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Test conditions for numerically controlled turning machines and turning centres —

Part 8: Evaluation of thermal distortions

Conditions d'essai des tours à commande numérique et des centres de tournage —

Partie 8: Évaluation des effets thermiques

Reference number
ISO 13041-8:2004(E)

Foreword

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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 13041-8 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

ISO 13041 consists of the following parts, under the general title *Test conditions for numerically controlled turning machines and turning centres*:

— *Part 1: Geometric tests for machines with a horizontal workholding spindle*

— *Part 2: Geometric tests for machines with vertical workholding spindle*

— *Part 3: Geometric tests for machines with inverted vertical workholding spindle*

— *Part 4: Accuracy and repeatability of positioning of linear and rotary axes*

— *Part 5: Accuracy of feeds, speeds and interpolations*

— *Part 6: Accuracy of a finished test piece*

— *Part 7: Evaluation of contouring performance in the coordinate planes*

— *Part 8: Evaluation of thermal distortions*

Introduction

The object of ISO 13041 is to supply information as wide and comprehensive as possible on geometric, positional, contouring, thermal and machining tests which can be carried out for comparison, acceptance, maintenance or any other purpose.

ISO 13041 specifies, with reference to the relevant parts of ISO 230, *Test code for machine tools,* tests for turning centres and numerically controlled turning machines with/without tailstocks standing alone or integrated in flexible manufacturing systems. ISO 13041 also establishes the tolerances or maximum acceptable values for the test results corresponding to general purpose and normal-accuracy turning centres and numerically controlled turning machines.

Test conditions for numerically controlled turning machines and turning centres —

Part 8:
Evaluation of thermal distortions

1 Scope

This part of ISO 13041 specifies, with reference to ISO 230-3, the tests which apply for the evaluation of thermal distortions of the machine structure and positioning system, up to 2 000 mm in length, of numerically controlled (NC) turning machines and turning centres.

Hence, this part of ISO 13041 defines three tests which are

— the environmental temperature-variation error test,

— the test for thermal distortion caused by a rotating spindle, and

— the test for thermal distortion caused by moving linear axes.

It should be noted that there is no intention of assigning any numerical tolerances associated with the tests described in this part of ISO 13041.

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

ISO 230-3:2001, *Test code for machine tools — Part 3: Determination of thermal effects*

ISO 13041-1:2003, *Test conditions for numerically controlled turning machines and turning centres — Part 1: Geometric tests for machines with a horizontal spindle*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13041-1 apply.

4 Preliminary remarks

4.1 Reference to ISO 230-3

To apply this part of ISO 13041, reference shall be made to ISO 230-3, especially for the installation of the machine before testing, description of measuring methods and presentation of the results.

4.2 Testing sequence

The tests in this part of ISO 13041 may be used either separately or in any combination.

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 13041. 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 are to be clearly stated when ordering a machine. Mere reference to this part of ISO 13041 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.

5 Environmental Temperature Variation (ETVE) test

5.1 General

ETVE tests are designed to reveal the effects of environmental temperature changes on the machine. They shall not be used for machine comparison.

It is recommended that the supplier/manufacturer should offer guidelines regarding what kind of thermal environment should be acceptable for the machine to perform with the specified accuracy. It shall be the responsibility of the user to provide an acceptable thermal environment for the operation. However, if the user follows the guidelines provided by the machine supplier/manufacturer, the responsibility for machine performance according to the specification reverts to the machine supplier/manufacturer.

5.2 Test method

The test method shall be in accordance with those defined in 5.2 of ISO 230-3. The ETVE test should last for a minimum of 4 h; if the readings of the measuring instruments still show any drift, the test should be continued up to a maximum of 24 h.

NOTE Vertical and slant-bed axes might warm up when under NC “HOLD” command. In such cases, it is recommended to execute the ETVE test with all controls “OFF”. This should be stated in the test protocol.

5.3 Measuring instruments

The measuring instruments are as follows: linear displacement probe, temperature sensors, test mandrel and data acquisition equipment.

5.4 Presentation of results

Table 1 provides an example of the format for the presentation of the results; in addition, a graphical presentation of results should be provided as specified in 5.3 of ISO 230-3:2001.

