# INTERNATIONAL STANDARD

**ISO 6545**

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# Acceptance conditions for gear hobbing machines — Testing of the accuracy

*Conditions de réception des machines à tailler les engrenages par fraise-mère — Contrôle de la précision*



Reference number
ISO 6545 : 1992 (E)

## 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 6545 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Sub-Committee SC 2, *Acceptance conditions for machines operating by removing metal.*





International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland

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# Acceptance conditions for gear hobbing machines — Testing of the accuracy

## 1 Scope

This International Standard specifies geometrical tests and practical tests, with reference to ISO 230-1 and also kinematic tests (accuracy of the transmission of motion) for general purpose and normal accuracy gear hobbing machines, with vertical or horizontal spindle. This International Standard also gives the terminology used for the main elements of the machine.

NOTE — In addition to terms used in the official ISO languages (English, French and Russian), this International Standard gives the equivalent terms in the German language; these are published under the responsibility of the member body for Germany (DIN). However, only the terms given in the official languages can be considered as ISO terms.

It deals only with the verification of the accuracy of the machine. It does not apply to the testing of the running of the machine (vibrations, abnormal noises, stick-slip motion of components, etc.) or to machine characteristics (such as speeds, feeds, etc.) which should generally be checked before the accuracy is tested.

## 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 230-1 : 1986, *Acceptance code for machine tools — Part 1: Geometric accuracy of machines operating under no-load or finishing conditions.*

ISO 701 : 1976, *International gear notation — Symbols for geometrical data.*

ISO 1328 : 1975, *Parallel involute gears — ISO system of accuracy.*

## 3 Preliminary remarks

**3.1** In this International Standard, the dimensions and the permissible deviations are expressed in millimetres and inches.

**3.2** To apply this International Standard, reference should be made to ISO 230-1, especially for the installation of the machine before testing, warming up of spindles and other moving parts, description of measuring methods and recommended accuracy of testing equipment.

**3.3** The sequence in which the geometrical tests are given is related to the sub-assemblies of the machine and this in no way defines the practical order of testing. In order to make the mounting of instruments or gauging easier, tests may be applied in any order.

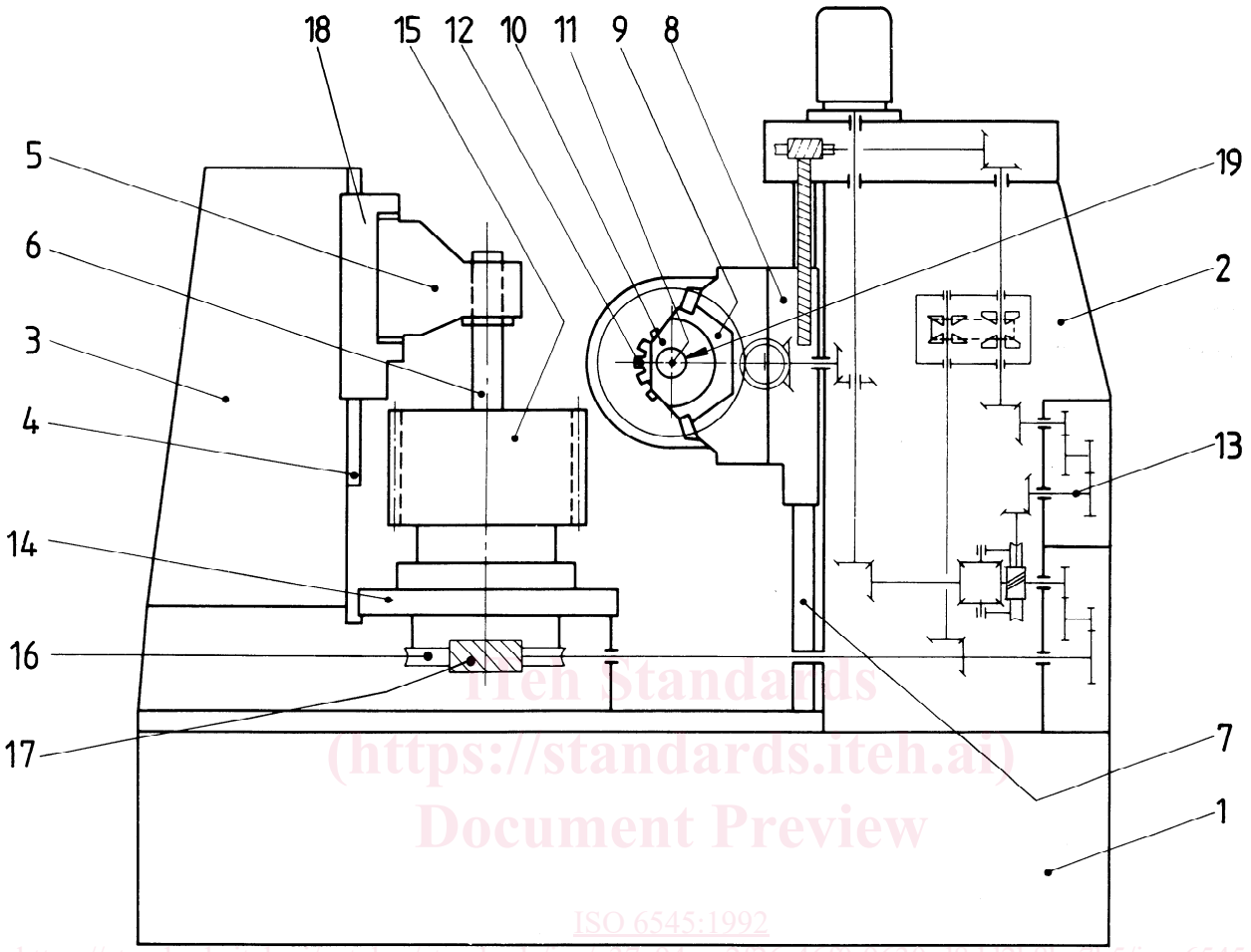
**3.4** When inspecting a machine, it is not always possible, or necessary, to carry out all the tests described in this International Standard. It is up to the user to choose, in agreement with the manufacturer, those tests relating to the existing elements of the machine or to the properties which are of interest, but these tests are to be clearly stated when ordering a machine.

