INTERNATIONAL STANDARD

ISO 13041-2

First edition
2008-10-15

Test conditions for numerically controlled turning machines and turning centres —

Part 2: Geometric tests for machines with a vertical workholding spindle

Conditions d'essai des tours à commande numérique et des centres de tournage —

Partie 2: Essais géométriques pour les machines à broche verticale

Reference number
ISO 13041-2:2008(E)

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Published in Switzerland

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 13041-2 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

ISO 13041 consists of the following parts, under the general title *Test conditions for numerically controlled turning machines and turning centres*:

— *Part 1: Geometric tests for machines with horizontal workholding spindle*

— *Part 2: Geometric tests for machines with vertical workholding spindle*

— *Part 3: Geometric tests for machines with inverted vertical workholding spindles*

— *Part 4: Accuracy and repeatability of positioning of linear and rotary axes*

— *Part 5: Accuracy of feeds, speeds and interpolations*

— *Part 6: Accuracy of a finished test piece*

— *Part 7: Evaluation of contouring performance in the coordinate planes*

— *Part 8: Evaluation of thermal distortions*

Introduction

The object of ISO 13041 (all parts) is to supply information as wide and comprehensive as possible on geometric, positional, contouring, thermal and machining tests which can be carried out for comparison, acceptance, maintenance or any other purpose.

ISO 13041 (all parts) specifies, with reference to ISO 230-1 and ISO 230-7, tests for turning centres and numerically controlled turning machines with/without tailstocks standing alone or integrated in flexible manufacturing systems. ISO 13041 (all parts) also establishes the tolerances or maximum acceptable values for the test results corresponding to general-purpose and normal-accuracy turning centres and numerically controlled turning machines.

Test conditions for numerically controlled turning machines and turning centres —

Part 2: Geometric tests for machines with a vertical workholding spindle

1 Scope

This part of ISO 13041 specifies, with reference to ISO 230-1 and ISO 230-7, the geometric tests on general purpose numerically controlled (NC) turning machines and tuning centres with vertical workholding spindles, as well as the corresponding applicable tolerances.

This part of ISO 13041 explains different concepts or configurations and common features of NC turning machines and turning centres with vertical workholding spindles. It also provides a terminology and designation of controlled axes (see Figures 1, 2, 3, and 4).

This part of ISO 13041 deals only with the verification of the accuracy of the machine. It does not apply to the operational testing of the machine (e.g. vibration, abnormal noise, stick slip motion of components) nor to machine characteristics (e.g. speeds, feeds) as such checks are generally carried out before testing the accuracy.

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 230-1:1996, *Test code for machine tools — Part 1: Geometric accuracy of machines operating under no-load or finishing conditions*

ISO 230-7:2006, *Test code for machine tools — Part 7: Geometric accuracy of axes of rotation*

ISO 841:2001, *Industrial automation systems and integration — Numerical control of machines — Coordinate system and motion nomenclature*

3 Terms and definitions

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

3.1
turning machine
machine tool in which the principal movement is the rotation of the workpiece against the stationary cutting tool(s)

3.2
manual control
mode of operation where each movement of the machine is individually initiated and controlled by the operator

3.3
numerical control (NC)
computerized numerical control (CNC)
automatic control of a process performed by a device that makes use of numerical data introduced while the operation is in progress

[ISO 2806:1994]

3.4
manually controlled turning machine
turning machine whose process steps for the machining are controlled or started by an operator without support from a numerically controlled machining program

3.5
numerically controlled turning machine
NC turning machine
turning machine that operates under **numerical control** (**NC**, 3.3) or **computerized numerical control** (**CNC**, 3.3)

3.6
numerically controlled vertical spindle-turning machine
numerically controlled turning machine where the workpiece is mounted on a vertical workholding spindle against the stationary cutting tool(s) and where cutting energy is brought by the workpiece and not by the tool

NOTE 1 This machine is controlled by a numerical control (NC) providing automatic function.

