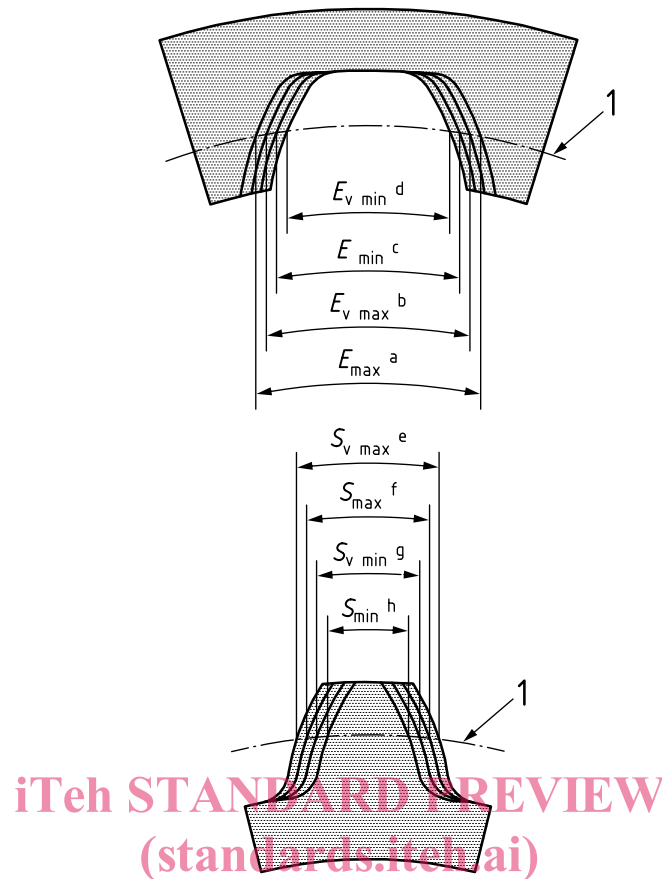
Table 3 — Size Inspection measuring instruments, methods and priorities

| 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<br>↓ | Measurement over and between pins<br>NO GO sector gauge<br>Variable sector gauge<br>Span size | Variable composite gauge<br>Analysis calculations using size and form deviations | Variable composite gauge | Measurement over and between pins<br>Variable sector gauge |

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#### Key

- 1 pitch circle
- a NO GO sector plug gauge or maximum measurement between balls or pins.
- b NO GO composite plug gauge.
- c Minimum measurement between balls or pins, auxiliary.
- d GO composite plug gauge.
- e GO composite ring gauge.
- f Maximum measurement over balls or pins, auxiliary.
- g NO GO composite ring gauge.
- h NO GO sector ring gauge or minimum 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.