INTERNATIONAL STANDARD

ISO 230-4

Second edition
2005-04-01

Test code for machine tools —

Part 4: Circular tests for numerically controlled machine tools

Code d'essai des machines-outils —

Partie 4: Essais de circularité des machines-outils à commande numérique

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 230-4:2005
https://standards.iteh.ai/catalog/standards/sist/0508849d-d71e-487e-94da-0ddcc915faeb/iso-230-4-2005

Reference number
ISO 230-4:2005(E)

© ISO 2005

PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 230-4:2005
https://standards.iteh.ai/catalog/standards/sist/0508849d-d71e-487e-94da-0ddcc915faeb/iso-230-4-2005

© ISO 2005

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

 © ISO 2005 – All rights reserved

Contents

Page

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 230-4:2005
https://standards.iteh.ai/catalog/standards/sist/05088849d-d71e-487e-94da-0ddcc915faeb/iso-230-4-2005

© ISO 2005 – All rights reserved

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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 230-4 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

This second edition cancels and replaces the first edition (ISO 230-4:1996), of which it constitutes a technical revision. The main changes are

ISO 230-4:2005
https://standards.iteh.ai/catalog/standards/sist/05088849d-d71e-487e-94da-0ddcc915faeb/iso-230-4-2005

— the replacement of circular hysteresis H by bi-directional circular deviation G(b), because of the difficulty of evaluating circular hysteresis H by commonly available metrology instruments, and because bi-directional circular deviation G(b) contains similar information,

— the introduction of the mean bi-directional radial deviation, D,

— addition of the word “counter-clockwise”, the US variant of “anticlockwise”, for purposes of clarity where US usage is the norm,

— mention of measurement and test uncertainty,

— the inclusion of parameters G(b) and D in Annex A, and

— modification of the wording of 3.8 and B.3.1.

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 machine tools*

— *Part 3: Determination of thermal effects*

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

— *Part 5: Determination of the emission*

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

© ISO 2005 – All rights reserved

— *Part 7: Geometric accuracy of axes of rotation*

— *Part 9: Estimation of measurement uncertainty for machine tool tests according to series 230, basic equations* [Technical Report]

The following parts are under preparation:

— *Part 8: Determination of vibration levels* [Technical Report]

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 230-4:2005
https://standards.iteh.ai/catalog/standards/sist/0508849d-d71e-487e-94da-0ddcc915faeb/iso-230-4-2005

© ISO 2005 – All rights reserved

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 230-4:2005
https://standards.iteh.ai/catalog/standards/sist/0508849d-d71e-487e-94da-0ddcc915faeb/iso-230-4-2005

Test code for machine tools —

Part 4:
Circular tests for numerically controlled machine tools

1 Scope

This part of ISO 230 specifies methods of testing and evaluating the bi-directional circular deviation, the mean bi-directional radial deviation, the circular deviation and the radial deviation of circular paths that are produced by the simultaneous movements of two linear axes. Relevant measuring instruments are described in ISO 230-1:1996, 6.63.

The objective of this part of ISO 230 is to provide a method for the measurement of the contouring performance of a numerically controlled machine tool.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

2 Normative references

The following referenced documents are indispensable for the application 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 230-4:2005
https://standards.iteh.ai/catalog/standards/sist/0508849d-d71e-487e-94da-0ddce915faeb/iso-230-4-2005

ISO 230-1:1996, *Test code for machine tools — Part 1: Geometric accuracy of machines operating under no-load or finishing conditions.*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
nominal path
numerically controlled and programmed circular path defined by its diameter (or radius), the position of its centre and its orientation in the working zone of the machine tool and which may be either a full circle or a partial circle of at least 90°

3.2
actual path
path produced by the machine tool when programmed to move on the nominal path

3.3
bi-directional circular deviation
G(b)
minimum radial separation of two concentric circles (minimum zone circles) enveloping two actual paths, where one path is carried out by a clockwise contouring motion and the other one by an anticlockwise (counter-clockwise) contouring motion

See Figure 1.

