INTERNATIONAL STANDARD

ISO 10791-7

Second edition
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Test conditions for machining centres —

Part 7: Accuracy of finished test pieces

Conditions d'essai pour centres d'usinage —

Partie 7: Exactitude des pièces d'essai usinées

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 39, *Machine Tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

This second edition cancels and replaces the first edition, which has been technically revised.

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 speeds and interpolations*

— *Part 7: Accuracy of finished test pieces*

— *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 thermal distortions*

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. Most machining centres have facilities for automatically changing the direction in which the workpieces are presented to the tool.

The purpose of ISO 10791 (all parts) is to supply information as wide and comprehensive as possible on tests and checks which can be carried out for comparison, acceptance, maintenance, or any other purpose.

This International Standard specifies, by reference to the relevant parts of ISO 230, 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. This International Standard also establishes the tolerances or maximum acceptable values for the test results corresponding to general purpose and normal accuracy machining centres.

This International Standard 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 7:
Accuracy of finished test pieces

1 Scope

This part of ISO 10791 specifies standard test pieces with reference to ISO 230-1, cutting tests under finishing conditions. It also specifies the characteristics and dimensions of the test pieces themselves. This part of ISO 10791 is intended to supply minimum requirements for assessing the cutting accuracy of the machine. This part of ISO 10791 takes into consideration 3- to 5-axis machining centres.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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*

3 Preliminary remarks

3.1 Measuring units

In this part of ISO 10791, all linear dimensions and deviations are expressed in millimetres. All angular dimensions are expressed in degrees. Angular deviations are, in principle, expressed in ratios (e.g. 0,00x/1 000), but in some cases, microradians or arcseconds can be used for clarification purposes. The following expression should be used for conversion of angular deviations or tolerances:

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

3.2 Reference to ISO 230-1

To apply this part of ISO 10791, reference shall be made to ISO 230-1, especially for the installation of the machine before testing, warming up of the machine, description of measuring methods, and 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 fixtures and machining easier, tests can be performed in any order.

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 manufacturer/supplier, 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.

In principle, no more than one piece of each type should be machined for acceptance purposes. In case of special requirements, such as statistical assessment of the machine tool performance (e.g. according to ISO 26303, short-term capability), the machining of more test pieces is to be submitted to agreement between manufacturer/supplier and user.

3.5 Measuring instruments

The measuring instruments indicated in the tests described in Clause 4 are examples only. Other instruments measuring the same quantities and having the same or smaller measurement uncertainty can be used.

3.6 Location of test pieces

The test piece should be placed approximately at mid-travel of the X- axis, and in positions along Y- and Z- axes suitable for the location of the test piece and/or fixture, and for the tool lengths if not specified otherwise in the test procedure.

3.7 Fixing of test pieces

The test piece shall be conveniently mounted on a proper fixture, such that maximum stability of tools and fixture is achieved. The mounting surfaces of the fixture and of the test piece shall be flat. It is recommended that a suitable means of fixturing should be used to allow for tool breakthrough and full length machining of, for example, a centre hole. It is further recommended to mount the test piece on the fixture with countersink/counterbored screws such that subsequent machining does not interfere with the screws. Other methods are possible and can be selected. Overall height of the test piece depends on the selected method of fixing.

3.8 Material of test pieces, tooling, and cutting parameters

The test piece material, tooling, and the subsequent cutting parameters are subject to agreement between manufacturer/supplier and user and shall be recorded. The parameters provided in the cutting tests are for suggestions only. The test piece material shall be specified with proper material designations.

3.9 Sizes of test pieces

If the test pieces come from previous cutting tests and are re-useable, their characteristic dimensions should remain within ±10 % of those indicated in this part of ISO 10791. When the test pieces are re-used, a shallow cut shall be made to clean up all surfaces before new finishing test cuts are taken.

It is also recommended that type and serial number of the machine, date of test, and names and orientation of the axes are marked on the test pieces.

Preliminary cuts should be taken in order to make the depth of cut as constant as possible.

The nominal size of test pieces can be modified by mutual agreement with the manufacturer/supplier and user. When the nominal size of test pieces is modified, the feed speed (for circular contouring) can be modified in an analogous manner as shown in ISO 230-4:2005, Annex C. The tool size and other machining conditions may be also modified.

