Australian Government
Department of Industry, Science, Energy and Resources

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 RN210392

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

Permanent distinguishing marks: Serial No: 364182

Date of verification: 29 April 2021

Period of certificate: From date of verification until 29 April 2023

Value(s) of standard of measurement: As stated in Report RN210392 of the National Measurement Institute

Accuracy of verification: Uncertainty of value(s) as stated in Report RN210392 of the National Measurement Institute

Values and uncertainties of relevant influence factors: As stated in Report RN210392 of the National Measurement Institute

Signature:  **Date: 6 May 2021**

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 RN210392 of the National Measurement Institute forms part of this Certificate.

Australian Government
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National Measurement Institute

MEASUREMENT REPORT ON

LEICA, TS30 EDM 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.

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Ref: RN210392 File: CB/13/0209 Checked: AB Date: 30 April 2021

For:	Landgate 1 Midland Square Morrison Road MIDLAND WA 6056 Australia
Description:	TS30 Electronic Distance Measuring instrument (barcode no. SI000320), GPH 1P circular prism with GZR 2 mount and GDF321 tribrach (each marked 9273 7111).
Maker:	LEICA
Identification:	EDM serial number 364182, prism serial number 100 and 1, tribrach serial number 1028
Previous Examination:	RN190883 dated 21 May 2019
Date(s) of Test:	21 April 2021 to 29 April 2021

General

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)	ATR settings:	N/A
EDM mode:	Precise	Automation:	None
Reflector:	Leica circular prism	Geo. ppm correction:	0.0
Additive constant:	0.0 mm	Refraction correction:	ON
Air Temperature:	12°C	Refraction coeff. (k):	0.13
Air Pressure:	1013.3 mbar	Compensator:	ON
Relative humidity:	60%	Hz correction:	ON
Atm. ppm correction:	0.0	Scale at C.M.:	1.000 000 000

Details of Test

To determine the scale correction factor, 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 30 second or 1 minute intervals interspersed occasionally with longer intervals of several minutes over periods of up to 50 minutes. Measurements were repeated on three separate occasions. Refer also to Note 3.

A functional test was performed over the range 6 m to 919 m using the Surveyor General of Victoria's 9 pillar baseline at Braeside to determine the instrument's zero point correction and standard deviation. Measurements were performed with the instrument in both "Face 1" and "Face 2" orientations. No significant difference between the Face 1 and Face 2 measurements was detected, so the reported results are the mean of both orientations. Note that baseline measurements shorter than 20 m and longer than 650 m are outside the scope of the laboratory's NATA accreditation. Refer also to Notes 4 to 8.

Results

The measurements for the scale correction factor are shown in Figure 1. The residual errors from the least squares fit for the measured baseline distances are shown in Figure 2. The results and uncertainties of measurement are given in Table 2. The results of the statistical tests recommended in ISO17123-4:2012 are given in Table 3.

