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Test code for machine tools —

Part 6: Determination of positioning accuracy on body and face diagonals (Diagonal displacement tests)

Code d'essai des machines-outils —

Partie 6: Détermination de la précision de positionnement sur les diagonales principales et de face (Essais de déplacement en diagonale)

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 part of ISO 230 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 230-6 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

ISO 230 consists of the following parts, under the general title *Test code for machine tools*:

— *Part 1: Geometric accuracy of machines operating under no-load or finishing conditions*

— *Part 2: Determination of accuracy and repeatability of positioning numerically controlled axes*

— *Part 3: Determination of thermal effects*

— *Part 4: Circular tests for numerically controlled machine tools*

— *Part 5: Determination of the noise emission*

— *Part 6: Determination of positioning accuracy on body and face diagonals (Diagonal displacement tests)*

— *Part 7: Axes of rotation — Methods for specifying and testing*

Annex A of this part of ISO 230 is for information only.

Test code for machine tools —

Part 6:
Determination of positioning accuracy on body and face diagonals (Diagonal displacement tests)

1 Scope

This part of ISO 230 specifies diagonal displacement tests which allow estimation of the volumetric performance of a machine tool. Complete testing of the volumetric performance of a machine tool is a difficult and time-consuming process. Diagonal displacement tests reduce the time and cost associated with testing the volumetric performance.

A diagonal displacement test is not in itself a diagnostic test, although conclusions of a diagnostic nature may sometimes be possible from the results. In particular, when face diagonal tests are included, a direct measurement of the axes squareness is possible. Diagonal displacement tests on body diagonals may be supplemented by tests in the face diagonals, by tests parallel to the machine axes in accordance with ISO 230-2, or by the evaluation of the contouring performance in the three coordinate planes as defined in ISO 230-4.

Diagonal displacement tests may be used for acceptance purposes and as reassurance of machine performance where parameters of the test are used as comparison index.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 230. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 230 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC 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 230-3:2001, *Test code for machine tools — Part 3: Determination of thermal effects*

ISO 230-4:1996, *Test code for machine tools — Part 4: Circular tests for numerically controlled machine tools*

3 Terms and definitions

For the purposes of this part of ISO 230, the following terms and definitions apply.

3.1
working volume
volume defined by the travel of the machine linear axes for machining operations (not including those travels used for auxiliary operations, e.g. tool change)

3.2
body diagonal
D
space diagonal of a rectangular prism within the working volume of the machine tool

NOTE 1 Four body diagonals are defined by the working volume.

NOTE 2 The user may reference a body diagonal using its starting position, for example +X+Y–Z is the diagonal that goes from +X+Y–Z to –X–Y+Z. An alternative nomenclature using NNP (for X positive, Y negative, Z positive, direction of travel) is also acceptable.

See Figure 1.

