INTERNATIONAL STANDARD

ISO 10791-4

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Test conditions for machining centres —

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

Conditions d'essai pour centres d'usinage —
Partie 4: Précision et répétabilité de positionnement des axes linéaires et rotatifs

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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.

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 10791-4 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

ISO 10791 consists of the following parts, under the general title *Test conditions for machining centres*:

— *Part 1: Geometric tests for machines with horizontal spindle and with accessory heads (horizontal Z-axis)*

— *Part 2: Geometric tests for machines with vertical spindle or universal heads with vertical primary rotary axis (vertical Z-axis)*

— *Part 3: Geometric tests for machines with integral indexable or continuous universal heads (vertical Z-axis)*

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

— *Part 5: Accuracy and repeatability of positioning of work-holding pallets*

— *Part 6: Accuracy of feeds, speeds and interpolations*

— *Part 7: Accuracy of a finished test piece*

— *Part 8: Evaluation of the contouring performance in the three coordinate planes*

— *Part 9: Evaluation of the operating times of tool change and pallet change*

— *Part 10: Evaluation of the thermal distortions*

— *Part 11: Evaluation of the noise emission*

— *Part 12: Evaluation of the vibration severity*

Annex A of this part of ISO 10791 is for information only.

Introduction

A machining centre is a numerically controlled machine tool capable of performing multiple machining operations, including milling, boring, drilling and tapping, as well as automatic tool changing from a magazine or similar storage unit in accordance with a machining programme.

The object of ISO 10791 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 10791 specifies, with reference to the relevant parts of ISO 230, *Test code for machine tools*, several families of tests for machining centres with horizontal or vertical spindle or with universal heads of different types, standing alone or integrated in flexible manufacturing systems. ISO 10791 also establishes the tolerances or maximum acceptable values for the test results corresponding to general purpose and normal accuracy machining centres.

ISO 10791 is also applicable, totally or partially, to numerically controlled milling and boring machines, when their configuration, components and movements are compatible with the tests described herein.

Test conditions for machining centres —

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

1 Scope

This part of ISO 10791 specifies, with reference to ISO 230-2, the tolerances which apply to the positioning tests for linear axes, up to 2 000 mm in length, and rotary axes of machining centres.

It does not deal with environmental conditions, warm-up of the machine and measuring methods, already described in ISO 230-2.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 10791. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 10791 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 230-1:1996, *Test code for machine tools — Part 1: Geometric accuracy of machines operating under no-load or finishing conditions.*

ISO 230-2:1997, *Test code for machine tools — Part 2: Determination of accuracy and repeatability of positioning numerically controlled axes.*

ISO 10791-1:1998, *Test conditions for machining centres — Part 1: Geometric tests for machines with horizontal spindle and with accessory heads (horizontal Z-axis).*

ISO 10791-2:— [1)], *Test conditions for machining centres — Part 2: Geometric tests for machines with vertical spindle or universal heads with vertical primary rotary axis (vertical Z-axis).*

ISO 10791-3:1998, *Test conditions for machining centres — Part 3: Geometric tests for machines with integral indexable or continuous universal heads (vertical Z-axis).*

1) To be published.

3 Preliminary remarks

3.1 Measuring units

In this part of ISO 10791, 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 arc seconds. The equivalence of the following expressions should always be kept in mind:

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

3.2 Reference to ISO 230-2

To apply this part of ISO 10791, reference shall be made to ISO 230-2, especially for the environmental conditions, warming up of the machine, description of measuring methods, evaluation and presentation of the results.

3.3 Testing sequence

The sequence in which the tests are presented in this part of ISO 10791 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.

3.4 Tests to be performed

When testing a machine, it is not always necessary nor possible to carry out all the tests described in this part of ISO 10791. 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 10791 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.

3.5 Position of linear axes not under test

During the check of an axis, those of the three basic linear axes not involved in the test shall be kept as far as possible in the middle of their working travel, or otherwise in a position such as to minimize deflections of elements affecting the measurements. Sliding spindles, rams, etc., when they are supplementary axes, shall be kept retracted.

4 Positioning of linear axes

4.1 Tolerances

Table 1 gives the positioning tolerances, as defined in clause 2 of ISO 230-2:1997, for machining centres of normal accuracy, related to different measurement travels up to 2 000 mm. In addition, a graphical presentation of results should be provided as specified in ISO 230-2:1997.