NOTE 2 For vertical spindle-turning machines with inverted workholding spindle, i.e. with workholding device at the lower end of the spindle, see ISO 13041-3.

3.7
vertical spindle-turning centre
numerically controlled vertical spindle-turning machine equipped with toolholding spindles and the capacity to orientate the workholding spindle around its axis

NOTE 1 This machine may include additional features such as automatic toolchanging from a magazine or Y-axis motion.

NOTE 2 For vertical spindle-turning machines with inverted workholding spindle, i.e. with workholding device at the lower end of the spindle, see ISO 13041-3.

4 Preliminary remarks

4.1 Units of measurement

In this part of ISO 13041, all linear dimensions, deviation, and corresponding tolerances are expressed in millimetres; angular dimensions are expressed in degrees, and angular deviations and the corresponding tolerance are expressed in ratios, but in some cases microradians or arc seconds may be used for clarification purposes. The equivalence of the following expressions should always be kept in mind.

$$0{,}010/1\,000 = 10 \times 10^{-6} = 10\ \mu\text{rad} \approx 2''$$

4.2 Reference to ISO 230-1 and ISO 230-7

To apply this part of ISO 13041, reference shall be made to ISO 230-1, especially for installation of the machine before testing, warming up of the spindle and over-moving components, description of measuring methods and recommended measurement uncertainty of testing equipment.

In the “Observation” block of the tests described in Clause 5, the instructions are preceded by a reference to the corresponding clause in ISO 230-1 or in ISO 230-7 in cases where the test concerned is in compliance with their specifications. Tolerances are given for each test (see G1 to G21).

4.3 Machine levelling

Prior to conducting tests on a machine, the machine should be levelled according to the recommendations of the supplier/manufacturer (see ISO 230-1:1996, 3.11).

4.4 Test sequence

The sequence in which tests are presented in this part of ISO 13041 in no way defines the practical order of testing. In order to make the mounting of instruments or gauging easier, tests may be performed in any order.

4.5 Test to be performed

When testing a machine, it is not always necessary or possible to carry out all the tests described in this part of ISO 13041. When the tests are required for acceptance purposes, it is up to the user to choose, in agreement with the supplier/manufacturer, those tests relating to the components and/or the properties of the machine which are of interest. These tests are to be clearly stated when ordering a machine. Mere reference to this part of ISO 13041 for the acceptance tests, without specifying the tests to be carried out, and without agreement on the relevant expenses, cannot be considered as binding for any contracting party.

4.6 Measuring instruments

The measuring instruments indicated in the tests described in the following are examples only. Other instruments measuring the same quantities and having at least the same measurement uncertainty may be used. Linear displacement sensors shall have a resolution of 0,001 mm or better.

4.7 Diagrams

In this part of ISO 13041, for reasons of simplicity, the diagrams associated with geometric tests generally illustrate only one type of machine.

4.8 Software compensation

When built-in software facilities are available for compensating geometric, positioning, contouring, and thermal deviations, their use during these tests should be based on an agreement between the user and the supplier/manufacturer. When software compensation is used, this shall be stated in the test report.

4.9 Minimum tolerance

When the tolerance for a geometric test is established for a measuring length different from that given in this part of ISO 13041 (see ISO 230-1:1996, 2.311), it shall be taken into consideration that the minimum value of tolerance is 0,005 mm.

4.10 Machine classifications

The machines considered in this part of ISO 13041 are divided into the following basic configurations:

— type A: single column machines (Figure 1);

— type B: dual column machines (Figure 2).

Type B machine configurations are further classified into the following types:

— fixed columns — portal type;

— moving columns — gantry type.

4.11 Linear motions

For simplicity, all the machine examples shown in Figures 1 and 2 use the axis designation of a letter and a number (e.g. X, X1, X2…) as defined in ISO 841:2001, 6.1. In all examples the use of the letters U, V, or W could be substituted.