© ISO 2005 – All rights reserved

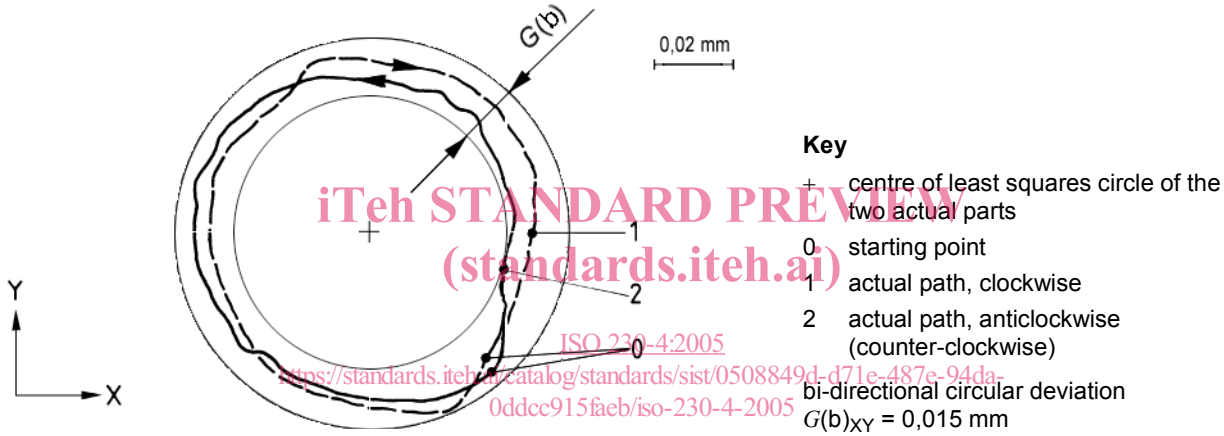
NOTE 1 The bi-directional circular deviation G(b) may be evaluated as the maximum radial range of deviations around the least squares circle. The least squares circle is calculated from 2 paths, i.e. the clockwise and the anticlockwise (counter-clockwise) path.

NOTE 2 Bi-directional circular deviation G(b) does not include set-up errors, i.e. centring errors of the measuring instrument.

NOTE 3 Bi-directional circular deviation G(b) measurement requires the use of test equipment only with calibrated displacement measurements (no need for calibrated length measurements for path diameter). The measurements of radial deviation F and mean bi-directional radial deviation value D require test equipment with both calibrated length and calibrated displacement (see Annex A).

NOTE 4 A line situated in a plane is said to be circular when all its points are contained between two concentric circles whose radial separation does not exceed a given value (see Figure 2 and also ISO 230-1:1996, 6.61).

NOTE 5 Designation G(b) is for measurements with external measurement equipment only, e.g. as described in ISO 230-1:1996, 6.63. Results from circular tests using a feed back signal are designated as "bi-directional circular deviation using feed back signal, $G(b)_f$," see Annex E.



iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 230-4:2005
https://standards.iteh.ai/catalog/standards/sist/0508849d-d71e-487e-94da-0ddcc915faeb/iso-230-4-2005

Figure 1 — Evaluation of bi-directional deviation G(b)