Figure 1: Scale correction factor (modulation frequency) measurements

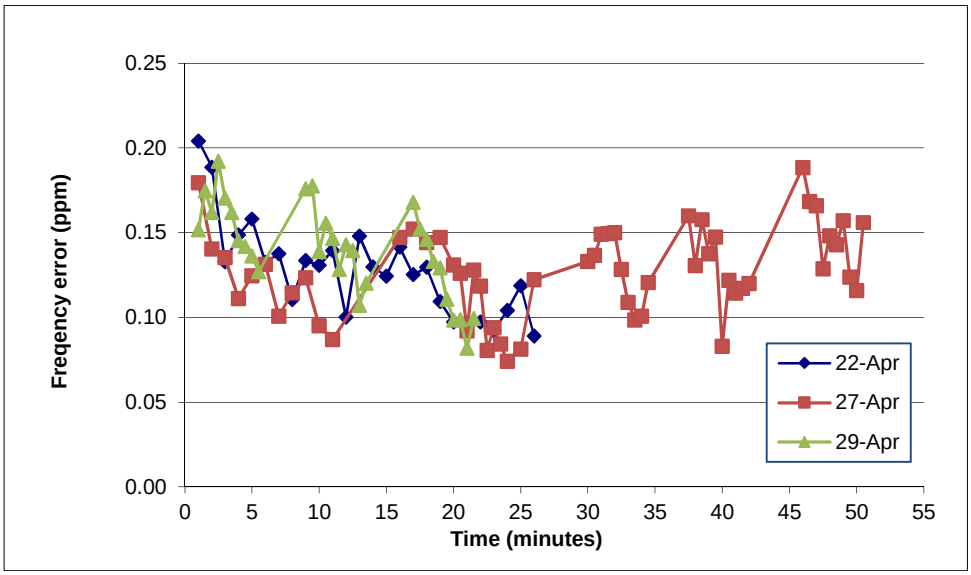

Figure 2: Residuals from least squares fit of the baseline measurements

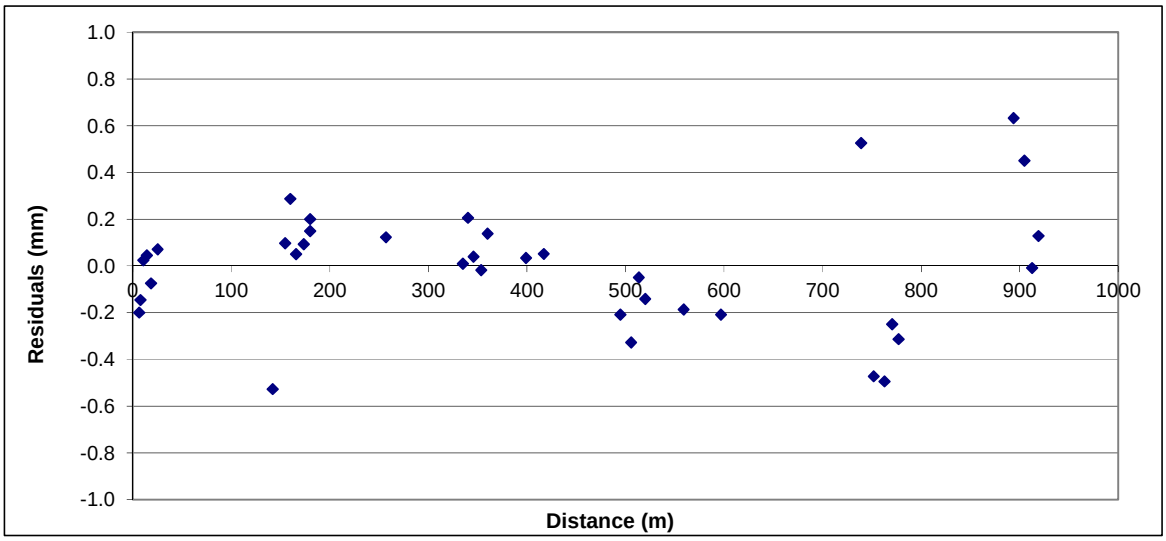

Table 2: Results of Measurement

Item	Result of Measurement	Uncertainty	Coverage Factor
Scale correction factor	1.000 000 13	± 0.000 000 06	2.0
Zero point correction, δ	- 0.03 mm	± 0.16 mm	2.1
Standard deviation, s	0.30 mm (degrees of freedom = 27)		

Table 3: Statistical Tests

Test Ident.	Null Hypothesis	Result	Confidence Level
A	Standard deviation, s < manufacturer's specified standard deviation (taken to be 0.5 mm)	Accept	95%
B	Standard deviation, s, belongs to the same population as the standard deviation obtained in the previous report for this instrument	Accept	95%
C	Zero point correction, $\delta = 0$ as specified by the manufacturer	Accept	95%

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 reported values are traceable to the International System of Units (SI) by comparison, directly or indirectly, with Australian and/or international physical standards of measurement providing a primary realisation of the SI units.

3. The instrument's modulated frequency was measured by switching the instrument into Frequency Test mode for periods of approximately 10 to 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 (20.0 ± 0.3) °C.

4. Baseline measurements were performed following the procedures given in Test Method PM-LEN-8.2.26-V6-EDM Long of the Length Project 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 edition, 2012-06-01.

5. Baseline measurements were carried out on 28th April over the period 8 am to 4 pm under clear and sunny conditions. Ambient atmospheric conditions during the measurements varied as follows: air temperature (12.0 ± 6.0) °C, air pressure (1024.0 ± 1.1) hPa and relative humidity (79 ± 20) %.

6. "Face 1" was taken to be the EDM instrument orientation when the horizontal azimuth adjustment knob was on the RHS of the instrument (and the small physical bubble level was visible to the operator).

7. The measured inter-pillar slope distances 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.

8. The uncertainty for the inter-pillar baseline measurements is given by Equation (1):

$$\mathrm{U}(L) = \pm\sqrt{0.5^2\mathrm{mm} + (1.3 \times 10^{-3} L)^2} \qquad (1)$$

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

9. When estimating the uncertainty of measured distances using this instrument, the uncertainties of the scale correction factor, zero point correction and the standard deviation should be included, along with 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. A sample uncertainty budget can be found in ISO17123-4:2012.

10. The calibration was conducted at the National Measurement Institute (NMI) Physical Metrology Branch, 1/153 Bertie Street, Port Melbourne, VIC, 3207 and at the Surveyor General of Victoria's baseline at Braeside Park, Lower Dandenong Road, Braeside, VIC, 3195.

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Mr Peter Cox
for Dr R B Warrington
Chief Metrologist

Mr Peter Cox
NMI approved signatory