**3.5** Practical tests shall be made with finishing cuts and not with roughing cuts which are liable to generate appreciable cutting forces. The actual feeds and speeds will be selected by the manufacturer to suit the particular machine.

**3.6** When the tolerance is established for a measuring range different from that given in this International Standard (see ISO 230-1 : 1986, 2.311) it should be taken into consideration that the minimum value of tolerance is 0,005 mm (0,000 2 in).

**3.7** The values using the formulae shall be rounded to the nearest 0,001 mm (0,000 1 in).

## 4 Terminology






| Ref. | English language | French language | Russian language | German language |
|---|---|---|---|---|
| 1 | Bed | Banc | Станина | Bett |
| 2 | Column | Montant | Передняя стойка | Hauptständer |
| 3 | Work-steady column | Montant de la lunette | Задняя стойка с люнетом | Gegenhalterständer |
| 4 | Work-steady slideway | Glissière de la lunette | Направляющая люнета | Gegenhalterführung |
| 5 | Work-steady | Lunette | Люнет | Gegenhalterarm |
| 6 | Work arbor (clamping arbor) | Arbre porte-piece | Оправка | Aufspanndorn |
| 7 | Axial slideway | Glissière du chariot axial | Направляющая суппорта фрезы | Axialschlittenführung |
| 8 | Axial slide | Chariot axial | Суппорт фрезы | Axialschlitten |
| 9 | Tangential slide | Chariot tangentiel (ou porte-fraise) | Поперечный суппорт | Tangentialschlitten |
| 10 | Outboard bearing | Contre-palier du madrin porte-fraise | Подшипник оправки фрезы | Fräsdorn-Gegenlager |
| 11 | Axis of rotation of the hob spindle | Axe de la broche porte-fraise | Ось шпинделя | Drehachse des Werkzeug-trägers |
| 12 | Hob | Fraise-mère | Фреза | Wälzfräser |
| 13 | Reference shaft | Arbre de référence | Эталонный вал | Bezugswelle |
| 14 | Work-table (-carrier; -spindle) | Plateau porte-pièce | Рабочий стол | Werkstückträger |
| 15 | Workpiece | Pièce | Обрабатываемая деталь | Werkstück |
| 16 | Index worm wheel | Roue de division | Делительное колесо | Teilschneckenrad |
| 17 | Index worm | Vis de division | Делительный винт | Teilschnecke |
| 18 | Work-steady slide | Chariot porte-lunette | Суппорт люнета | Gegenhalterschlitten |
| 19 | Hob arbor | Arbre porte-fraise | Фрезерная оправка | Fräserdorn |

## 5 Symbols

For the purposes of this International Standard, the following symbols in addition to those given in ISO 701 apply.