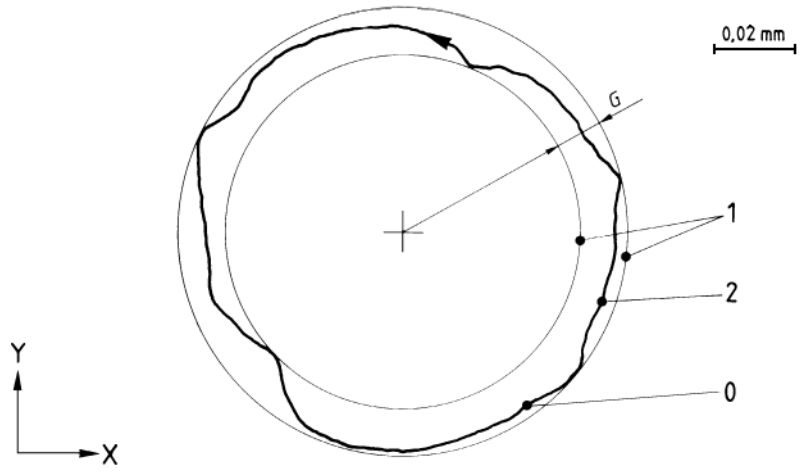
3.4
circular deviation
G
minimum radial separation of two concentric circles enveloping the actual path (minimum zone circles) of a clockwise or anticlockwise (counter-clockwise) contoured path and which may be evaluated as the maximum radial range around the least squares circle

See Figure 2.

NOTE 1 The notes for bi-directional circular deviation G(b) apply for circular deviation G. For differences between the circular deviation G and the radial deviation F, see Annex A.

NOTE 2 Designation G is for measurements with external measurement equipment, e.g. described in ISO 230-1, 6.63, only. Results from circular tests using feed back signal shall be designated circular deviation using feed back signal G_f, see Annex D.

© ISO 2005 – All rights reserved



Key

+ centre of least squares circle of the two actual parts
0 starting point
1 minimum zone circles
2 actual path

circular deviation G_{XY} = 0,012 mm

Figure 2 — Evaluation of circular deviation G

3.5
radial deviation
F

deviation between the actual path and the nominal path, where the centre of the nominal path is obtained either

iTeh STANDARD PREVIEW
(standards.iteh.ai)

a) from the centring of the measuring instruments on the machine tool, or

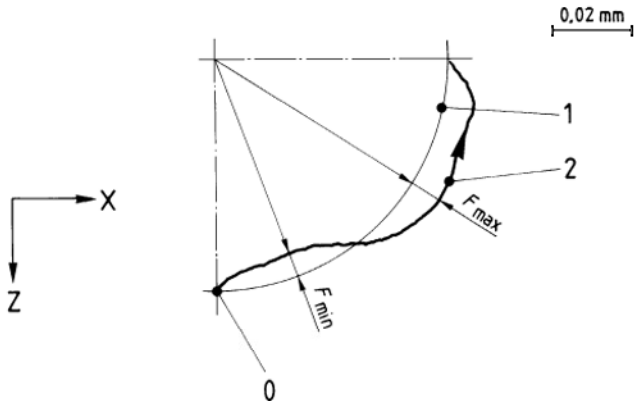
b) from the least squares centring analysis for a full circle only.

ISO 230-4:2005
https://standards.iteh.ai/catalog/standards/sist/05098494-471c-487a-90da-0ddcc915faeb/iso-230-4-2005

NOTE 1 Positive deviations are measured away from the centre of the circle and negative ones towards the centre of the circle (see Figure 3). The radial deviation is given by the maximum value, F_{max}, and the minimum value, F_{min}.

NOTE 2 Set-up errors may be included in the radial deviation F; this is applicable only to a) above.

NOTE 3 For differences between the radial deviation F and the circular deviation G, see Annex A.



Key

+ centre of nominal circles
0 starting point
1 nominal path
2 actual path

radial deviation: $F_{ZX,\,max}$ = +0,008 mm
$F_{ZX,\,min}$ = –0,006 mm

Figure 3 — Evaluation of radial deviation F

© ISO 2005 – All rights reserved

3.6
mean bi-directional radial deviation
D
deviation between the radius of the nominal path and the radius of the least squares circle of two full circle actual paths, where one path is carried out by a clockwise contouring motion and the other one by a anticlockwise (counter-clockwise) contouring motion

NOTE For differences between mean bi-directional radial deviation D and bi-directional circular deviation G(b), see Annex A.

