Your Ref.: PO No.:
Our Ref.: RN190883
File No.: CB/13/0209

7 June 2019

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Australian Government
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Attention: Mr Tony Castelli

Subject: Regulation 13 Certificate and Measurement Report RN190883

Dear Tony,

Enclosed are Regulation 13 Certificate and Measurement Report RN190883 on the TS30 LEICA electronic distance measuring instrument s/n: 364182 submitted to this laboratory for examination as per our quotation Q190883.

The fee for this service is $4,332.38. Our Finance Section is handling the payment arrangements and will contact you shortly if necessary.

Yours faithfully

Mr. Peter Cox
Project Leader

Encl.

Australian Government
Department of Industry, Innovation and Science

National Measurement Institute

Certificate of Verification of a Reference Standard of Measurement in accordance with Regulation 13 of the *National Measurement Regulations 1999* (Cth) in accordance with the *National Measurement Act 1960* (Cth)

Certificate Number RN190883

Description of standard of measurement: Leica TS30 Electronic Distance Measuring (EDM) instrument with Leica GPH1P prism

Permanent distinguishing marks: Serial No. (EDM): 364182
Serial No. (prism): 100

Date of verification: 16 May 2019

Period of certificate: From date of verification until 16 May 2021

Value(s) of standard of measurement: As stated in Report RN190883 of the National Measurement Institute

Accuracy of verification: Uncertainty of value(s) as stated in Report RN190883 of the National Measurement Institute

Values and uncertainties of relevant influence factors: As stated in Report RN190883 of the National Measurement Institute

Signature:  **Date: 6 June 2019**

Name of Signatory: Mr. Peter Cox

Being a person with powers delegated by the Chief Metrologist acting under section 18D of the *National Measurement Act 1960* (Cth) in respect of regulation 13 of the *National Measurement Regulations 1999* (Cth), I hereby certify that the above standard is verified as a reference standard of measurement in accordance with the regulations.

Note: Report RN190883 of the National Measurement Institute forms part of this Certificate.

Australian Government

Department of Industry, Innovation and Science

National Measurement Institute

MEASUREMENT REPORT ON

LEICA, TS30 electronic distance measuring instrument

Serial number: 364182

Accredited for compliance with ISO/IEC 17025 - Calibration.

Accreditation Number 1.

The National Measurement Institute is responsible for Australia's units and standards of measurement. The measurement results presented in this report are traceable to Australia's primary standards.

Headquarters

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For further information contact: Mr. Andrew Baker
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Email: andrew.baker@measurement.gov.au

Ref: RN190883 File: CB/13/0209 Checked: AB Date: 21/05/2019

For:	Landgate, Head Office 1 Midland Square Morrison Road (cnr Gt Northern Hwy) MIDLAND WA 6056
Description:	TS30 Electronic Distance Measuring (EDM) instrument and a GPH 1P prism reflector
Maker:	LEICA
Identification:	EDM serial no: "364182" and barcode "S1000320" Prism serial no: "100" and "1"
Previous Examination:	RN170995 dated 19 June 2017
Date(s) of Test:	15 May 2019 to 16 May 2019

General

After acclimatization to the ambient conditions, the instrument parameters: *l, t, i, c* and ATR were determined according to the manufacturer's instructions using the instrument's built-in self-adjustment routines.

The instrument settings used at the time of measurement are given in Table 1.

Table 1: Instrument Settings

Parameter	Value	Parameter	Value
EDM type:	Reflector (IR)	Air Temperature:	12°C
EDM mode:	Precise	Air Pressure:	1013.3 mbar
Reflector:	Leica Circular Prism	Air Humidity:	60%
Additive constant:	0.0 mm	Atm ppm correction:	0.0
ATR settings:	OFF	Scale at C.M.	1.000 000 000
Automation:	None	Geo. ppm correction:	-0.1
Refraction correction:	ON	Compensator:	ON
Refraction coeff. (k):	0.13	Hz Correction:	ON

Details of Test

The instrument's modulation frequency was measured by comparison with the 10MHz reference signal generated by the Australian National Frequency Standard. Measurements were made periodically at 1 and 2 minute intervals over a period of approximately 30 minutes. Refer also to Note 2.

A functional test was performed over the range 20 m to 649 m using the NMI 7 pillar baseline and the supplied reflector assembly to determine the instrument's zero point correction and standard deviation. Refer also to Notes 3, 4 and 5 and 6.

Results

The results and uncertainties of measurement are given in Table 2, where the modulation frequency deviation is expressed as a scale correction factor. The results of the statistical tests recommended in ISO17123-4:2012 are included in Table 3. The residual errors from the least squares fit for the measured baseline distances are shown in Figure 1.

