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## Test conditions for numerically controlled turning machines and turning centres —

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

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

*Partie 3: Essais géométriques pour les machines à broches verticales inversées*

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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.

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ISO 13041-3 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 a horizontal workholding spindle*
- *Part 2: Geometric tests for machines with a 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*

# Test conditions for numerically controlled turning machines and turning centres —

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

### 1 Scope

ISO 13041-3:2008 specifies, with reference to ISO 230-1 and ISO 230-7, the geometric tests on general-purpose, numerically controlled (NC) turning machines and turning centres with inverted vertical workholding spindles, as well as the corresponding applicable tolerances.

This part of ISO 13041 presents the different concepts or configurations and common features of NC turning machines and turning centres with inverted vertical 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 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*

### 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 principle movement is on 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 by an NC-machining program

**3.5**  
**numerically controlled turning machine**  
**NC turning machine**

turning machine that operates under numerical control (NC) or computerized numerical control (CNC)

**3.6**  
**turning centre**

NC turning machine equipped with power-driven tool(s) and the capacity to orientate the work-holding spindle around its axis.

NOTE It can include additional features such as automatic tool changing from a turret and/or magazine.

**3.7**  
**numerically controlled turning machine with inverted vertical workholding spindle**  
**NC turning machine with inverted vertical workholding spindle**

NC turning machine where the workpiece is mounted on an inverted vertical workholding spindle equipped with a workholding device at the lower end of the workholding spindle.

NOTE For other types of vertical workholding spindle machine, see ISO 13041-2.

**3.8**  
**turning centre with inverted vertical workholding spindle**

turning centre having an inverted vertical workholding spindle equipped with a workholding device at the lower end of the vertical workholding spindle.

NOTE 1 It can include additional features such as automatic tool changing from a magazine or Y-axis motion.

NOTE 2 For other types of vertical workholding spindle turning centre, see ISO 13041-2.

## 4 Preliminary remarks

### 4.1 Measuring units

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

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

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

For application of this part of ISO 13041, reference shall be made to ISO 230-1 or ISO 230-7, especially for the installation of the machine before testing, warming-up of spindles and other moving parts, the description of measuring methods, and recommended accuracy of testing equipment.

In the "Observations" block of tests described in Clauses 5 and 6, the instructions are preceded by a reference to the corresponding clause/subclause in ISO 230-1 and/or ISO 230-7 in cases where the test concerned is in compliance with their specifications. Tolerances are given for each test (see G1 to G20 and R1 to R2).

## 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 Testing sequence

The sequence in which the geometric tests are given 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 Tests to be performed

When testing a machine, it is not always necessary or possible to carry out all the tests given in this part of ISO 13041. When the tests are required for acceptance purposes, the choice of tests relating to the components and/or the properties of the machine of interest is at the discretion of the user, in agreement with the supplier/manufacturer. The tests to be used are to be clearly stated when ordering a machine. A 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 relation to the tests given in Clauses 5 and 6 are examples only. Other instruments measuring the same quantities and having at least the same measurement uncertainty and the same resolution may be used. Linear displacement sensors shall have a resolution of 0,001 mm or better.

## 4.7 Diagrams

For reasons of simplification, the figures in this part of ISO 13041 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 agreement between the user and the supplier/manufacturer. When the software compensation is used, this shall be stated in the test reports.

