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Test conditions for numerically controlled turning machines and turning centres —

Part 1:
Geometric tests for machines with a horizontal workholding spindle

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

Partie 1: Essais géométriques pour les machines à broche horizontale

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Foreword

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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 13041-1 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 vertical workholding spindle*

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

— *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 is to supply information as wide and comprehensive as possible on tests which can be carried out for comparison, acceptance, maintenance or any other purpose.

ISO 13041 specifies, with reference to the relevant parts of ISO 230, *Test code for machine tools,* tests for turning centres and numerically controlled turning machines with/without tailstocks, standing alone or integrated in flexible manufacturing systems. ISO 13041 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.

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Test conditions for numerically controlled turning machines and turning centres —

Part 1:
Geometric tests for machines with a horizontal workholding spindle

1   Scope

This part of ISO 13041 specifies, with reference to ISO 230-1, the geometric tests on numerically controlled (NC) turning machines and turning centres, of normal accuracy, with horizontal work spindle(s) as defined in 3.1 and 3.2.

This part of ISO 13041 specifies the applicable tolerances corresponding to the tests mentioned above.

This part of ISO 13041 explains different concepts or configurations and common features of NC turning machines and turning centres. It also provides a terminology and designation of controlled axes (see Figure 1 and Table 1).

This part of ISO 13041 deals only with the verification of the accuracy 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 841:2001, *Industrial automation systems and integration — Numerical control of machines — Coordinate system and motion nomenclature*

ISO 3442:1991, *Self-centring chucks for machine tools with two-piece jaws (tongue and groove type) — Sizes for interchangeability and acceptance test specifications*
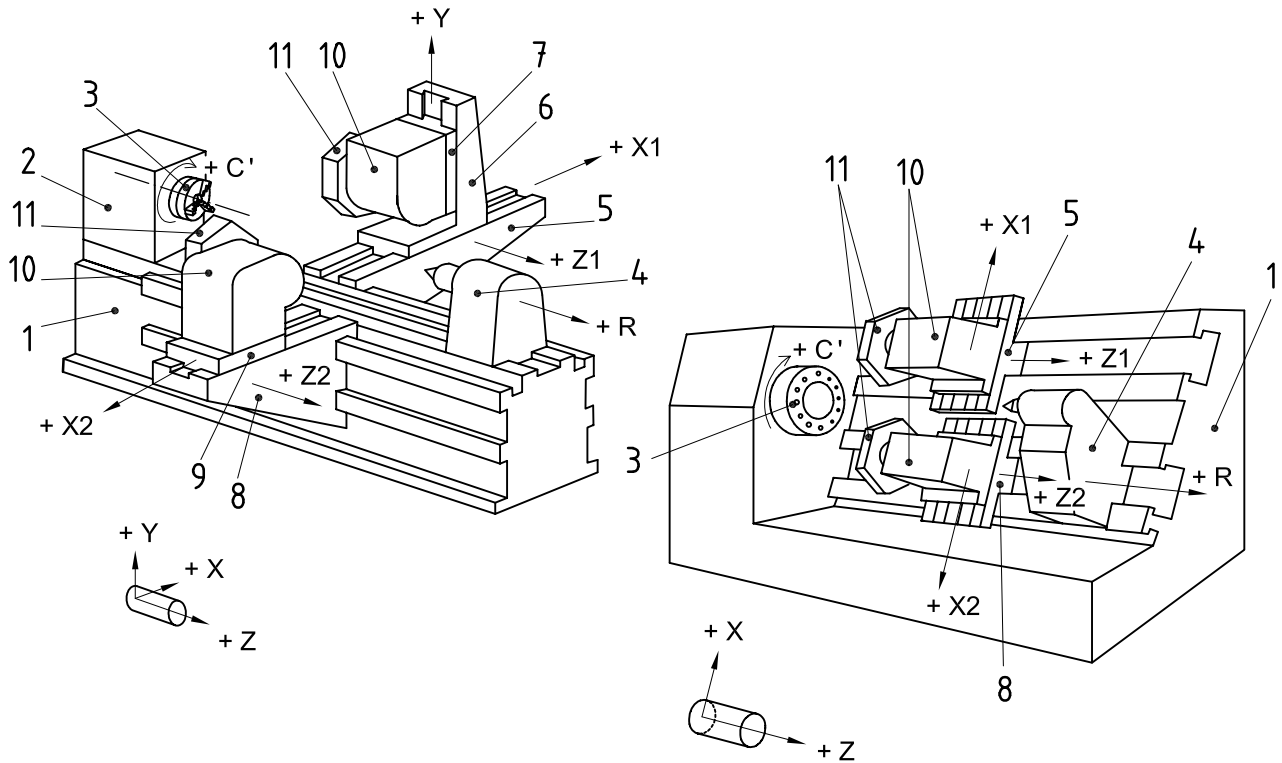
Figure 1 — Example of a horizontal-spindle turning centre