4.12 Turrets — toolholding components (element)

Depending on the machine configuration, cutting tools (stationary or power driven) can be located on the railhead ram and/or the side head ram and/or the turret. An automatic tool change device can also be used. However, ISO 13041 (all parts) does not provide any test methods for automatic tool change operations.

4.13 Machine size category

The machines are classified into four size categories, on the basis of the criteria specified in Table 1.

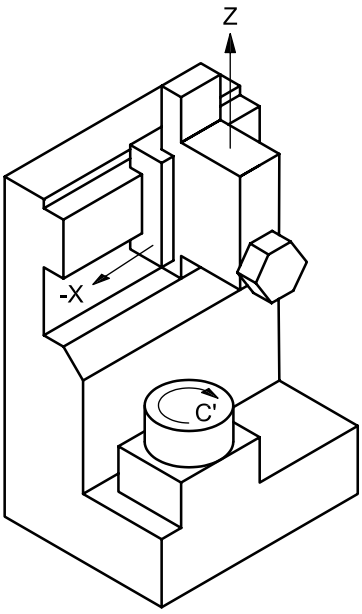
Table 1 — Machine size range

Criteria	Category 1	Category 2	Category 3	Category 4
Nominal diameter of chuck d	$d \leqslant 500$	$500 < d \leqslant 1\,000$	$1\,000 < d \leqslant 5\,000$	$d > 5\,000$
Diameter of workholding spindle/table D	$D \leqslant 500$	$500 < D \leqslant 1\,000$	$1\,000 < D \leqslant 5\,000$	$D > 5\,000$

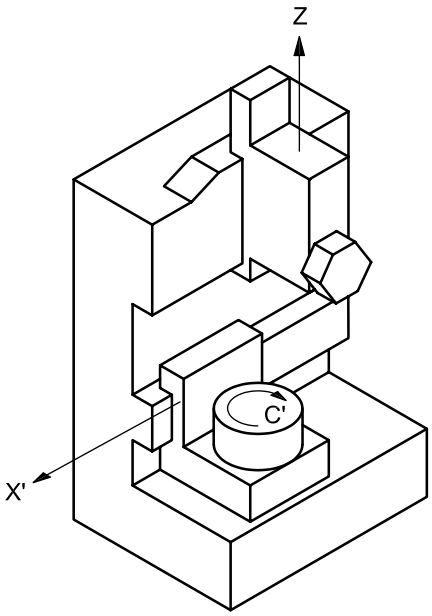
NOTE 1 The choice of criteria is at the manufacturer's discretion.

NOTE 2 Nominal diameter of chuck (up to 800 mm) is defined in ISO 3442-1, ISO 3442-2, and ISO 3442-3.