Table 1 — Format for the presentation of the ETVE results

Parameter		Results		
		Category 1	Category 2	Category 3
Time	min			
$ETVE_X$	mm			
$ETVE_Y$	mm			
$ETVE_Z$	mm			
$ETVE_A$	arcseconds			
$ETVE_B$	arcseconds			

5.5 Information to be recorded

a) the name of the manufacturer;

b) the year of construction, if available;

c) the type and serial number;

d) the location of the measurement set-up;

e) the location of temperature sensors;

f) the type of sensors;

g) the design and material of the test mandrel and fixture;

h) the thermal compensation procedure;

i) the any special test procedures;

j) the time and date of test;

k) the machine preparation procedure prior to testing;

l) the control OFF.

6 Thermal distortion caused by rotating spindle

6.1 Number of tests

One test per spindle shall be carried out.

6.2 Test method

The test method shall be in accordance with those defined in 6.2 of ISO 230-3:2001, however for practical reasons, the test procedure should be the variable speed spectrum.

NOTE A possible example of the speed spectrum cycle could be a percentage of the maximum spindle speed for a set time followed by a spindle stop for another fixed time, (e.g. 70 % maximum spindle speed for 3 min followed by a 1 min stop). This cycle is then repeated for the complete test duration. The exact details of the speed spectrum needs to be discussed between the user and manufacturer/supplier.

The test shall last for 4 h plus 1 h with the spindle stopped.

6.3 Measuring instruments

The measuring instruments are as follows: linear displacement probe, temperature sensors, test mandrel and data acquisition equipment.

6.4 Presentation of results

Table 2 provides an example of the format for the presentation of the results; in addition, a graphical presentation of results should be provided as specified in 6.3 of ISO 230-3:2001.

Table 2 — Format for the presentation of the thermal effects caused by a rotating spindle

Parameter	Results								
	Category 1			Category 2			Category 3		
	After 60 min	After end of period t	Distance l	After 60 min	After end of period t	Distance l	After 60 min	After end of period t	Distance l
X1 mm									
Y1 mm									
Z mm									
A mm/mm									
B mm/mm									

6.5 Information to be recorded

a) the name of the manufacturer;

b) the year of construction, if available;

c) the type and serial number;

d) the location of the measurement set-up;

e) the location of temperature sensors;

f) the type of sensors;

g) the design and material of the test mandrel and fixture;

h) the thermal compensation procedure;

i) the spindle speed regime;

j) the any special test procedures;

k) the time and date of test;

l) the machine preparation procedure prior to testing.

7 Thermal distortion caused by moving linear axes

7.1 Test method

The test method shall be in accordance with those defined in 7.2 of ISO 230-3:2001.

NOTE In practice, there should be different feed rates for principal and auxiliary axes (e.g. for principal axes, the limits might be set at 50 % of F_{max} and for auxiliary axes it they might be set at 20 % of F_{max}.

The test shall last for 4 h.

7.2 Measuring instruments

The measuring instruments are as follows: laser interferometer or bidirectional linear displacement probes and a special test mandrel. When the laser interferometer is used, proper precautions shall be taken according to A.13 of ISO 230-1:1996.

7.3 Presentation of results

Table 3 provides an example of the format for the presentation of the results, in addition, a graphical presentation of results should be provided as specified in 7.4 of ISO 230-3:2001.

Table 3 — Format for the presentation of the thermal effects caused by moving axes

Parameter	Results								
	Category 1			Category 2			Category 3		
	X	Y	Z	X	Y	Z	X	Y	Z
$e1_+$ mm									
$e2_+$ mm									
$e1_-$ mm									
$e2_-$ mm									

7.4 Information to be recorded

a) the name of the manufacturer;

b) the year of construction, if available;

c) the type and serial number;

d) the displacement rate;

e) the location of measurement line;

f) the start and end positions;

g) compensation capabilities and facilities;

h) the instruments used;

i) the temperature sensor location;

j) the coefficient of thermal expansion used;

k) the dwell times

l) the time and date of test;

m) the warm-up procedure;

n) the temperature of the measured object at the start of the test

Bibliography

[1] ISO 1:2002, *Geometrical Product Specifications (GPS) — Standard reference temperature for geometrical product specification and verification*

[2] ISO 2806:1994, *Industrial automation systems — Numerical control of machines — Vocabulary*

[3] ISO/TR 16015:2003, *Geometrical product specifications (GPS) — Systematic errors and contributions to measurement uncertainty of length measurement due to thermal influences*