3.7
identification of axes
designation of the axes which are moved to produce the actual path

3.8
sense of contouring
〈clockwise/anticlockwise (counter-clockwise) contouring〉 sequence of indices denoting the direction of contouring

NOTE The order of the indices matches the order in which the circular arc crosses the positive extreme of each axis. For example GXY denotes the anticlockwise (counter-clockwise) circular deviation, because an anticlockwise (counter-clockwise) arc in the XY plane crosses the X+ axis immediately followed by the Y+ axis. In the case of a bi-directional result, the indices denote the direction of the first arc.

4 Test conditions

iTeh STANDARD PREVIEW
(standards.iteh.ai)

4.1 Test environment

Where the temperature of the environment can be controlled, it shall be set at 20 °C. Otherwise, the output of the measuring instrument and the machine nominal readings shall be adjusted to yield results corrected to 20 °C (for radial deviation measurements only).

ISO 230-4:2005
https://standards.iteh.ai/catalog/standards/sist/050884 9d-d71e-487e-94da-0ddcc915faeb/iso-230-4-2005

The machine and, if relevant, the measuring instrument shall have been in the test environment long enough to have reached a thermally stable condition before testing. They shall be protected from draughts and external radiation such as sunlight, overhead heaters, etc.

4.2 Machine to be tested

The machine shall be completely assembled and fully operational. All necessary levelling operations and functional checks shall be completed before starting the tests.

The circular tests shall be carried out with the machine in the unloaded condition, i.e. without a workpiece.

4.3 Machine warm-up

The tests shall be preceded by an appropriate warm-up procedure, as specified by the manufacturer of the machine and/or agreed between the supplier/manufacturer and the user.

If no other conditions are specified, the preliminary movements shall be restricted to only those necessary to set up the measuring instrument.

© ISO 2005 – All rights reserved

4.4 Test parameters

Parameters of the test are the following:

a) diameter (or radius) of the nominal path;

b) contouring feed;

c) sense of contouring — clockwise or anticlockwise (counter-clockwise) according to 3.8;

d) machine axes moved to produce the actual path;

e) location of the measuring instrument in the machine tool working zone;

f) temperature (environment temperature, measuring instrument temperature, machine temperature) and expansion coefficient (of machine tool, of measuring instrument) used for compensation for mean bi-directional radial deviation D *and* radial deviation F measurement only;

g) data acquisition method (data capture range if different from 360°, starting and stop points of the actual movement, number of measuring points taken for digital data acquisition, and whether a data smoothing process is applied or not);

h) any machine compensation routines used during the test cycle;

i) positions of slides or moving elements on the axes which are not being tested.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

4.5 Test instrument calibration

For the checking of the mean bi-directional radial deviation D and the radial deviation F, the reference dimension of the test instrument shall be known.

ISO 230-4:2005
https://standards.iteh.ai/catalog/standards/sist/0508849d-d71e-487e-94da-0d4ce81556eb/iso-230-4-2005

NOTE For circular tests using a feed back signal, see Annex D.

4.6 Test uncertainty

The main contributors to the test uncertainty for the bi-directional circular deviation G(b) and the circular deviation G are the

— measurement uncertainty of the test equipment;

— repeatability of the machine tool, checked, for example, by repetition of the circular test;

— temperature drift of the machine tool and/or the test equipment, checked, for example, by a drift test according to ISO/TR 16015.

The main contributors to the test uncertainty for the mean bi-directional radial deviation D and the radial deviation F are the

— contributors for the deviations G(b) and G (see above);

— uncertainty of the temperature measurement of the machine tool and the test equipment [caused by the uncertainty of the temperature sensor(s) and the uncertainty due to the location of the temperature sensor(s)];

— uncertainty of the thermal expansion coefficients of the machine tool and the test equipment (used for the compensation to 20 °C).

© ISO 2005 – All rights reserved