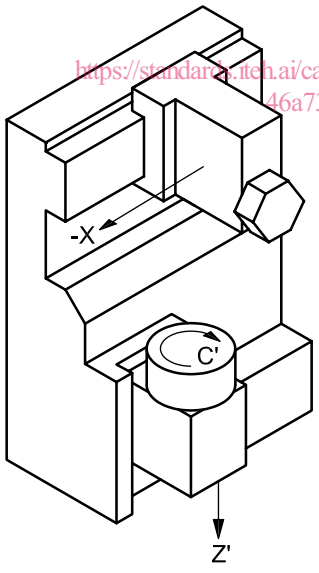
4.14 Machine configurations



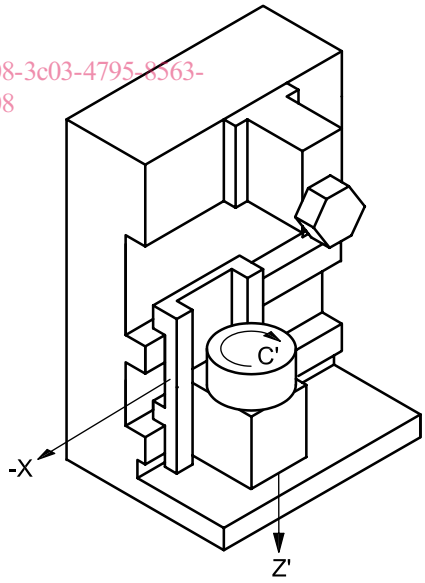
a) Compound head type



b) Shared motion (moving workholding spindle) type

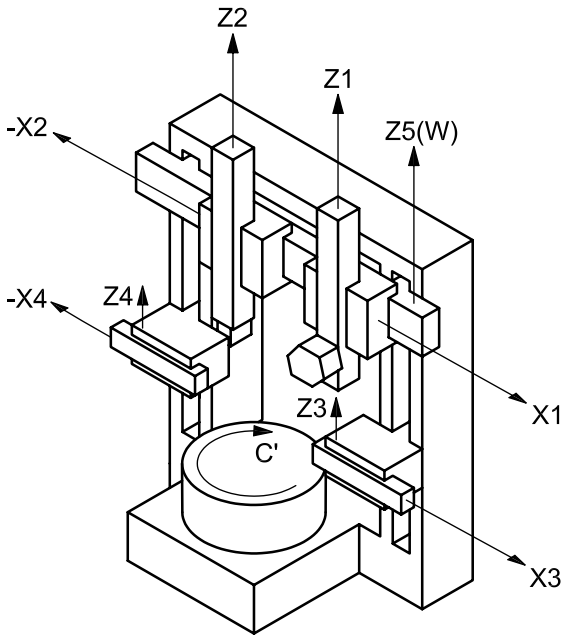


c) Shared motion (moving head/saddle) type

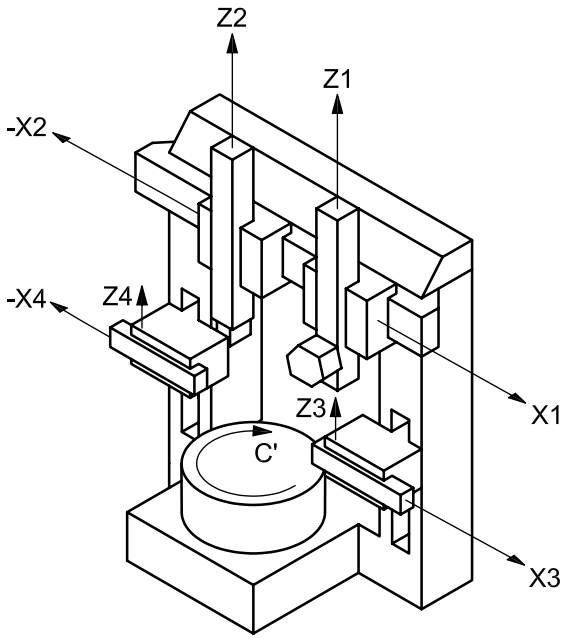


d) Compound workholding spindle type

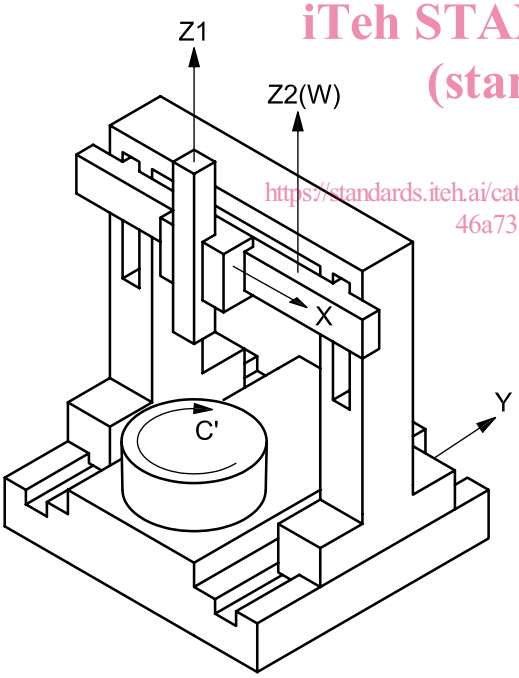
Figure 1 — Examples of machine configurations: single column machines (type A)