### 5.1 Reference workpiece

| | |
|---|---|
| $d_u$ | reference diameter |
| $m_{tu}$ | transverse module |
| $P_{tu}$ | transverse diametral pitch |
| $z_u$ | number of teeth |

### 5.2 Test workpiece

| | |
|---|---|
| $b$ | face width |
| $d$ | reference diameter |
| $m$ | normal module |
| $m_t$ | transverse module |
| $P$ | normal diametral pitch, in reciprocal inches |
| $P_t$ | transverse diametral pitch, in reciprocal inches |
| $z$ | number of teeth |
| $\beta$ | helix angle |

### 5.3 Capacity of the machine

| | |
|---|---|
| $d_{max}$ | reference diameter of the largest workpiece that can be hobbed on the machine |
| $m_{0,max}$ | maximum hob module |
| $P_{0,min}$ | minimum diametral pitch of the hob, in reciprocal inches |

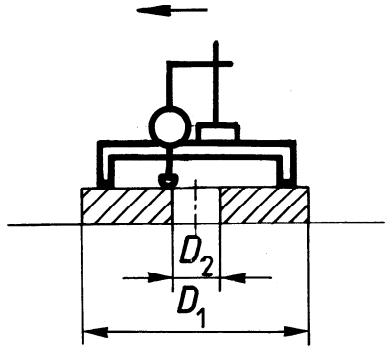
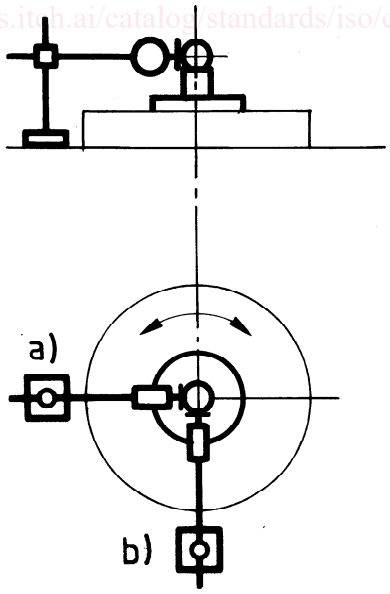
### 5.4 Accuracy of the machine or of the test gear

| | |
|---|---|
| $f_{dk}$ | high-frequency component of the angular transmission deviation |
| $f_{dk0}$ | part of $f_{dk}$ proportional to the transverse module of a reference or test workpiece |
| $f_{dkT}$ | part of $f_{dk}$ proportional to the reference diameter of a reference or test workpiece |
| $f_{dl}$ | low-frequency component of the angular transmission deviation |
| $f_{dl,max}$ | maximum amplitude (peak to peak) of the low-frequency component of the angular transmission deviation |
| $f_{f\beta}$ | helix form deviation |
| $f_{H\beta}$ | helix slope deviation |
| $f_{pt}$ | single pitch deviation |
| $f_{tk}$ | high-frequency component of the tangential linear transmission deviation |
| $f_{tl}$ | low-frequency component of the tangential linear transmission deviation |
| $f_{xk}$ | high-frequency component of the axial linear transmission deviation |
| $f_{xl}$ | low-frequency component of the axial linear transmission deviation |
| $F_d$ | angular transmission deviation |
| $F_p$ | total cumulative pitch deviation |
| $F_{pj}$ | cumulative pitch deviation |
| $F_t$ | tangential linear transmission deviation |
| $F_x$ | axial linear transmission deviation |
| $F_\alpha$ | total profile deviation |