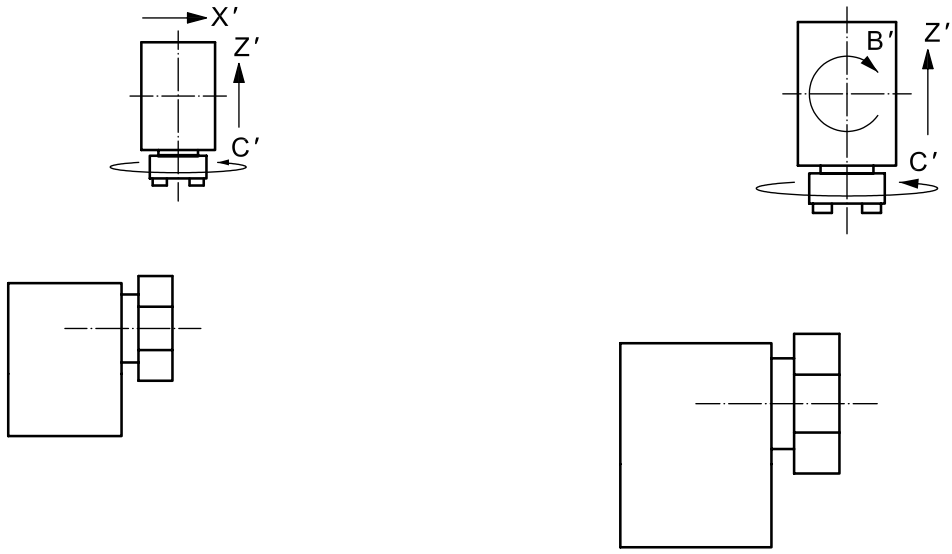
## 4.9 Minimum tolerance

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, descriptions, terminology and designation of axes

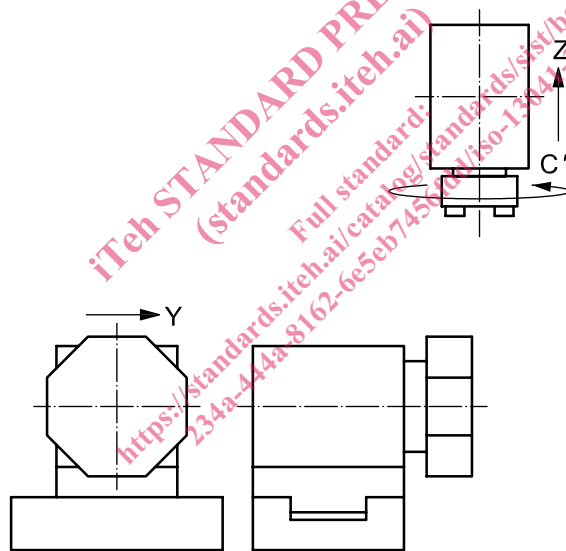
The machines considered in this part of ISO 13041 are divided into three basic configurations, as shown in Figure 1.

This type of machine tool may also be considered as a machining unit in an FMS (flexible manufacturing system).



