INTERNATIONAL STANDARD

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Test conditions for machining centres —

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

Conditions d'essai pour centres d'usinage —
Partie 5: Précision et répétabilité de positionnement des palettes porte-pièces

Reference numbe
ISO 10791-5:1998(E)

Contents

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet central@iso.ch
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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 10791-5 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 universal heads with horizontal primary rotary axis (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 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 5:
Accuracy and repeatability of positioning of work-holding pallets

1 Scope

This part of ISO 10791 specifies, with reference to ISO 230-1 and ISO 230-2, the tests intended to assess the repeatability of positioning of individual pallets and the total accuracy of positioning of a batch of pallets associated with a specific machine.

In a manufacturing system the accuracy of positioning of a workpiece or a work-holding fixture depends on the fitting between pallets and receivers. It should be noted that this part of ISO 10791 applies to a single machining centre, i.e. to the single receiver, with multiple pallets.

The results of the tests considered here could be extended to the whole manufacturing system only if the measuring instruments were placed on the different machines exactly in the same position with respect to the origins of the linear axes. This, in practice, is difficult and inaccurate, because origins of the linear axis are affected by the repeatability of the axes.

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 of numerically controlled axes.*

ISO 8526-1:1990, *Modular units for machine tools — Workholding pallets — Part 1: Workholding pallets up to 800 mm nominal size.*

ISO 8526-2:1990, *Modular units for machine tools — Workholding pallets — Part 2: Workholding pallets of nominal size greater than 800 mm.*

3 Preliminary remarks

3.1 Measuring units

In this part of ISO 10791, all linear dimensions, deviations and corresponding tolerances are expressed in millimeters; 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:

$$0{,}010/1\ 00 = 10 \times 10^{-6} = 10\ \mu\text{rad} \approx 2''$$

3.2 Reference to ISO 230-1 and ISO 230-2

To apply this part of ISO 10791, reference shall be made to ISO 230-1 as far as geometric measurements and the recommended accuracy of testing equipment are concerned.

ISO 230-2 shall be referred to for the methods of determining repeatability and accuracy of positioning.

3.3 Axes coding

In this part of ISO 10791, some letters have been used with a general meaning, which has to be clarified for each case. These letters and relevant meanings are indicated hereunder:

— M and N correspond to the horizontal axes of the machine and shall be replaced by X and Z (or Z and X) for horizontal machining centres and X and Y (or Y and X) for vertical machining centres, in function of the approaching direction of the pallet;

— P corresponds to the vertical axis and shall be replaced by Y for horizontal machining centres and by Z for vertical machining centres;

— R corresponds to the rotary axis of the pallet and shall be replaced by B for horizontal machining centres and by C for vertical machining centres;

— *i* is the progressive number related to the pallet (the *i*-th pallet);

— *j* is the progressive number related to the approach (the *j*-th approach);

— *k* is used in the formulae for indicating the individual axes M, N, P and R.

3.4 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 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, as well as the batch size to be used as a sample for the accuracy test, 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.

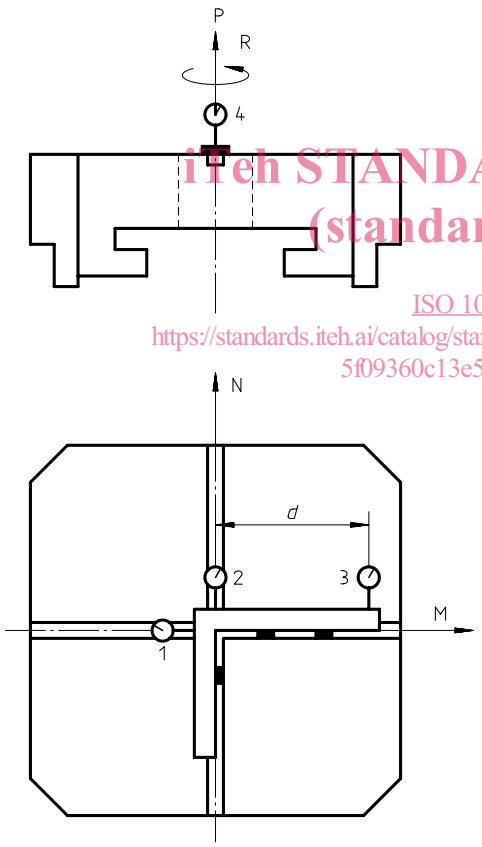
3.5 Measuring instruments

The measuring instruments indicated in the tests described in the following sections are examples only. Other instruments measuring the same quantities and having at least the same accuracy may be used. Dial gauges shall have a resolution of 0,001 millimeters.