Table 2: Results of Measurement

Item	Result of Measurement	Uncertainty	Coverage Factor
Scale correction factor	1.000 000 08	± 0.000 000 06	2.1
Zero point correction, *d*	+ 0.32 mm	± 0.34 mm	2.0
Standard deviation, *s*	0.32 mm (degrees of freedom = 14)		

Table 3: Statistical Tests (for information only)

Test I.D.	Null Hypothesis	Result	Confidence Level
A	Standard deviation, s < manufacturer's specified standard deviation (taken to be 0.5 mm)	Accept	95%
B	Standard deviations belong to the same population as the previous report	Reject	95%
C	Zero point correction, $d = 0$ as specified by the manufacturer	Accept	95%

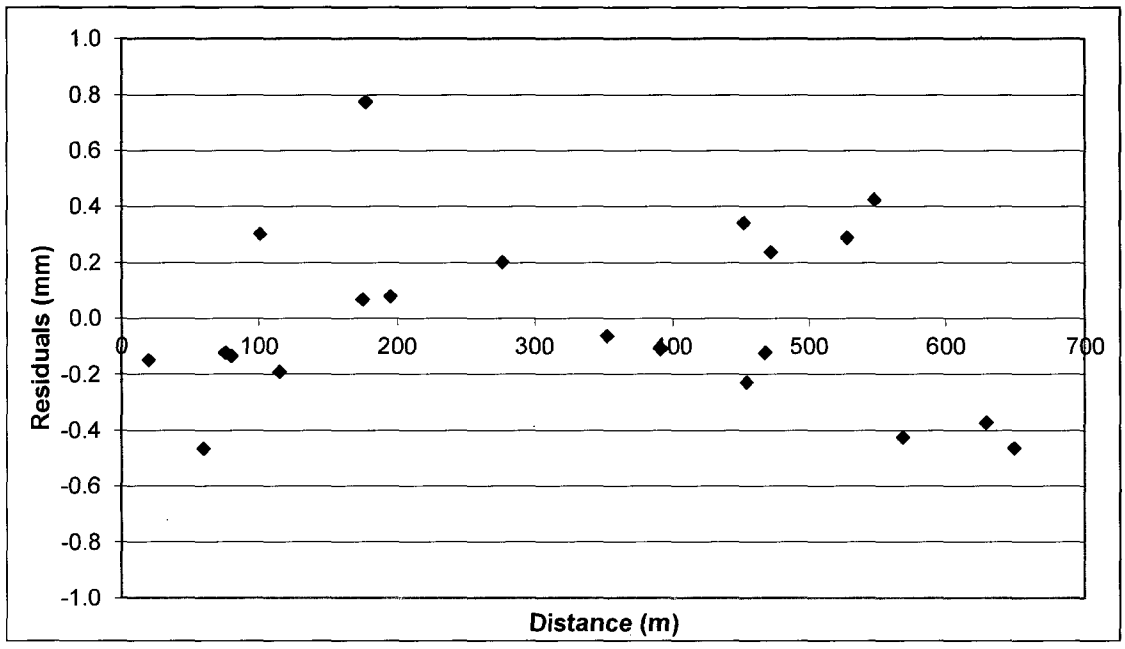

Figure 1: Residuals from least squares fit of the baseline measurements

Notes

1. The uncertainty stated in this Report has been calculated in accordance with the principles in *JCGM 100:2008 - Evaluation of measurement data - Guide to the expression of uncertainty in measurement*, and gives an interval estimated to have a level of confidence of 95%. Unless otherwise stated, a coverage factor (k) of 2.0 has been used. The uncertainty applies at the time of measurement only and takes no account of any drift or other effects that may apply afterwards. When estimating the uncertainty at any later time, other relevant information should also be considered, including, where possible, the history of the performance of the instrument and the manufacturer's specification.
2. The instrument's modulated frequency was measured by switching the instrument into Test mode for periods of approximately 15 seconds duration. Between measurements the instrument was left switched on but switched out of Test mode to avoid excessive heating of the instrument's oscillator. Ambient laboratory temperature at the time of measurement was within the range (20.15 ± 0.1) °C.
3. The functional test was performed following the procedures given in Test Method PM-LEN-8.2.26-V6-EDM Long of the Melbourne Physical Metrology site operations manual. The method is based on the full test procedure described in ISO17123-4 *Optics and optical instruments – Field procedures for testing geodetic and surveying instruments – Part 4: Electro-optical distance meters (EDM measurements to reflectors)*, 2nd ed., 2012-06-01.
4. Baseline measurements were carried out on 16th May 2019 over the period 7 am to 9:30 am under clear and sunny conditions. Ambient atmospheric conditions during the measurements varied as follows: air temperature (13.2 ± 4.0) °C, air pressure (1021.6 ± 0.5) hPa and relative humidity (86 ± 14) %.

5. The baseline measurements were corrected for the ambient atmospheric conditions using a nominal carrier wavelength of 658 nm. After applying the scale correction factor, the distances were referred to a common height and axis.
6. The uncertainty for the inter-pillar baseline measurements is given by Equation (1):

$$U(L) = \pm\sqrt{0.5\,mm + \left(1.1 \times 10^{-3}\,L\right)^2} \qquad (1)$$

Where L is the measured distance in metres. The coverage factor associated with the above uncertainty is, k = 2.0.

7. When estimating the uncertainty of measured distances using this instrument, additional factors such as the centering of the EDM instrument and the reflector, the ambient environmental conditions at the time of measurement and the instrument resolution need to be taken into consideration. A sample uncertainty budget can be found in ISO17123-4:2012.
8. The calibration was conducted at the National Measurement Institute (NMI) Physical Metrology Branch, 36 Bradfield Road, West Lindfield, NSW, 2070.

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Mr Peter Cox
for Dr R B Warrington
Chief Metrologist

Mr Peter Cox
NMI approved signatory
Length

Dr Michael Wouters
NMI approved signatory
Time & Frequency