Table 1 — Terminology

Item number	English		French		German	
1	Bed		Banc		Bett	
2	Workhead		Porte-pièce		Spindelkasten	
3	Work spindle,	C′ axis	Broche porte-pièce,	axe C′	Arbeitsspindel,	C′-Achse
4	Tail stock,	R axis	Contre-poupée,	axe R	Reitstock,	R-Achse
5	Carriage 1,	Z axis	Chariot 1,	axe Z	Schlitten 1,	Z- Achse
6	Turret slide 1,	X axis	Chariot de tourelle,	axe X	Revolverschlitten 1,	X-Achse
7	Vertical slide,	Y axis	Chariot vertical,	axe Y	Verticalschlitten,	Y-Achse
8	Carriage 2,	Z2 axis	Chariot 2,	axe Z2	Schlitten 2,	Z2-Achse
9	Turret slide 2,	X2 axis	Chariot de tourelle 2,	axe X2	Revolverschlitten 2,	X2-Achse
10	Turret head 1 and 2		Tourelles 1 et 2		Revolverkopf 1 und 2	
11	Indexing turret 1 and 2		Tourelles à indexage 1 et 2		Revolverscheibe 1 und 2	
NOTE In addition to terms used in two of the three official ISO languages (English and French), this part of ISO 13041 gives the equivalent terms in German; these are published under the responsibility of the member body/National Committee for Germany (DIN). However, only the terms and definitions given in the official languages can be considered as ISO terms and definitions.						

3 Terms and definitions

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

3.1
numerically controlled turning machine
numerically controlled machine tool in which the principal movement is the rotation of the workpiece against the stationary cutting tool(s) and where cutting energy is provided by the workpiece and not by the tool

NOTE   The numerical control provides an automatic function.

3.2
turning centre
NC turning machine equipped with power driven tool(s) and the capacity to orientate the work-holding spindle around its axis

NOTE   This machine may include additional features such as automatic tool changing from a magazine.

3.3
machine modes of operation
modes of operation of the numerically controlled or data entry devices where entries are interpreted as functions to be executed

3.3.1
manual mode of numerical control
non-automatic mode of numerical control of a machine in which the operator controls it without the use of pre-programmed numerical data

EXAMPLE   By push button or joystick control.

3.3.2
manual data input mode
entry of programme data by hand at the numerical control

3.3.3
single block mode
mode of numerical control in which, at the initiation of the operator, only one block of control data is executed

3.3.4
automatic mode
mode of numerical control in which the machine operates in accordance with the programme data until stopped by the programme or the operator

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.

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

4.2   Reference to ISO 230-1

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

In the "Observations" block of the tests described in Clause 5, the instructions are preceded by a reference to the corresponding clause in ISO 230-1:1996 in cases where the test concerned is in compliance with the specifications of ISO 230-1:1996. Tolerances are given for each test (see G1 to G24).

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 3.11 of ISO 230-1:1996).

4.4   Testing sequence

The sequence in which the 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   Tests 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   Diagrams

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

4.7   Turrets and tool spindle(s)

As already defined in 3.1 and 3.2, turning centres have not only stationary tools but also power-driven rotary tools which means that the turret should also have power-driven mechanisms. 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, may be provided. An automatic tool-changing device may also be required in cases of power-driven spindles in which the tool can be automatically set.