a) Basic configuration

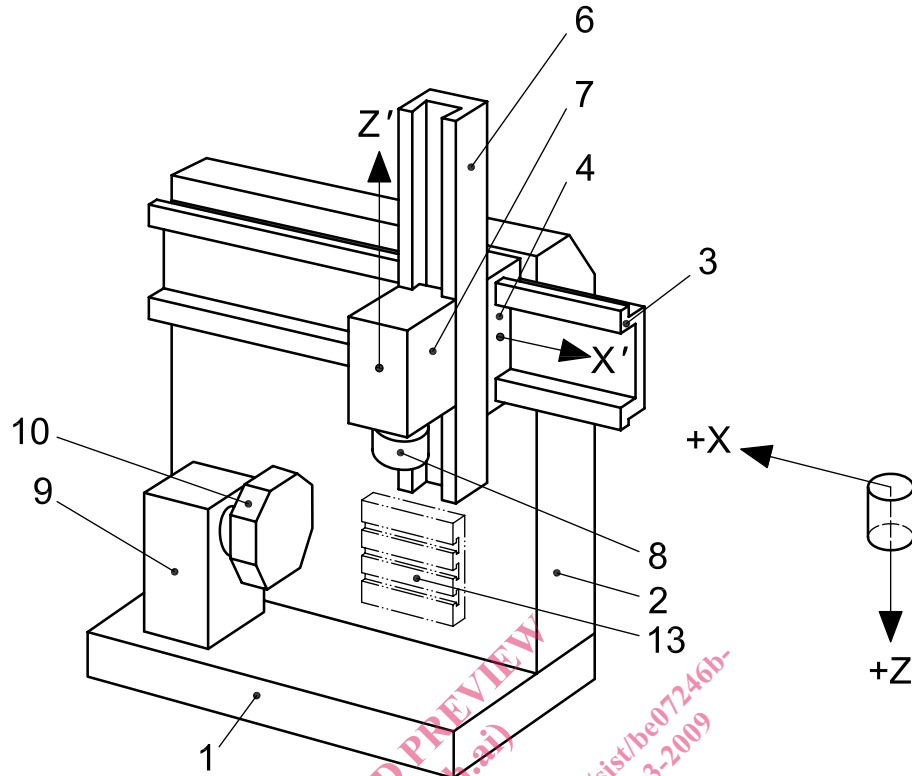
b) Workhead with B axis



c) Turret with Y axis

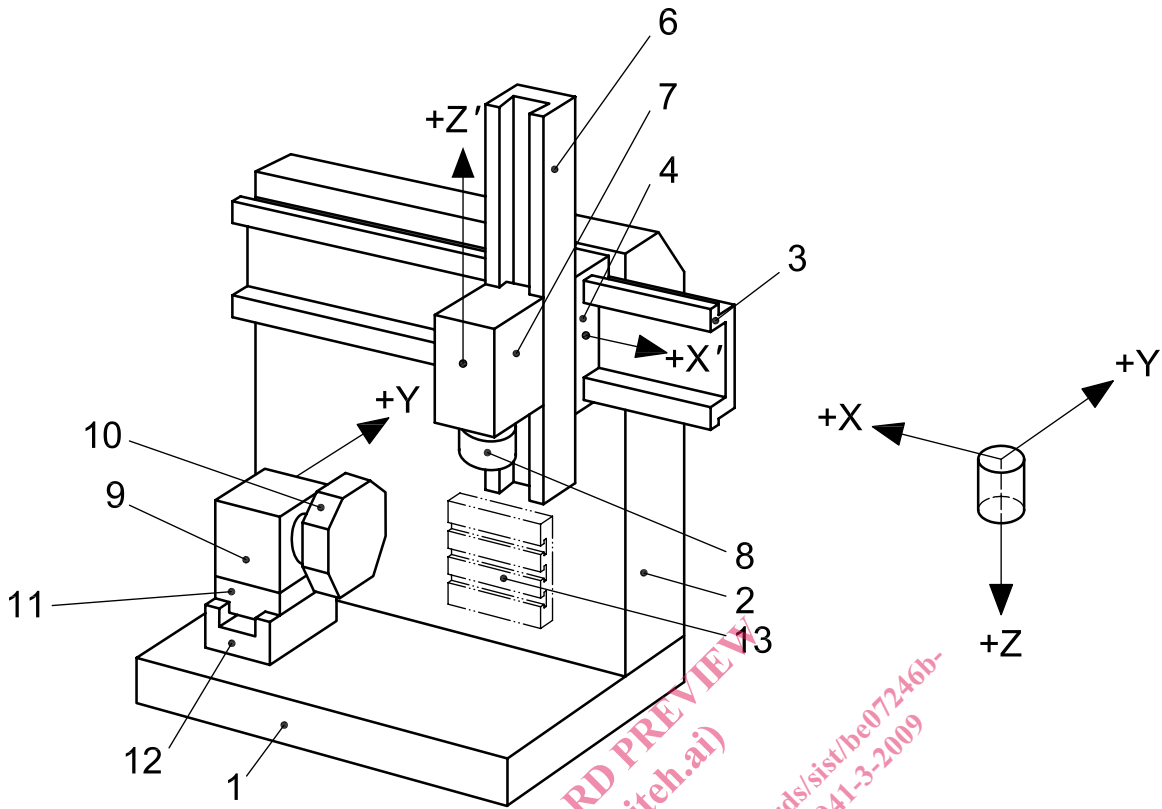
Figure 1 — Three machine configurations with one workhead and one turret





