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Accuracy of machine tools and methods of test —

**Part 28: Specification for numerically
controlled turning machines up to and
including 1500 mm turning diameter**

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Committees responsible for this British Standard

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- Advanced Manufacturing Technology Research Institute
- Cranfield Institute of Technology
- Department of Trade and Industry
- Health and Safety Executive
- Institution of Production Engineers
- Ministry of Defence
- University of Aston in Birmingham

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Foreword

This Part of BS 4656 has been prepared under the direction of the Machine, Engineers and Hand Tools Standards Committee and is based on a draft submitted by the former Machine Tool Industry Research Association now known as the Advanced Manufacturing Technology Research Institute. This standard is being used in support of discussions by the International Organization for Standardization (ISO).

NOTE Numerically controlled turning machines are manufactured in a variety of configurations and sizes for both bar and chucking work. This standard includes suitable tests for differing spindle nose and turret configurations.

This Part is a revision of BS 4656-28:1981 which is withdrawn.

For this type of machine, **3.5** now gives independent status to both geometrical and practical tests and therefore the latter no longer override the former. Other changes are as follows.

Tests.

- G8. Measuring instruments.
- G12. Statement in column 4 amplified.
- G17. Alternative method introduced as G 17(b).
- G18. Repeatability test. Deleted now that BS 4656-16 is published even though Part 16 does not specify tolerances.
- G19. Test renumbered as G 18.
- P1 and P3. Permissible deviations tightened.
- Figure 3. Editorial comment.

Instrumentation test. An instrumentation test G18 to assess contouring accuracy under no load conditions, together with test P5, is included as an optional addition to tests P1 to P4. Figure 3 shows test piece dimensions for test P5. The test involves checking the circular movement produced by two linear axes that are nominally perpendicular to each other, by the use of circle comparison standards. The circle comparison standards can take different forms, namely a ball bar fixed at points corresponding to the tool and workpiece positions or a master disc fixed at the workpiece position and a linear displacement probe attached at the tool position. With some form of data acquisition system interfaced to the circle comparison standard, it is possible to obtain graphs which show the radial deviations of the machine's circular interpolation.

This test can be used for checking the stated tolerances in relation to the accuracy of the machine, and as an aid to machine diagnostics in defining the causes of the deviation in terms of geometric error, servo drive error or control system error.

Unlike a cutting test this instrumentation test is analysed on a statistical basis using a number of runs from differing directions of travel. The operating conditions can be changed after each test to establish the optimum contouring accuracy of the machine. All this is achieved in situ with the time required to assess each change kept to a minimum and with the knowledge that the results are not influenced by cutting problems.

Test piece for practical test P5. The main criteria in selecting the shape of the special test piece for test P5 are as follows:

- a) maximum verification of contouring accuracy;
- b) simplicity of shape generation (programming);
- c) ease of measurement.

The test pieces (for tests P1 to P4) as shown in Figure 1 and Figure 2 only meet the first requirement, i.e. maximum verification of contouring accuracy. The over-centre test piece (in test P5) readily meets all three requirements. By using a 105° arc segment a range of information can easily be derived using standard metrology equipment.

The shape of the test piece is easy to generate on most types of machine and, as previously stated, relatively straight-forward to measure. Additionally, by imposing intermediate programmable blocks, e.g. every 15°, the dynamic transition of block to block information can be observed. A positive witness at points of transition would indicate the form characteristics of a multi-block contour.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 18, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of BS 4656 specifies, with reference to BS 3800, both geometrical and practical tests for numerically controlled turning machines up to and including 1 500 mm turning diameter over the bed, and gives corresponding permissible deviations which apply.

This standard is applicable to machines of general purpose use and normal accuracy.

It deals only with the verification of accuracy of the machine. It does not apply to the testing of the running of the machine (vibrations, abnormal noises, stick-slip motion of components, etc.) nor to its characteristics (speeds, feeds, etc.) which should be generally checked before testing accuracy.

This standard does not apply to sequence controlled lathes, such as those with plug-boards or decade switches.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 4656 the following definitions apply.

2.1

numerically controlled machine tool

a machine tool that operates in accordance with the instructions and numerical data introduced, usually as its operations proceed, from a machine readable data medium or from a computer, without direct human control other than in the initiation of command signals

2.2

primary plane

the plane in which errors in tool positioning have the major effect on workpiece diameter sizing, parallelism and repeatability. In general, this will be the plane containing the tool cutting path

2.3

secondary plane

the plane perpendicular to the primary plane, i.e. of secondary importance in workpiece diameter sizing, etc.

3 Application of test methods

3.1 In applying the tests detailed in Table 1 and Table 2, reference should be made to BS 3800, especially concerning the installation of the machine before testing, warming up of spindles and other moving parts, the description of measuring methods and the recommended accuracy of testing equipment.

3.2 The tests may be applied in any order that is practicable and that makes for ease of mounting of instruments or gauging. The sequence in which the geometrical tests are listed in Table 1 is related to the sub-assemblies of the machine and it is not intended to impose the practical order in which the tests are to be done.

3.3 It is not always necessary for all the tests specified in this standard to be carried out. The purchaser shall be at liberty to select, in agreement with the manufacturer, those tests relating to the properties that are of interest to him. The appropriate tests are to be clearly stated when the machine is ordered.

3.4 When establishing the tolerance for a measuring range different from that given in this standard (see **2.311** of BS 3800:1964), it should be taken into consideration that the minimum value of tolerance is 0.01 mm for geometrical and practical tests.

3.5 Practical tests should be made with finishing cuts (e.g. depth 0.1 mm, feed 0.1 mm per revolution) and not with roughing cuts, which are liable to generate appreciable cutting forces. The manufacturer shall select the actual feeds and speeds for the practical tests to suit the particular machine.

The results obtained from practical tests shall be independent of those obtained from geometrical tests where these check the same feature.

4 Abbreviations

For the purposes of this Part of BS 4656, various methods of expressing permissible deviations are employed, each having a particular type of application. The methods employed are as follows.

- / -- This type of expression applies to deviations of perpendicularity that are ratios.
- for any length of -- This type of expression applies to deviations of straightness and parallelism, and is used in fact for local permissible deviations, the measurement length being obligatory.
- per -- This type of expression applies to deviations of straightness and parallelism and is used to recommend a measurement length, but in this case the proportionality rule comes into operation if the measurement length differs from that indicated.

5 Diagrams

For reasons of simplicity the diagrams in this standard illustrate only one type of machine.

6 Machine size ranges

For the purposes of this Part of BS 4656, machines are divided in two size ranges. In general, permissible deviations are applied according to the machine's size. Machine size ranges are based on the maximum diameter that can be machined over the bed thus:

Range 1. Maximum turning diameter less than or equal to 500 mm.

Range 2. Maximum turning diameter greater than 500 mm but less than or equal to 1 500 mm.

Where appropriate, allowances are also made for the distance between centres (*DC*).