Table 1 — Positioning tolerances for axes up to 2 00 mm

Tolerances mm		Measurement travel of the axis mm			
		≤ 500	> 500 ≤ 800	> 800 ≤ 1 250	> 1 250 ≤ 2 000
Bidirectional accuracy of positioning	A	0,022	0,025	0,032	0,042
Unidirectional accuracy of positioning	$A\uparrow$ and $A\downarrow$	0,016	0,020	0,025	0,030
Bidirectional repeatability of positioning	R	0,012	0,015	0,018	0,020
Unidirectional repeatability of positioning	$R\uparrow$ and $R\downarrow$	0,006	0,008	0,010	0,013
Reversal value	B	0,010	0,010	0,012	0,012
Mean reversal value	$\bar{B}$	0,006	0,006	0,008	0,008
Bidirectional systematic deviation of positioning	E	0,015	0,018	0,023	0,030
Unidirectional systematic deviation of positioning	$E\uparrow$ and $E\downarrow$	0,010	0,012	0,015	0,018
Range of the mean bidirectional positional deviation	M	0,010	0,012	0,015	0,020

4.2 Measuring instruments

Laser interferometer, or other measuring systems with comparable accuracy may be used (see 5.1 of ISO 230-1:1996).

4.3 Observations and references to ISO 230-1 and ISO 230-2

When the laser interferometer is used, proper precautions shall be taken according to A.13 of ISO 230-1:1996.

As for the performance of the test, the procedures indicated in ISO 230-2:1997 shall be followed, in particular 4.3.2 for the full check up to 2 000 mm.

4.4 Calculated deviations

Table 2 provides an example of the format for the presentation of the results determined through the statistical analysis of the measured data. In addition, a graphical presentation of results should be provided as specified in ISO 230-2:1997.

Table 2 — Format for the presentation of the results of the full test up to 2 00 mm

Results mm		Axis name and relevant travel mm			
Bidirectional accuracy of positioning	A				
Accuracy of positioning (positive)	$A^{\uparrow}$				
Accuracy of positioning (negative)	$A^{\downarrow}$				
Bidirectional repeatability of positioning	R				
Repeatability of positioning (positive)	$R^{\uparrow}$				
Repeatability of positioning (negative)	$R^{\downarrow}$				
Reversal value	B				
Mean reversal value	$\bar{B}$				
Bidirectional systematic deviation of positioning	E				
Systematic deviation of positioning (positive)	$E^{\uparrow}$				
Systematic deviation of positioning (negative)	$E^{\downarrow}$				
Range of the mean bidirectional positional deviation	M				

5 Positioning of rotary axes

5.1 Tolerances

Table 3 gives the positioning tolerances, as defined in clause 2 of ISO 230-2:1997, for machining centres of normal accuracy, related to measurement travels up to 360°.

Table 3 — Positioning tolerances for axes up to 360°

Tolerances arc seconds		
Bidirectional accuracy of positioning	A	28
Unidirectional accuracy of positioning	$A^{\uparrow}$ and $A^{\downarrow}$	22
Bidirectional repeatability of positioning	R	16
Unidirectional repeatability of positioning	$R^{\uparrow}$ and $R^{\downarrow}$	8
Reversal value	B	12
Mean reversal value	$\bar{B}$	8
Bidirectional systematic deviation of positioning	E	20
Unidirectional systematic deviation of positioning	$E^{\uparrow}$ and $E^{\downarrow}$	14
Range of the mean bidirectional positional deviation	M	12

5.2 Measuring instruments

Laser angle interferometer with indexing table, autocollimator with polygonal mirror, or other measuring systems with comparable accuracy may be used.

5.3 Observations and references to ISO 230-1 and ISO 230-2

When the autocollimator is used, proper precautions shall be taken according to A.11 of ISO 230-1:1996.

As for the performance of the test, the procedures indicated in ISO 230-2:1997 shall be followed, in particular 4.3.4 for the full check up to 360°.

5.4 Calculated deviations

Table 4 provides an example of the format for the presentation of the results determined through the statistical analysis of the measured data. In addition, a graphical presentation of results should be provided as specified in ISO 230-2:1997.

Table 4 — Format for the presentation of the results of the full test up to 360°

Results arc seconds		**Axis name**			
Bidirectional accuracy of positioning	A				
Accuracy of positioning (positive)	$A^{\uparrow}$				
Accuracy of positioning (negative)	$A^{\downarrow}$				
Bidirectional repeatability of positioning	R				
Repeatability of positioning (positive)	$R^{\uparrow}$				
Repeatability of positioning (negative)	$R^{\downarrow}$				
Reversal value	B				
Mean reversal value	$\bar{B}$				
Bidirectional systematic deviation of positioning	E				
Systematic deviation of positioning (positive)	$E^{\uparrow}$				
Systematic deviation of positioning (negative)	$E^{\downarrow}$				
Range of the mean bidirectional positional deviation	M				

6 Information to be recorded

To comply with this part of ISO 10791, the test report shall include the information given in 6.1 to 6.3.

6.1 Data identifying the machine

a) name of the manufacturer;

b) year of construction, if available;

c) type and serial number;

d) configuration of the machine according to 3.9 or 3.10 of ISO 10791-1:1998, ISO 10791-2:— and ISO 10791-3:1998, if possible.