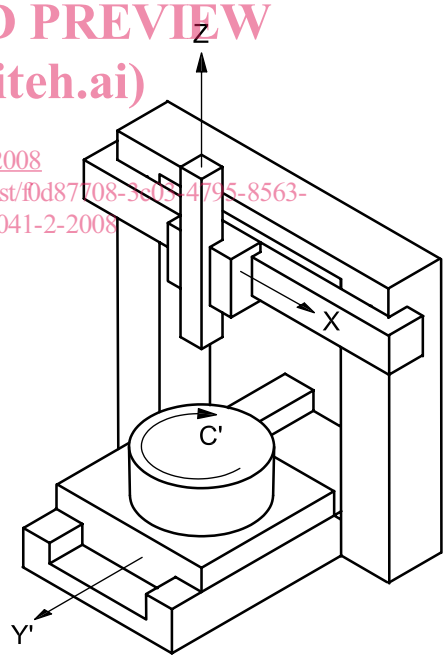
a) Fixed column, moving cross-rail



b) Fixed column, fixed cross-rail



c) Moving column (gantry type), moving cross-rail



d) Fixed column (portal type), moving workholding spindle (Y axis)

Figure 2 — Examples of machine configurations: dual column machines (type B)

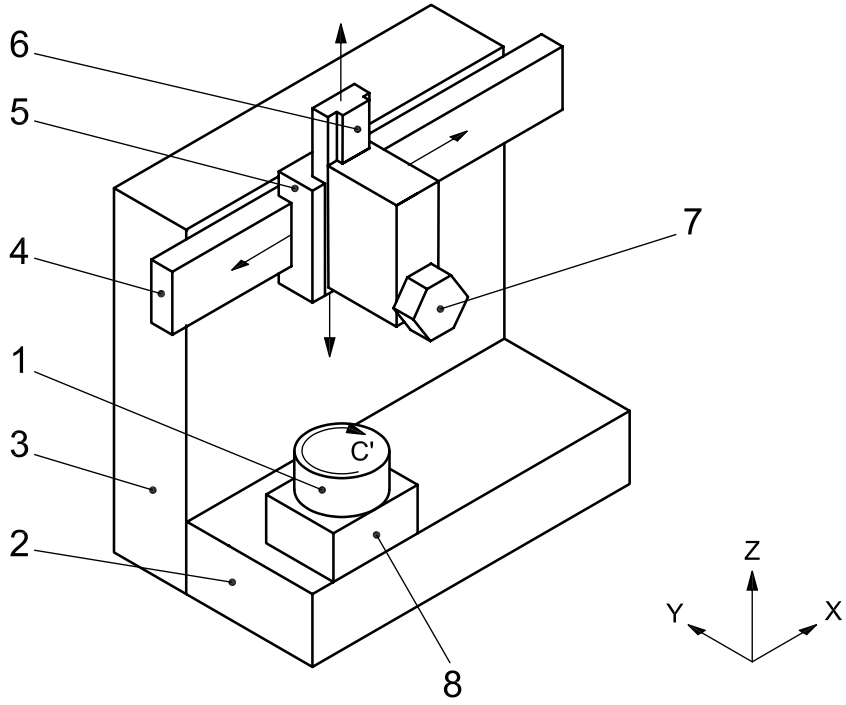


Figure 3 — Machine with single column

Table 2 — Terminology corresponding to Figure 3

Item number	Designation		
	English	German	French
1	workholding spindle (turntable)	Spannfutter	broche porte-outils
2	base	Maschinenbett	base
3	column	Maschinenständer	montant
4	cross-rail	Querführung	traverse porte-chariot
5	railhead (saddle)	Querschlitten	chariot de traverse (traînard)
6	turret slide	Revolverschlitten	chariot de tourelle
7	turret	Revolver	tourelle
8	workholding spindle head	Spindelkasten	tête de broche porte-outils