3.10 Types of test piece

In this part of ISO 10791, four types of test piece are considered, each of them in two or three sizes. Types, sizes, and corresponding designation of the particular test piece are shown in Table 1. Among

these types, Type M1 and M2 are applicable for 3-, 4-, and 5-axis machining centres. M3 is applicable only for 5-axis machining centres. M4 is applicable for 4- and 5-axis machining centres.

Table 1 — Types, sizes, and designation of the test pieces

Type	Nominal size	Designation
M1 Positioning and contouring test piece	80	Test piece ISO 10791-7, M1_80
	160	Test piece ISO 10791-7, M1_160
	320	Test piece ISO 10791-7, M1_320
M2 Face milling test piece	80	Test piece ISO 10791-7, M2_80
	160	Test piece ISO 10791-7, M2_160
M3 Cone frustum test piece	15[a]	Test piece ISO 10791-7, M3_15
	45[a]	Test piece ISO 10791-7, M3_45
M4 Three-step square test piece	80	Test piece ISO 10791-7, M4_80
	160	Test piece ISO 10791-7, M4_160
	320	Test piece ISO 10791-7, M4_320

[a] Half-apex angle of test piece.

3.11 Information to be recorded

For tests made according to the requirements of this part of ISO 10791, the following information shall be compiled as completely as possible and included in the test report:

a) material and designation of the test piece;

b) material, dimensions, and number of teeth of the tool;

c) cutting speed;

d) feed speed;

e) depth of cut;

f) other cutting parameters, e.g. cutting fluid;

g) position and orientation of the workpiece in the work space;

h) direction of cuts (where applicable).

3.12 Software compensation

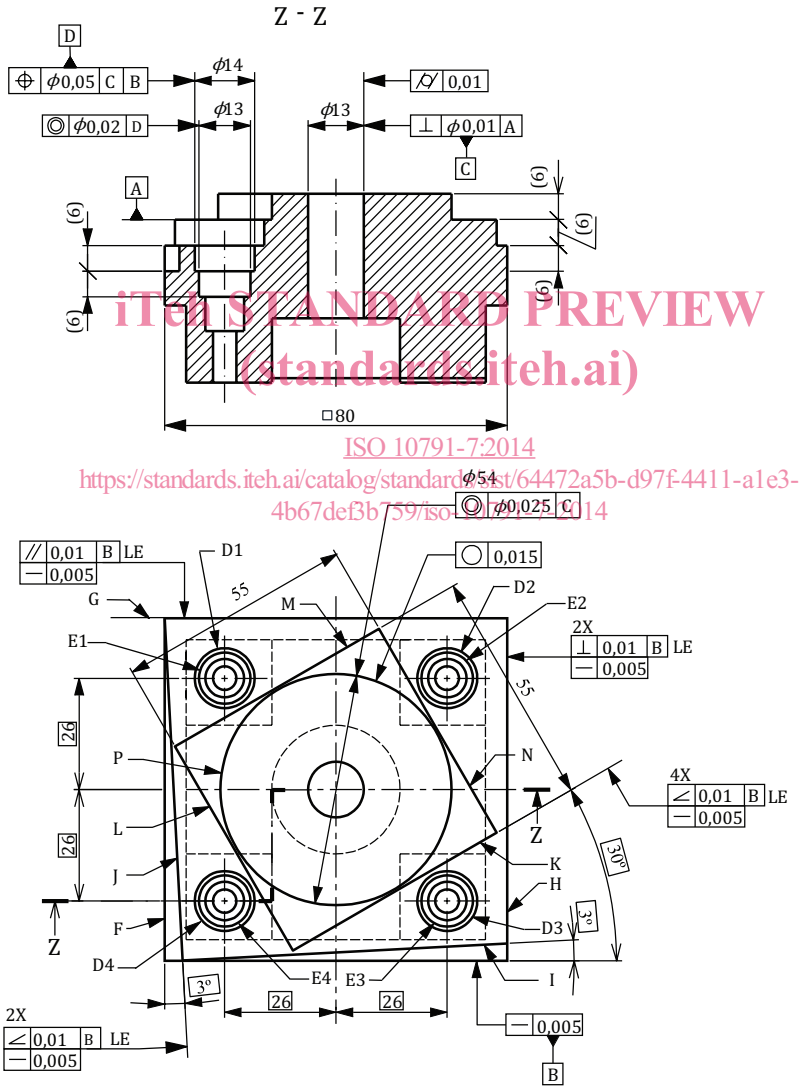
When software facilities are available for compensating some geometric errors, based on an agreement between the manufacturer/supplier and user, the relevant test can be carried out with these compensations. When the software compensation is used, this shall be stated in the test report.

