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Test conditions for machining centres —

Part 2: Geometric tests for machines with vertical spindle (vertical Z-axis)

Conditions d'essai pour centres d'usinage —

Partie 2: Essais géométriques des machines à broche verticale (axe Z vertical)

Reference number
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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 10791-2:2001), which has been technically revised.

The main changes are as follows:

— Tests applying to all configurations of machines have now been grouped in Clause 5 (tests G5.1 to G5.14).

— Tests for optional horizontal spindles and integral or accessory spindle heads forming the object of Annexes A through C in the first edition of this document, have been deleted and will be covered by a more general standard, as they are not only used in machining centres.

— Tests for the movements of four types of work holding tables have been introduced, respectively as Clauses 6, 7, 8 and 9, as explained in 4.5 and Table 1.

— Three new Annexes A, B and C have been introduced, dealing with error motion of rotary axes belonging to spindles and to rotary and tilting tables.

— The test of the table flatness (formerly G15) has been deleted for several reasons, including:

  — the table surface is not normally used as a reference for the location of the workpiece;

  — sometimes, the machine is supplied with some fixtures already mounted on the table;

  — sometimes, the machine is provided with a receiver where several pallets can be mounted;

  — for tests made during the working life of the machine, the table surface can be unsuitable for accurate measurements, mostly on large machines.

A list of all parts in the ISO 10791 series can be found on the ISO website.

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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 program.

The object of the ISO 10791 series is to provide information as widely and comprehensively as possible on tests which can be carried out for comparison, acceptance, maintenance or any other purpose deemed necessary by user or manufacturer/supplier.

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Test conditions for machining centres —

Part 2:
Geometric tests for machines with vertical spindle (vertical Z-axis)

1 Scope

This document specifies, with reference to the ISO 230 series, the geometric tests for machining centres with vertical spindle (i.e. vertical Z-axis).

This document also establishes the tolerances for the test results corresponding to general purpose and normal accuracy machining centres.

This document is also applicable, totally or partially, to other numerically controlled machines, when their configuration, components and movements are compatible with the tests described herein.

This document applies to machining centres having three numerically controlled linear axes (X-axis up to 5 000 mm length, Y-axis up to 2 000 mm length, and Z-axis up to 2 000 mm length), but refers also to supplementary movements, such as those of rotary, tilting, and swivelling tables. Further tests, contained in Annexes A, B and C, cover axes of rotation of spindles, rotary tables and tilting cradles. Movements other than those mentioned are considered as special features and the relevant tests are not included in this document.

This document takes into consideration in Clauses 6 through 9 four possible types of tables, fixed and rotary, as hereunder described:

— Clause 6: horizontal non-rotating tables;

— Clause 7: tables rotating only around a vertical C'-axis;

— Clause 8: tables rotating around a vertical C'-axis and tilting around a horizontal A'-axis;

— Clause 9: tables rotating around a vertical C'-axis and tilting around a horizontal B'-axis.

This document deals only with the verification of geometric accuracy of the machine and does not apply to the testing of the machine operation, which are generally checked separately. Tests not concerning the pure geometric accuracy of the machine are dealt with in other parts of the ISO 10791 series.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 230-1:2012, *Test code for machine tools — Part 1: Geometric accuracy of machines operating under no-load or quasi-static conditions*

ISO 230-7:2015, *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*

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3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 230-1 and ISO 230-7 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Preliminary remarks

4.1 Measurement units

In this document all linear dimensions, errors, and corresponding tolerances are expressed in millimetres; angular dimensions are expressed in degrees, and angular errors and the corresponding tolerances are expressed in ratios as the primary method, but in some cases, microradians or arcseconds can be used for clarification purposes. Formula (1) should be used for conversion of the units of angular errors or tolerances:

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

4.2 Reference to the ISO 230 series

4.2.1 General

To apply this document, reference shall be made to ISO 230-1 and ISO 230-7 when required, especially for the installation of the machine before testing, warming up of the spindle and other moving components, description of measuring methods and recommended uncertainty of testing equipment.

Where the test concerned is in compliance with the specifications of the relevant part of the ISO 230 series (i.e. ISO 230-1 or ISO 230-7), a reference to the corresponding subclause of that standard is shown before the instructions in the "Observations" block of the tests described in Clauses 5 to 9 and Annexes A to C.

4.2.2 Consideration of relative measurements

As indicated in ISO 230-1, all geometric measurements are carried out between the tool side and the workpiece side of the machine.

When such measurement is not possible using a single instrument (e.g. a precision level), and the motion of the axis under test causes an angular movement of both spindle head and workholding component, differential measurements are required.

4.3 Reference to ISO 10791-6

In ISO 10791-6:2014, Annexes A, B and C, kinematic tests are described for testing circular interpolation motion by simultaneous three-axis control (AK1, AK2, BK1, BK2, CK1, CK2). These are based on using displacement sensor(s) with a sphere-ended test mandrel or using a ball bar.

These kinematic tests can be used for determining the position and orientation of rotary axes with respect to the linear axes.

Kinematic test BK2 b) in ISO 10791-6:2014 can be used as an alternative for the following tests if all relevant geometric error compensation functions are identical: see G7.6, G7.7, G8.6 b), G8.7, G9.6 b) and G9.7.

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