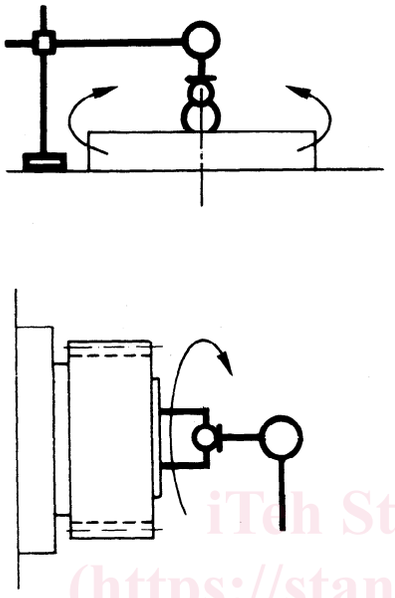
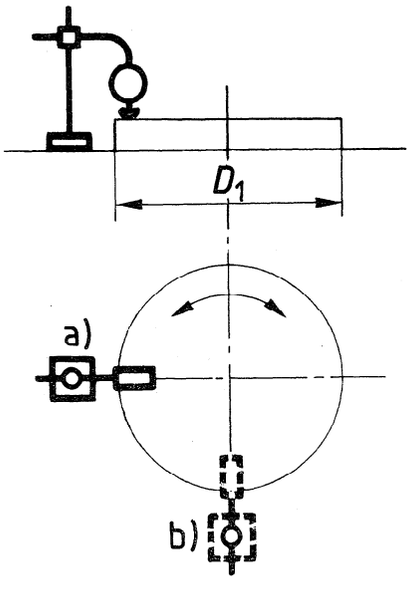
### 5.5 Additional symbols

| | |
|---|---|
| $p_1$ | number of periods of the cumulative pitch deviation defined in accordance with 8.2 |
| $s$ | length of arc on a reference circle |
| $z_S$ | number of starts of the index worm |
| $z_T$ | number of teeth of the index worm wheel |

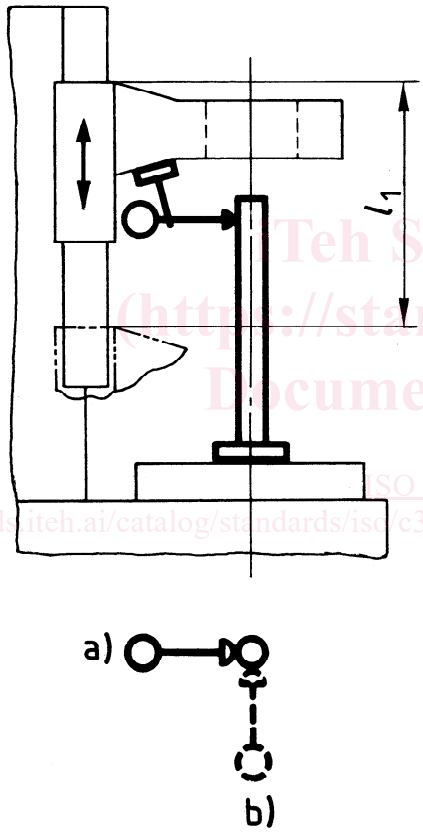
## 6 Geometrical tests

| No. | Diagram | Object |
|---|---|---|
| | | **A — WORK-TABLE** |
| G1 |  | Measurement of the diametral straightness of the surface of the work-table |
| G2 |  | Measurement of radial run-out of the axis of rotation of the work-table or work-spindle |

| Permissible deviation | | Measuring instruments | Observations and references to the ISO 230-1 : 1986 acceptance code |
|---|---|---|---|
| 0,001 mm | 0,000 1 in | | |
| $d$, $D$, $l$, $m$ in millimetres | $d$, $D$, $l$, $m$, $\frac{1}{P}$ in inches | | |
| $6 + 0{,}6\sqrt{D_1 - D_2}$ | $2{,}36 + 1{,}19\sqrt{D_1 - D_2}$ | Straightedge and dial gauge, level or other equipment | Subclauses 5.2 and 5.3<br>Trace the surface of the work-table with a precision dial gauge using the bridge-type straightedge as a reference.<br>Machines without work-tables do not require this test. For machines up to 500 mm diameter work-table check the straightness on two diameters and on machines with a work-table greater than 500 mm on four diameters. |
| Straight or concave | | | |
| $4 + 0{,}1\sqrt{d_{max}}$ | $1{,}57 + 0{,}2\sqrt{d_{max}}$ | Flat-tipped dial gauge, ball, and special support or test cylinder | Subclause 5.612<br>Place two gauges, located 90° apart at a) and b) against the ball, perpendicular to the axis of rotation of the work-spindle. Adjust the ball on the support so that the variations of the indicator readings of both dial gauges during one revolution of the work-table will be as small as possible.<br>The variations of the indicator readings at a) and b) shall be recorded as the measured radial run-out.<br>Take measurements in both directions of rotation of the work-spindle at a) and b). The largest of the indicator reading variations shall be recorded as the measured radial runout.<br>These measurements can also be made by using a test cylinder in place of the ball and special support. |