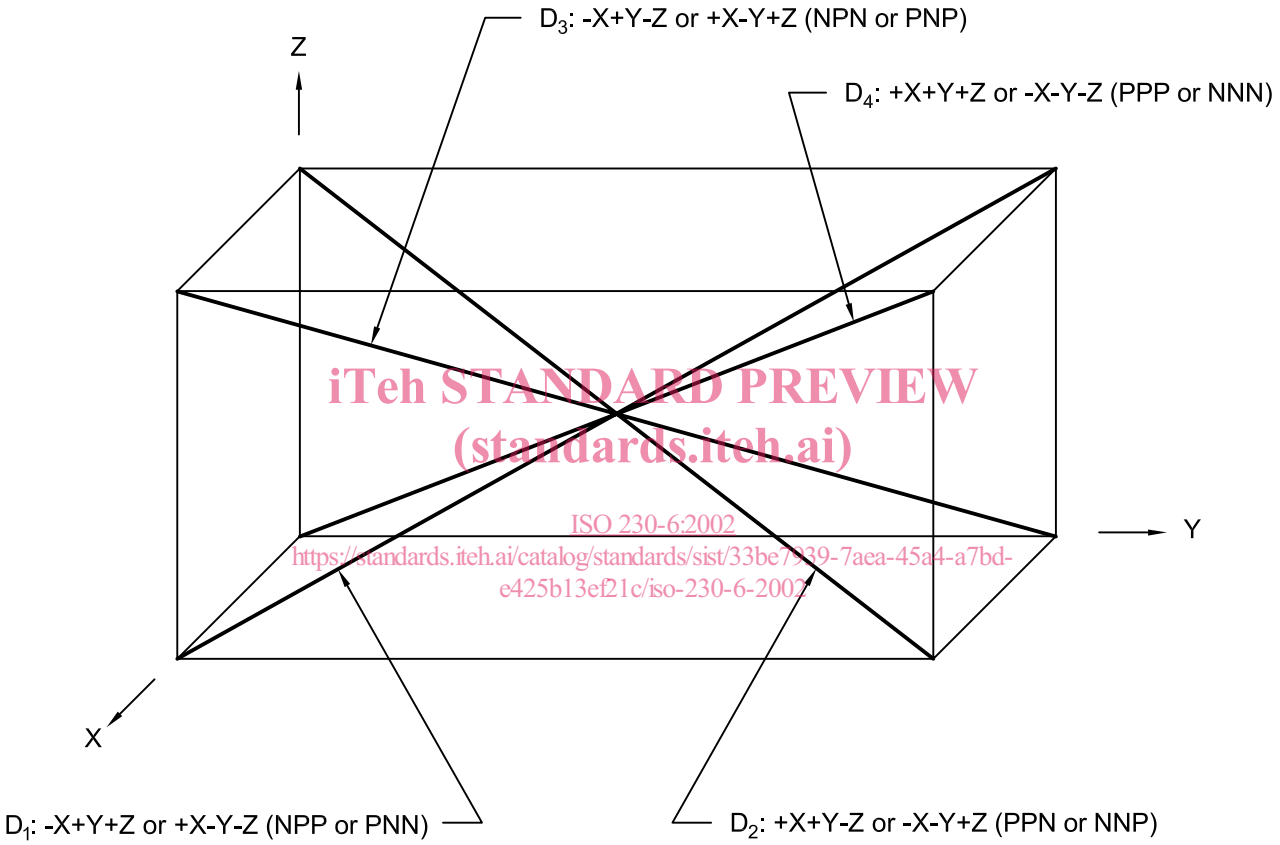

Figure 1 — Four body diagonals of a rectangular prism

3.3
face diagonal
F
diagonal in a face plane of a rectangular prism within the working volume of a machine tool

NOTE 1 Six different types of face diagonal may be defined within the working volume. For each diagonal selected, it is necessary to define further its location in the third axis. Ideally, the plane of the face diagonals should be either an external face or a central slice, as shown in Figure 2.

NOTE 2 The user may reference a face diagonal using its start position, for example +X–Y is the diagonal that goes from +X–Y to –X+Y. To define the third axis, the form +X –Y Z300 may be used to define an XY diagonal at Z = 300. An alternative nomenclature using NP or NP300 (for X negative, Y positive, Z missing, directions of travel) is also acceptable.

NOTE 3 Face diagonals are usually selected in crossed pairs for each plane as shown in Figure 2.

See Figure 2.

