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Extent of Calibration for Cylindrical Diameter Standards

PURPOSE

This guidance document is intended to improve the harmonisation within EAL for the extent of measurements to be carried out for the calibration of cylindrical standards such as ring and plug gauges. It applies only to standards where the diameter is the primary quantity to be calibrated. The document stresses the fact that the diameter calibration must include — to a certain extent — an assessment of the **variation of diameter**, either through form measurement or by measurement of several diameters. The information about diameter variation is important for both the estimation of measurement uncertainty of the calibration and the user to quantify the measurement uncertainty for further application of the standard.

Authorship

This document has been revised by EAL Committee 2 (Calibration and Testing Activities), based on the draft produced by the EAL Expert Group on Dimensional Metrology.

Official language

The text may be translated into other languages as required. The English language version remains the definitive version.

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Guidance Publications

This document represents a consensus of EAL member opinion and preferred practice on how the relevant clauses of the accreditation standards might be applied in the context of the subject matter of this document. The approaches taken are not mandatory and are for the guidance of accreditation bodies and their client laboratories. Nevertheless, the document has been produced as a means of promoting a consistent approach to laboratory accreditation amongst EAL member bodies, particularly those participating in the EAL Multilateral Agreement.

Further information

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Contents

1   Introduction

1.1   This guidance document applies to cylindrical standards such as ring and plug gauges where the diameter is the primary quantity to be calibrated. It is generally recognised that the measurement of a single diameter is not sufficient for the calibration of a cylindrical standard. Additional information about the diameter variations is required for the evaluation of the uncertainty of measurement as well as for the further use of the standard.

1.2   The variation of the diameter shall be assessed either by the measurement of several diameters close to the nominal measurement direction or by form measurement (roundness, straightness, parallelism). Note that the roundness measurement determines primarily the variation in radius. Therefrom the diameter variation can be computed or estimated.

1.3   The purpose of the document is to give guidance to:

- the accreditation bodies for evaluating the scope of accredited laboratories and their procedures;
- the calibration laboratories and their clients in the choice of the appropriate calibration category, taking into account the needs of the client (user) for his specific application of the gauges.

1.4   Three categories for the extent of measurements for the calibration of cylindrical standards are proposed. For each of these categories, appropriate examples for the further use of the standards will be given.

1.5   It has to be pointed out that the three categories do not cover all possibilities. Other methods or combinations of methods can be applied as well. Calibration procedures and guidance regarding the evaluation of measurement uncertainty are not within the scope of this document.

2 Minimum extent of calibration: Calibration of diameter without measuring form

2.1 The following three sets of measurements constitute the minimum recommended extent of calibration. It might be applied to setting devices which are used for the calibration of 2-point inside or outside diameter measurements.

- Measurement of one diameter in the nominal direction in a specified plane P orthogonal to the cylinder axis (cf. Fig.1).
- Measurement of two diameters in the plane P rotated around the cylinder axis with respect to the nominal direction by for example ±1 mm on the circumference or by ±10°, whatever is smaller.
- Measurement of two diameters in the nominal direction translated to the planes parallel to P having a separation of for example ±1 mm.

2.2 The position in which the diameter is calibrated has to be described precisely. The result of this calibration is a diameter which is only relevant for the contacting points of the nominal direction. In general, the average of the five diameter measurements shall be reported in the certificate. The variations in measured diameter will contribute — together with the repeatability in one and the same measurement direction and other contributions — to the uncertainty of measurement.
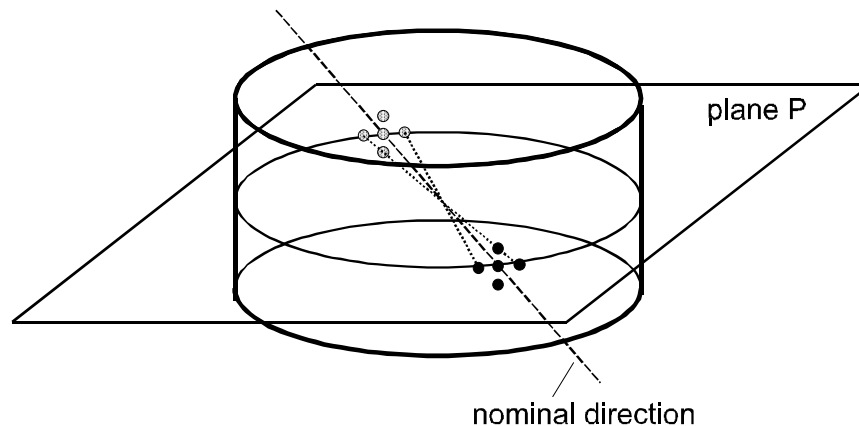

Fig.1 Nominal and four additional measurement directions allowing the assessment of diameter variation.

3 Calibration of diameter and roundness

3.1 This partial calibration is composed of diameter and roundness measurements as follows. It can be applied to cylindrical setting gauges used to calibrate 2-point or 3-point diameter measuring instruments as well as for plain plug and ring gauges used for limit gauging.

- Three measurements of roundness (for limit gauges central and close to the end faces, for setting gauges at half height and approximately at ¼ and ¾ of the height of the cylinder).
- Measurements of diameter in the three planes of roundness measurement in a common axial section. Dependent on the device and its application, it might be necessary to carry out additional diameter measurements in heights closer to the central plane of the cylinder.

3.2 In general, all three diameter and roundness measurements shall be reported in the certificate. Since no straightness and parallelism measurements are carried out, particular form deviations (such as banana form) cannot be detected. These could, however, be examined by other means.

4 Calibration of diameter, roundness, straightness and parallelism

4.1 The complete calibration is adequate when the form is relevant for the application of the standard (e.g. for mating of pistons and cylinders) and generally for highly accurate standards. It can further be applied to cylindrical setting gauges used to calibrate 2-point or 3-point diameter measuring instruments. The extent of calibration shall contain the following measurements:

- At least three measurements of roundness (central and close to the end faces).
- Measurement of straightness and parallelism of generating lines of the cylinder surface, in at least two orthogonal, axial sections.
- At least one measurement of diameter in points of intersection of the central radial and one of the axial measuring planes.

4.2 In general, all diameter and form measurements shall be reported in the certificate. Attention has to be drawn to the fact that the different form measurements generally relate to different data and that some measurements are radial and not diametrical. The combination of the form measurements is therefore not straightforward. Additional diameter measurements might be carried out in order to obtain a more reliable image of the actual cylinder surface.

5 Certificate of calibration

5.1 The certificate of calibration shall conform to the requirements of document EAL-R1 [ref. 1]. The extent of measurements and the measurement locations must be clearly indicated. This is particularly important for the minimum extent of calibration where the measurand has to be clearly defined.

5.2 With respect to the reported form measurement results, the certificate shall highlight any measurements which are outside the accredited scope.

6 References

1 EAL-R1 : 1995. *Requirements Concerning Certificates Issued by Accredited Calibration Laboratories*