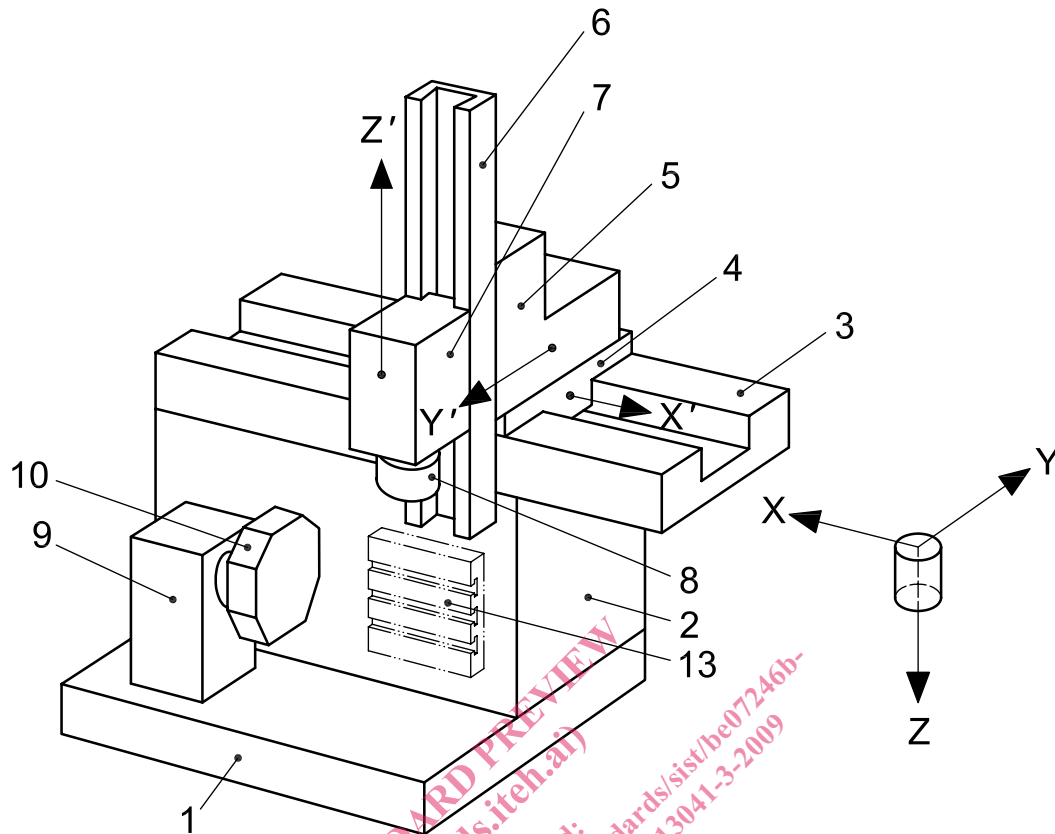
For the component nomenclature, refer to Table 1.

Figure 2 — Example of inverted vertical turning machine



For the component nomenclature, refer to Table 1.

Figure 3 — Example of inverted vertical turning machine (turret head with Y-axis motion)



For the component nomenclature, refer to Table 1.

Figure 4 — Example of inverted vertical turning machine (spindle with Y-axis motion)

Table 1 — Component nomenclature (see Figures 2, 3 and 4)

Item number	Designation		
	English	French	German
1	base	base	Maschinenbett
2	column	montant	Maschinenständer
3	cross rail	traverse porte-chariot	Querführung
4	carriage, X axis	chariot, axe X	Schlitten, X Achse
5	carriage, Y axis	chariot, axe Y	Schlitten, Y Achse
6	carriage, Z axis	chariot, axe Z	Schlitten, Z Achse
7	workholding spindle head stock	poupée fixe de la broche	Spindelkasten
8	workholding spindle	broche porte-pièce	Werkstückspindel
9	turret head	porte-tourelle	Revolverkopf
10	turret	tourelle	Revolver
11	turret head carriage	chariot du porte-tourelle	Revolverkopfschlitten
12	turret head slideway, Y axis	coulisseau du porte-tourelle, axe Y	Revolverkopfführung, Y Achse
13	tool plate	plateau à outils	Werkzeugspannplatte

**4.11 Turrets**

Vertical turning centres have not only stationary tools but also power-driven rotary tools, which are fitted on the turret or tool plate (item 13 in Figures 2, 3 and 4). When the number of tools expected to be used exceeds the capacity of the turret, an automatic change of tools in the turret, or a change of turret, can be provided. An automatic tool change device can also be required in cases of power-driven spindles in which the tools can be automatically set. However, ISO 13041 does not provide any test methods for automatic tool change operations.

**4.12 Machine size categories**

Machines are classified into three size categories, on the basis of the criteria specified in Table 2.

**Table 2 — Machine size range**

Criteria	Category 1	Category 2	Category 3
Nominal chuck diameter, <i>d</i>	$d \leq 250$	$250 < d \leq 400$	$400 < d$
Maximum turning diameter, <i>D</i>	$D \leq 315$	$315 < D \leq 500$	$500 < D$
NOTE 1	The choice of criteria is at the manufacturer's discretion.		
NOTE 2	Nominal chuck diameter is defined in ISO 3442-1, in ISO 3442-2 and in ISO 3442-3.		

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