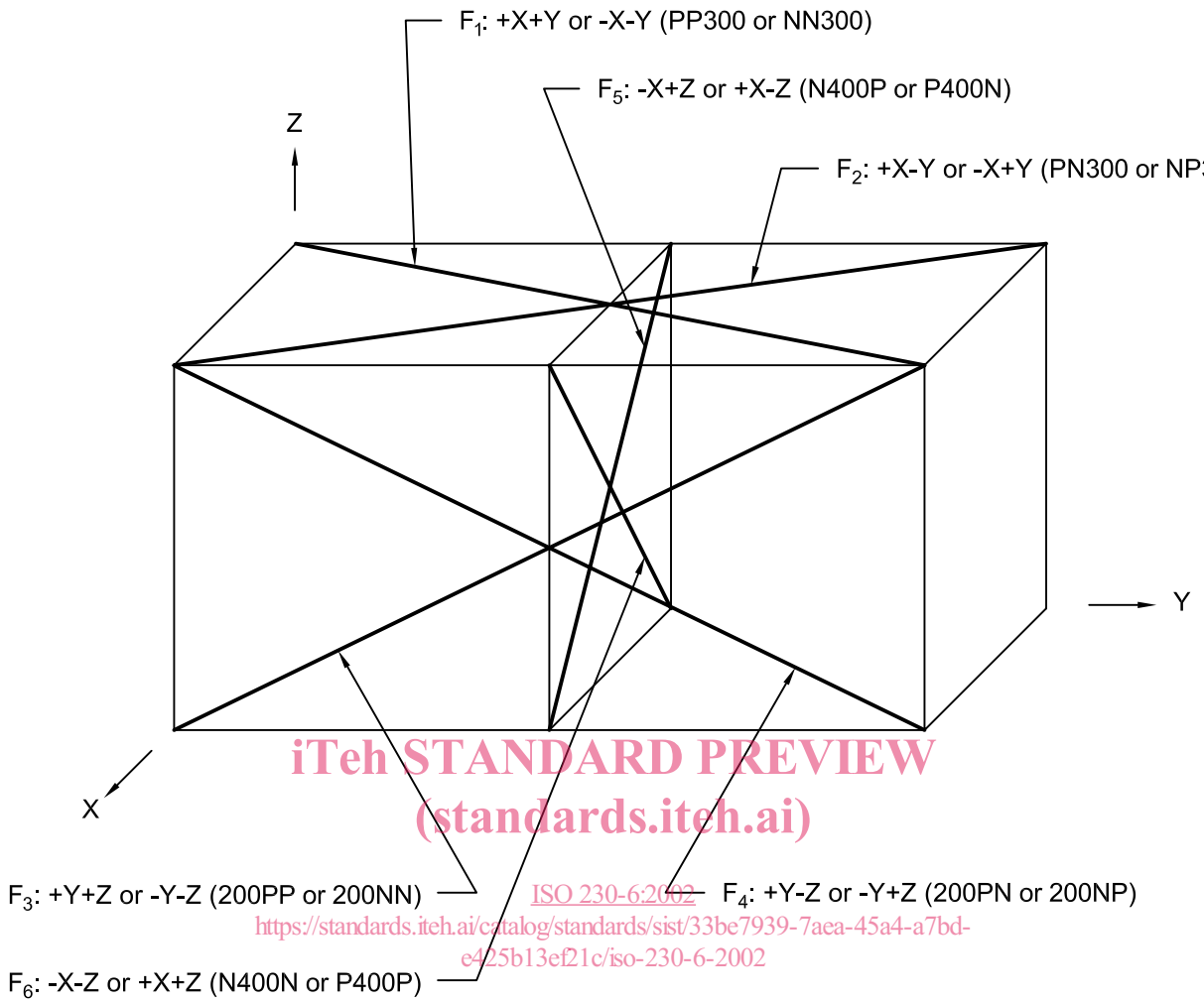

Figure 2 — Examples of face diagonals of a rectangular prism

3.4
diagonal systematic deviation of positioning
E_d
maximum bidirectional systematic deviation of positioning (in accordance with ISO 230-2) of the four body diagonals, E_1, E_2, E_3, E_4 (evaluation of E_i, see Figure 3)

E_d = max. [E_1], E_2, E_3, E_4

3.5
diagonal systematic deviation of positioning in face diagonals
E_d (ab)
maximum bidirectional systematic deviation of positioning (in accordance with ISO 230-2) of the two face diagonals, E_1(ab), E_2(ab), where “ab” defines the coordinate plane of measurement

EXAMPLE E_d(XY) = max. [E_1(XY), E_2(XY)] for the two face diagonals in the XY plane.

3.6
diagonal reversal value
B_d
maximum reversal value (in accordance with ISO 230-2) of the four body diagonals, B_1, B_2, B_3, B_4 (evaluation of B_i see Figure 3)

B_d = max. [B_1, B_2, B_3, B_4]