4 Repeatability of positioning of individual pallets on the machine

4.1 Location of instruments

In figure 1, a measurement setup is shown which makes use of a square placed on the pallet, lying against gauge blocks set against the reference slots. If the pallet references for locating the workpiece or the work holding fixture are different (e.g., location holes or edge locators as shown in ISO 8526-1 and ISO 8526-2), it is important that the checking instruments be located on each pallet exactly in the same position compared with the references. Measurement instruments 1, 2 and 4 should be located as close as possible to the centre lines of the pallet.



M and N are horizontal axes

P is the vertical axis

R is the rotary axis of the pallet

The correspondence between these axes and the actual axes of the machine is given in table 1.

Figure 1

4.2 Measurement procedure

Whenever possible, the axes shall be locked. A special fixture, or a square, or any other suitable artifact shall be located on the pallet. The locating references for the work holding fixture shall be used to ensure the placement of the artifacts exactly in the same position and orientation on each pallet.

The dial gauges shall be fixed in such positions as to allow for the movements for the pallet loading and unloading without interference. To prevent interference between the styli and the artifacts, the readings shall be taken by means of gauge blocks always placed between the artifact and the stylus of the dial gauge.

The dial gauges shall be zeroed only at the first positioning approach of the first pallet. Each pallet shall be loaded and unloaded five times without resetting the dial gauges. The five readings of each dial gauge shall be recorded. The general deviation *a* in the various directions shall be determined from the individual readings as indicated in 4.3.

NOTE — The a_R deviation might also be measured by means of an autocollimator provided that the mirror is placed on the different pallets exactly with the same orientation with respect to the locating references for the work holding fixture.

4.3 Formulae for calculating the deviations from individual readings

Representing the dial gauge reading in general as *a*, and the repeatability of positioning of the pallet along (or around) each axis as *W*, the required quantities are determined from the individual readings in the following way:

$a_M = a_1$

$a_N = a_2$ (suffix 2 indicates the dial gauge closer to the rotary axis of the pallet)

$a_P = a_4$

$a_R = (a_2 - a_3)/d$

$W_{ik} = (a_{j\,max})_{ik} - (a_{j\,min})_{ik}$

where

i is the progressive number of the pallet;

j is the progressive number of the positioning approach;

k is M, N, P and R (i.e, X, Y, Z and B or C).

4.4 Tolerances

For			L	$\leqslant$	500	$W_{X,Y,Z}$	=	0,008
For	500	<	L	$\leqslant$	800	$W_{X,Y,Z}$	=	0,010
For	800	<	L	$\leqslant$	1 250	$W_{X,Y,Z}$	=	0,013
For	1 250	<	L	$\leqslant$	2 000	$W_{X,Y,Z}$	=	0,016
For any value of L						W_R	=	0,013/1 000

where

L is the shorter side of the pallet.

4.5 Checking and measuring instruments

Dial gauges, gauge blocks, squares or special fixtures, or other instruments allowing the same measurements.

4.6 Reference to ISO 230-2

Derogating from ISO 230-2, the repeatability is not expressed here as range of 4s (four times the estimator of the standard uncertainty) but as range W between the maximum reading and the minimum reading, making the determination easier.

4.7 Measured deviations

Table 1 gives an example of how the individual readings can be noted and how the requested deviations can be determined. The first line in the table permits identification of which actual axes X, Y, Z, B and C correspond to the axes M, N, P and R shown in figure 1 and described in 3.3.

Table 1 — Repeatability of positioning of individual pallets

Pallet i = __				d = ___		Pallet i = ___				d = ___	
Positioning j	a_1 (M)	a_2 (N)	a_3	a_4 (P)	$\frac{a_2 - a_3}{d}$ (R)	Positioning j	a_1 (M)	a_2 (N)	a_3	a_4 (P)	$\frac{a_2 - a_3}{d}$ (R)
1						1					
2						2					
3						3					
4						4					
5						5					
$(a_{j\,max})_k$						$(a_{j\,max})_k$					
$(a_{j\,min})_k$						$(a_{j\,min})_k$					
W_k						W_k					
Pallet i = __				d = ___		Pallet i = ___				d = ___	
Positioning j	a_1 (M)	a_2 (N)	a_3	a_4 (P)	$\frac{a_2 - a_3}{d}$ (R)	Positioning j	a_1 (M)	a_2 (N)	a_3	a_4 (P)	$\frac{a_2 - a_3}{d}$ (R)
1						1					
2						2					
3						3					
4						4					
5						5					
$(a_{j\,max})_k$						$(a_{j\,max})_k$					
$(a_{j\,min})_k$						$(a_{j\,min})_k$					
W_k						W_k					
NOTE — In the case of horizontal spindle machining centre X Z Y B shall be used instead of M N P R; and for vertical spindle machining centre X Y Z C shall be used.											