4 Machining tests

Object	M1
Checking the performance of the machine under different kinematic conditions, i.e. only one axis feed, linear interpolation of two axes and circular interpolation by machining five bored holes and a series of finishing passes on different profiles. NOTE 1 This test is usually performed in the XY plane of the machine, but may be performed in the other coordinate planes when a universal spindle head is available. NOTE 2 Test M4 defines additions to test M1 for testing accuracy and positioning of rotary and swivelling axes.	

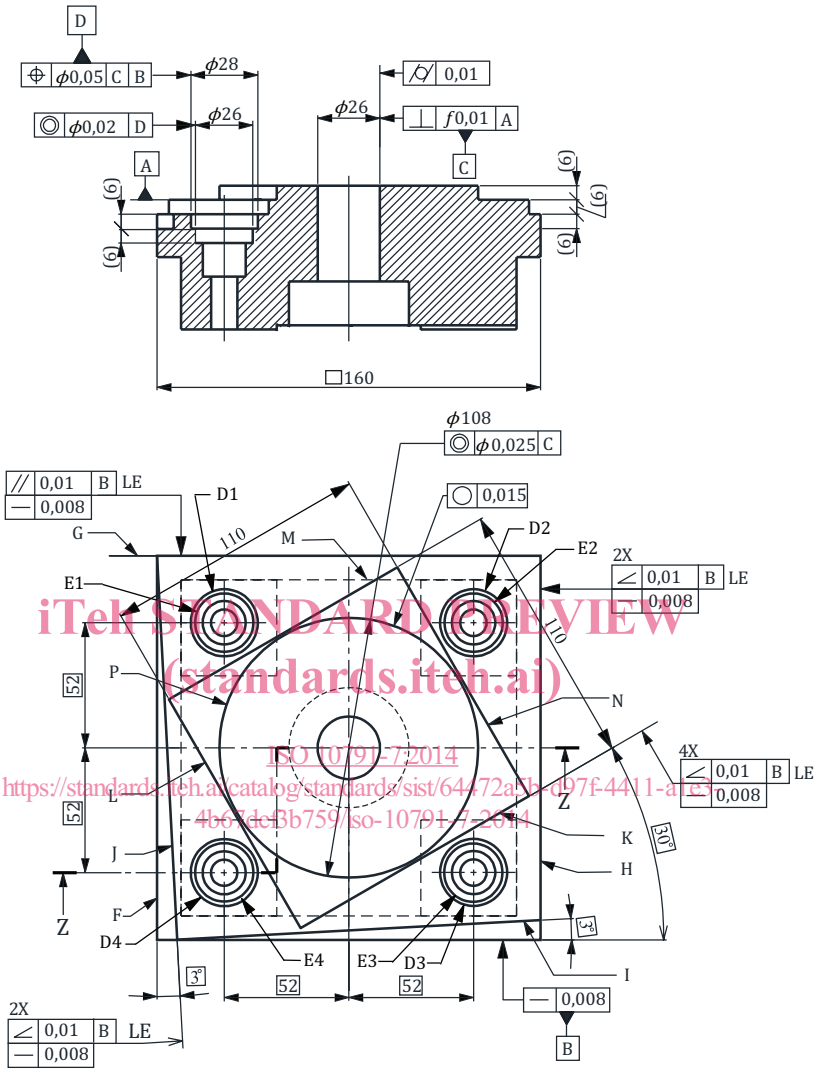
Diagram
Three sizes of contouring test piece are considered and their dimensions are shown below.

Test piece ISO 10791-7, M1_80: Dimensions in millimetres



Test piece ISO 10791-7, M1_160 Dimensions in millimetres

Z-Z



Test piece ISO 10791-7, M1_320 Dimensions in millimetres