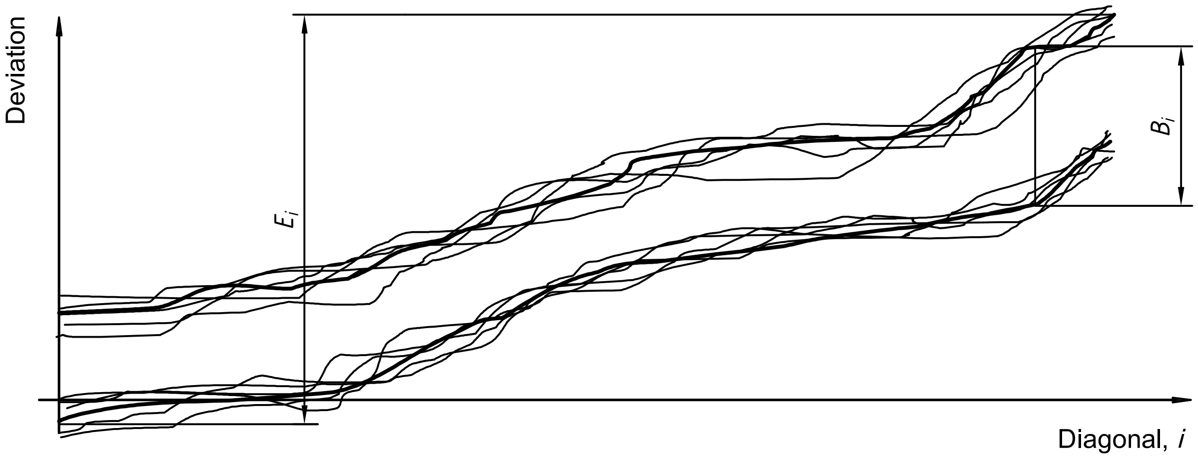

Figure 3 — Evaluation of E_i and B_i

3.7
diagonal reversal value for face diagonals
B_d(ab)
maximum reversal value (in accordance with ISO 230-2) in the two face diagonals, B_1(ab), B_2(ab), where "ab" defines the coordinate plane of measurement

EXAMPLE B_d(XY) = max. [E_1(XY), E_2(XY)] for the two face diagonals in the XY plane.

3.8
volumetric performance
ability of a machine tool to perform the intended multi-axes functions anywhere within the working volume or a smaller volume as agreed between manufacturer/supplier and user

NOTE Indication for reduced volume shall be by wording "reduced volume" after any parameter stated, e.g. E_d (reduced volume) = 0,012 mm.

4 Preliminary remarks

4.1 Measuring units

In this part of ISO 230, all linear dimensions are expressed in millimetres.

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

To apply this part of ISO 230, reference should be made to ISO 230-1, especially for the installation of the machine before testing, warming-up of moving parts and recommended accuracy of test equipment.

Reference should also be made to ISO 230-2, especially for set-up and instrumentation, evaluation of results and presentation of results.

4.3 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 230. 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 features which are of interest to him, or relating to the components forming parts of the machine. Nevertheless these tests shall be clearly stated when ordering a machine and submitted to agreement as to the resulting expenses.

A solitary reference to this part of ISO 230 for acceptance tests, without agreement on the tests to be applied and on the resulting expenses, cannot be considered binding on any contracting party.

4.4 Measuring instruments

Laser interferometer or other measuring systems with comparable accuracy may be used (see 2.2 of ISO 230-1:1996).

4.5 Position of linear axes not under test

The position of the axis slides or moving components on the axes that are not under test shall be stated in the test sheet.

4.6 Measurement uncertainty

The measurement uncertainty is influenced by

— the uncertainties of the measuring instruments used for a single test;

— the uncertainties of possible alignments of the measuring instruments (dead path error, cosine error; see clause A.13 of ISO 230-1:1996);

— the uncertainties due to environmental influences, e.g. temperature influences (see clause 4 of ISO 230-3:2001).

The combined measurement uncertainty of a test should not be larger than a portion of the tolerance. The permissible portion should be agreed upon between the supplier/manufacturer and the user.

5 Test procedure, parameters, set-up procedure

5.1 Test procedure

The test procedure is conceptually similar to that described in ISO 230-2 for linear axes, except that linear displacements are not measured parallel to a linear axis, but along the diagonal of the working volume or plane of the machine tool.

NOTE On machines where one of the axes is much larger than the others, the diagonal displacement tests can be insensitive to certain systematic machine deviations.

The measurements shall be carried out along the four body diagonals (see Figure 1) of the working volume of a three-dimensional machine, and the two face diagonals of a two-dimensional machine (e.g. turning machine). Additionally, any or all of the six face diagonals of a three-dimensional machine (see Figure 2) may be carried out as required or as agreed between the supplier/manufacturer and the user.

5.2 Target positions

A minimum of five equally spaced target positions per metre diagonal length with an overall minimum of five target positions shall be selected.