Figure 2 shows typical examples of turrets and tool spindles. The following configurations are shown:

a)   Horizontal turret: the tools are set radial to the axis of rotation of the turret. This turret type can have either stationary or power-driven tools or a combination of both.

b)   Wheel-type turret for radial tools: the tools are set radial to the axis of rotation of the turret. This turret type can have stationary tools only, power-driven tools only or both stationary and power-driven tools.

c)   Wheel-type turret for axial tools: the tools are set axially to the axis of rotation of the turret. Combinations of b) and c) are possible.

d)   Linear turret.

e)   Oblique turret: the tools can be used in the X or Z direction only.

f)   Single tool spindle with single tool head: by swivelling the head, the tool spindle can be in both the X- and Z-axis directions. A tool changer and a tool magazine are needed.

g)   Oblique dual spindle tool head: one spindle is provided for stationary tools and the second for power-driven tools. Machining is possible in both the Z- and X-axis directions. A tool changer and a tool magazine are needed.
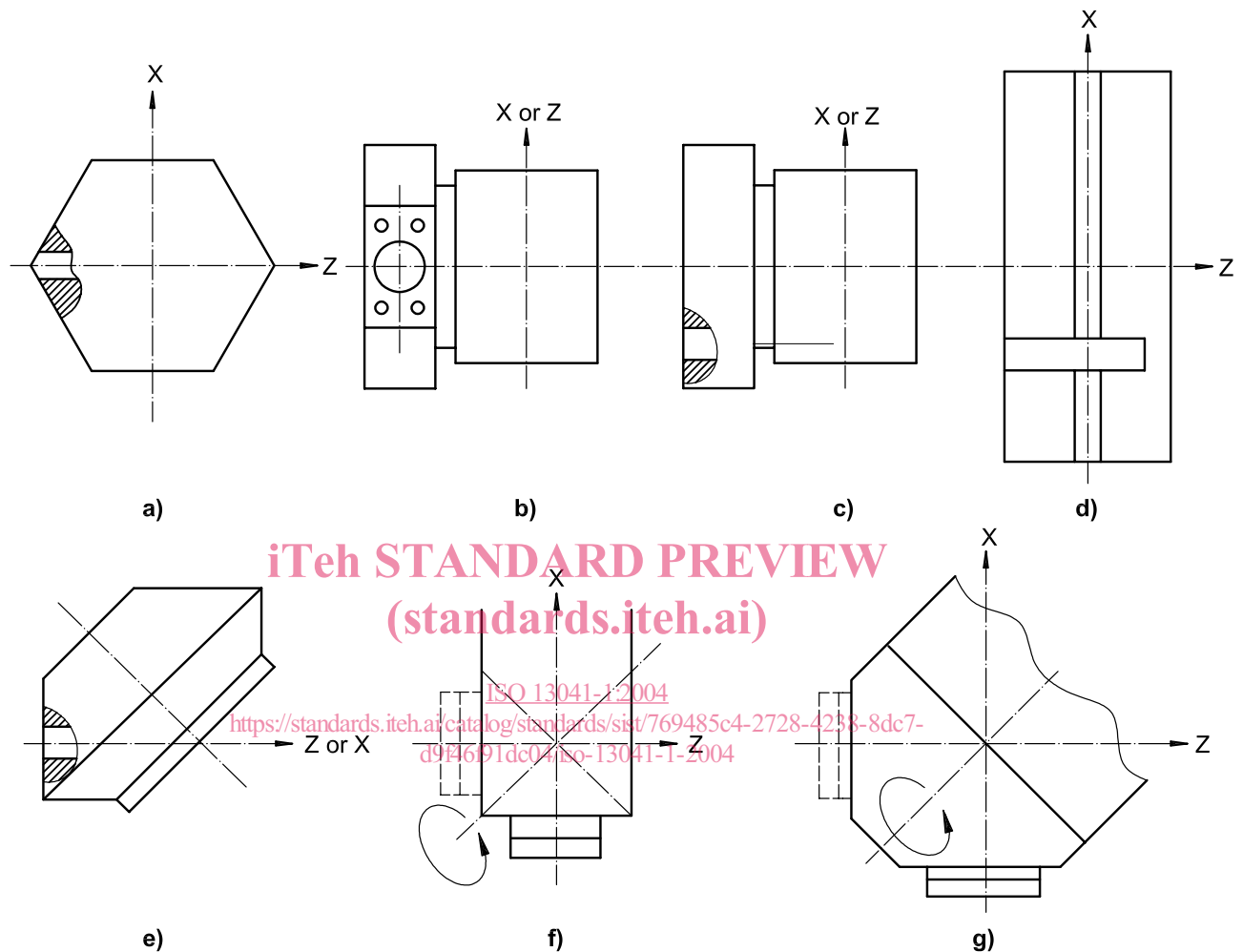
Figure 2 — Examples of turret and tool spindle configurations