| No. | Diagram | Object |
|---|---|---|
| G3 |  | Measurement of periodic axial slip of the work-spindle |
| G4 |  | Measurement of camming of the work-table |

| Permissible deviation | | Measuring instruments | Observations and references to the ISO 230-1 : 1986 acceptance code |
|---|---|---|---|
| 0,001 mm | 0,000 1 in | | |
| $d$, $D$, $l$, $m$ in millimetres | $d$, $D$, $l$, $m$, $\frac{1}{P}$ in inches | | |
| $4 + 0{,}06\sqrt{d_{max}}$ | $1{,}57 + 0{,}12\sqrt{d_{max}}$ | Flat-tipped dial gauge, ball and special support | Subclauses 5.622.1 and 5.622.2<br><br>Place the stylus of the dial gauge in alignment with the axis of rotation of the work-spindle and against the ball adjusted as in test G2.<br><br>Take measurements in both directions of rotation of the work-spindle.<br><br>On machines where the work arbor axis is horizontal, apply a force $F$, if necessary*), in order to eliminate the axial play in the bearing; the value of this force shall be specified by the manufacturer.<br><br>*) Not necessary in the case of axially preloaded bearings. |
| $6 + 0{,}25\sqrt{D_1}$ | $2{,}36 + 0{,}5\sqrt{D_1}$ | Crown-tipped dial gauge | Subclause 5.632<br><br>Touch the work-table surface with a dial gauge successively at two points a) and b) located 90° apart on the largest possible measuring circle diameter (one measuring point a) or b) opposite the hob).<br><br>Take measurements in both directions of rotation of the work-table. The largest of the indicator reading variations shall be recorded as the measured camming.<br><br>On machines where the work arbor axis is horizontal, apply a force $F$, if necessary*), as in test G3.<br><br>NOTE — It may be useful to put a flat block between the stylus and the table surface.<br><br>*) Not necessary in the case of axially preloaded bearings. |

| No. | Diagram | Object |
|---|---|---|
| | | **B — WORK-STEADY** |
| G5 |  <br>$l_1$ maximum working traverse of the work-steady | Measurement of parallelism of the work-steady movement with the axis of rotation of the work arbor |

| Permissible deviation | | Measuring instruments | Observations and references to the ISO 230-1 : 1986 acceptance code |
|---|---|---|---|
| 0,001 mm | 0,000 1 in | | |
| $d$, $D$, $l$, $m$ in millimetres | $d$, $D$, $l$, $m$, $\frac{1}{P}$ in inches | | |
| a) | | Crown-tipped dial gauge and cylindrical test mandrel | Subclause 5.422.3 |
| Permissible deviation at the free end of the test mandrel | | | Attach the dial gauge to the work-steady near the bore of the steady, and place the tip against the test mandrel in positions a) and b). Adjust the test mandrel to its position of mean radial run-out for each measuring direction. |
| towards the axis of the hob spindle: | | | |
| $8 + 0{,}8\sqrt{l_1}$ | $3{,}15 + 1{,}59\sqrt{l_1}$ | | Take measurements at a) and b) over the full working traverse of the work-steady, with the work-steady slide clamped, if applicable. |
| in the opposite direction: | | | |
| $4 + 0{,}4\sqrt{l_1}$ | $1{,}57 + 0{,}79\sqrt{l_1}$ | | Determine the mean of the variations of the indicator readings at a) and b) per spindle revolution. The variation of the mean values is the deviation of parallelism. |
| b) | | | |
| $6 + 0{,}5\sqrt{l_1}$ | $2{,}36 + 0{,}99\sqrt{l_1}$ | | These measurements may also be taken with a recording instrument while the work arbor is rotating. |