

Centre for Basic, Thermal and Length Metrology
National Physical Laboratory

MOY/SCMI/36

**SPECIFICATION OF ACCURACY FOR A
PRECISION CLINOMETER**

A “Watts” Precision Clinometer fitted with a circular glass scale and an optical micrometer graduated to read direct to $1/6^{\text{th}}$ minute of arc (10 seconds of arc). A bubble unit is supplied for fiducial setting.

Made by: Messrs. Hilger & Watts Ltd. (Watts Division).

FOREWORD

In the 1940s and 1950s, NPL was involved in drafting a special series of Specifications of Accuracy that covered a wide range of precision measuring apparatus. This series has been built on first hand experience gained in the design and construction of prototype measuring equipment at NPL and in the design and calibration of measuring equipment of British and foreign manufacture. Each specification in the series originally conformed to a general pattern and was allocated a permanent serial number which, in addition to its title, serves as its identity.

The MOY/SCMI (Metrology/Specification Certification Measuring Instruments) standards are complementary to the Standards issued by the British Standards Institute (BSI). The majority relate to measurement equipment of a proprietary kind designed either at NPL or by British manufacturers which, in the ordinary way, would not fall within BSI's terms of reference. In some cases, in which the equipment is of a more general nature, the Specification has provided a useful basis for formulating a British Standard. The specifications are to enable manufacturers to base their inspection on mutually agreed specifications of accuracy both in workmanship and performance.

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SCOPE

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Figure 1 A Clinometer (5 second graduations)

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1 GENERAL

- 1.1 The general workmanship and finish shall be in keeping with a precision instrument of this class.
- 1.2 The instrument shall be marked with an identification number and with the maker's name or trademark.
- 1.3 The circular glass scale and its optical micrometer scale shall focus simultaneously. The position of normal focus of these two scales shall be approximately in the centre of the eyepiece travel.
- 1.4 The graduation lines of both scales shall be cleanly cut and free from blemishes.
- 1.5 The readings of the exterior setting scale and those of the circular glass scale shall agree to within **± 0.5 degree**.
- 1.6 The value of the scale divisions of the optical micrometer shall be clearly indicated.
- 1.7 The fine-setting device shall operate smoothly.
- 1.8 The steel base shall have a hardness of not less than **750 HV**, when tested in accordance with BS EN ISO 6507-1:1998.

2 ALIGNMENTS

NOTE: The front bearing edge shall be regarded as the datum edge for the clinometer.

- 2.1 The underside of the base shall be flat. When the instrument is placed on a truly flat surface it shall be free from rock to within **0.013 mm**.
- 2.2 The front and side bearing edges of the base shall be flat to within **0.013 mm**.
- 2.3 The front and side bearing edges of the base shall be mutually square to within **0.05 mm** as measured over the longer side.
- 2.4 The front and side bearing edges of the base shall be square to the underside of the base to within **0.025 mm** over their depth.

3 BUBBLE UNIT

NOTE: This unit shall be in general accordance with the requirements of BS 958 with regard to:

Scale

- 3.1 It is recommended that the scales on all levels be divided into 2.5 mm divisions (0.1 inch).

Marking

- 3.2 It is recommended that the glass tube of the level be etched with the nominal sensitivity in terms of a base length of 10 in. (or in terms of mm per metre), e.g.

1 div = 0.001 in./10 in.

(1 div = 0.1 mm/metre)

Accuracy of Calibration

- 3.3 When tested on a tilting table, readings being taken at each division at both ends of the bubble, the level should comply with the following limits of error:

- (i) The average sensitivity shall not differ from the value marked on the level by more than **10 per cent**
- (ii) The maximum deviation of the value of any one division from the average value shall not exceed **0.2 division**

4 ACCURACY

- 4.1 Identical fiducial settings of the bubble unit shall be made and the departure of any one reading from the mean of six readings shall not exceed **one half micrometer scale division (5 seconds of arc)**.

- 4.2 The maximum error of indication between any two readings, including those of the optical micrometer scale, shall not exceed **one-micrometer scale division - 10 seconds of arc**.

5 UNCERTAINTIES

- 5.1 It will normally be necessary to consider the uncertainty of measurement when ascertaining compliance (or non-compliance) with this specification. UKAS document M3003 '*Uncertainty and confidence in measurement*' gives guidance in Appendix J.

6 REPORTING OF COMPLIANCE

- 6.1 Certain clauses in any specifications are necessary to support manufacture and assembly but may be difficult or unnecessary to check in subsequent checks for compliance with this specification. In certain cases checking a feature may require disassembly of the item, which may be undesirable. Although it is not essential that all clauses be checked on subsequent verification, it is important that those clauses omitted do not detract from the metrological value of the test. Where applicable, a performance check should always be carried out as this may allow indirect verification of those parameters that are not easily measured individually without disassembly.
- 6.2 When making statements of compliance or non-compliance, it is recommended that this specification and the relevant clauses within it be unambiguously identified in the calibration certificate or test report.

Example wording for a set of angle gauges follows.

This set of angle gauges has been examined for compliance with the accuracy requirements of clauses 2 and 3 of NPL Specification of Accuracy MOY/SCMI/18 (Issue 5), a copy of which is attached to this certificate.

For free measurement advice and information on other specifications in this series call the NPL Help line on 020 8943 6880

E-mail: enquiry@npl.co.uk

Internet: www.npl.co.uk

National Physical Laboratory
Queens Road
Teddington
Middlesex
TW11 0LW

Further information on angle measurement can be found in '*Measurement of Angle in Engineering*' by J C Evans and C O Taylerson (Third Edition Revised by E W Palmer and S P Poole).

The standard reference temperature for industrial length measurements is defined in ISO 1:1975 *Standard reference temperature for industrial length measurements*.

United Kingdom Accreditation Service (UKAS) can be contacted at

21-47 High Street
Feltham
Middlesex
TW13 4UN

Tel 020 8917 8400

Internet: www.ukas.com