4.8   Machine classifications

4.8.1   General

The machines considered in this part of ISO 13041 are divided into two basic configurations (see Table 2):

Type A: Machines with tailstock

Type B: Machines without tailstocks

Type A machines can be generally classified into two further groups:

Group A-1   with one turret

Group A-2   with two turrets

Type B machines can be generally classified into four further groups:

Group B-1   with one workhead

Group B-2   with two coaxial interfacing heads

Group B-3   with a coaxial rotating head

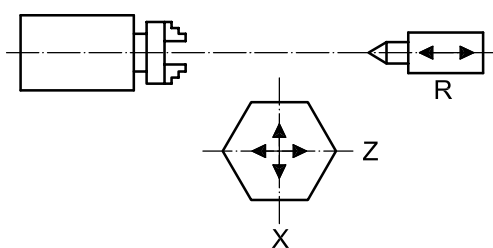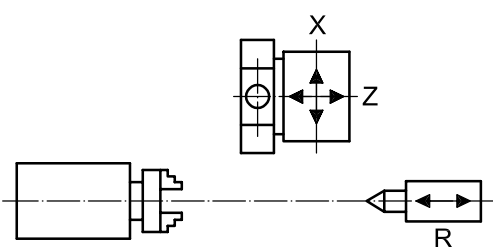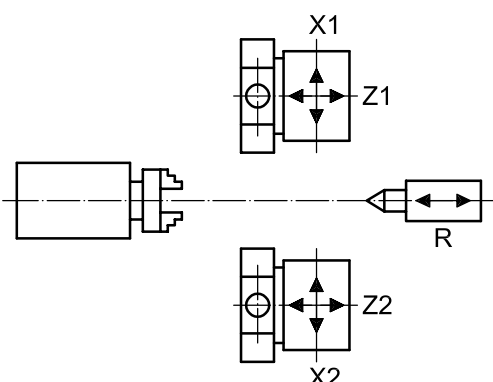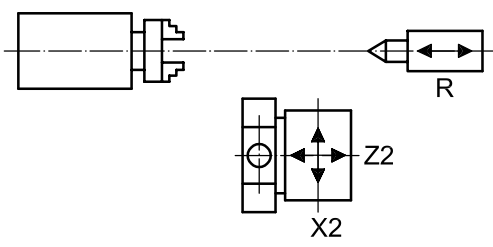Group B-4   with two parallel heads

4.8.2   Linear motions

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

4.9   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 the software compensation is used, this shall be stated in the test results.

Table 2 — Examples of machine configuration

Type A — With tailstock	
1. With one turret	**2. With two turrets**
Turret type: all types except d)	Turret type: all types except d)
	NOTE The two turret types can be different.
With turret type a)	With two turrets of type b)
	X1 Z1 R Z2 X2
	R
With turret type b)	With turret types b) and f)
X Z R	R Z2 X2

Type B — Without tailstock
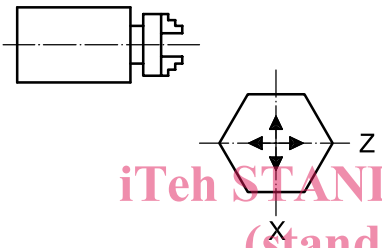
1. With one workhead

Turret type: any of a), b), c), f) or g)
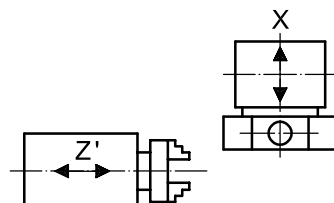
Axes motion	1	2	3	4
Turret	Z or X	Z	X	—
Workhead	—	X	Z	X or Z

Optional: Y axis turret motion (turning centre)
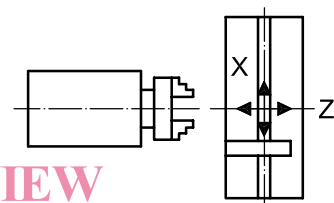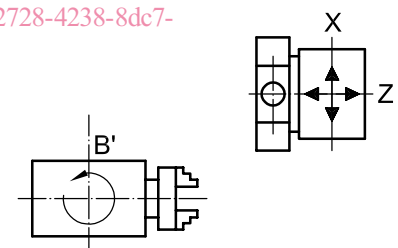   B' axis rotation of workhead

With turret type b)

With turret type a)

With turret type d)

With B' axis rotary head