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 RN150413

Description of standard of measurement:	Leica TS30, electronic distance measuring instrument with Leica GPH 1P prism
Permanent distinguishing marks:	Serial No: 364182, Prism number 100
Date of verification:	17 June 2015
Period of certificate:	From date of verification until 17 June 2017
Value(s) of standard of measurement:	As stated in Report RN150413 of the National Measurement Institute
Accuracy of verification:	Uncertainty of value(s) as stated in Report RN150413 of the National Measurement Institute
Values and uncertainties of relevant influence factors:	As stated in Report RN150413 of the National Measurement Institute

Signature: Peter Cox **Date:** 26 June 2015

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 RN150413 of the National Measurement Institute forms part of this Certificate.

Australian Government

National Measurement Institute

MEASUREMENT REPORT ON

Leica TS30 Electronic Distance Measuring Instrument serial number: 364182

Accredited for compliance with ISO/IEC 17025.

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: RN150413 *File:* CB/13/0209 *Checked:* AB *Date:* 18 June 2015

For:	Landgate, Head Office 1 Midland Square Morrison Road (cnr Gt Northern Hwy) MIDLAND WA 6056
Description:	TS30 Electronic Distance Measuring (EDM) instrument and GPH 1P Prism reflector
Manufacturer:	Leica
Serial Number:	364182, Prism number 100
Date(s) of Test:	15 June 2015 to 17 June 2015

Scale Factor

The instrument's scale correction factor was determined by comparing the instrument's modulated frequency to the 10MHz reference signal generated by the Australian National Frequency Standard (see Note 2). The result and uncertainty of measurement are given in Table 1.

Table 1: Modulation Frequency Measurement Results

Mean Indicated Frequency (MHz)	Mean Measured Frequency (MHz)	Scale Correction Factor -	Uncertainty -
100.383 700	100.383 701 0	0.999 999 991	± 0.000 000 033

The instrument's indicated distance measurement should be multiplied by the scale correction factor to give the corrected distance reading.

Calibration on Baseline

A total of 21 different pillar-to-pillar distances were measured on the NMI 7 pillar, 20 m to 649 m baseline using the supplied Leica GPH 1P reflector assembly. After applying the scale correction factor given in Table 1 and correcting for ambient temperature, pressure and relative humidity, the measured inter-pillar slope distances were referred to a vertical plane running through pillars 1 and 7 and to a horizontal plane at the height of pillar 1. A least squares analysis was performed on the resulting distances using the Gauss-Markov model (see Note 3).

The residual errors for the measured distances are shown in Figure 1. The standard deviation of the residuals is 0.22 mm. The zero point correction resulting from the least squares fit is (+0.65 ± 0.24) mm with a coverage factor, k = 2.0. The instrument settings used at the time of measurement are given in Table 2.

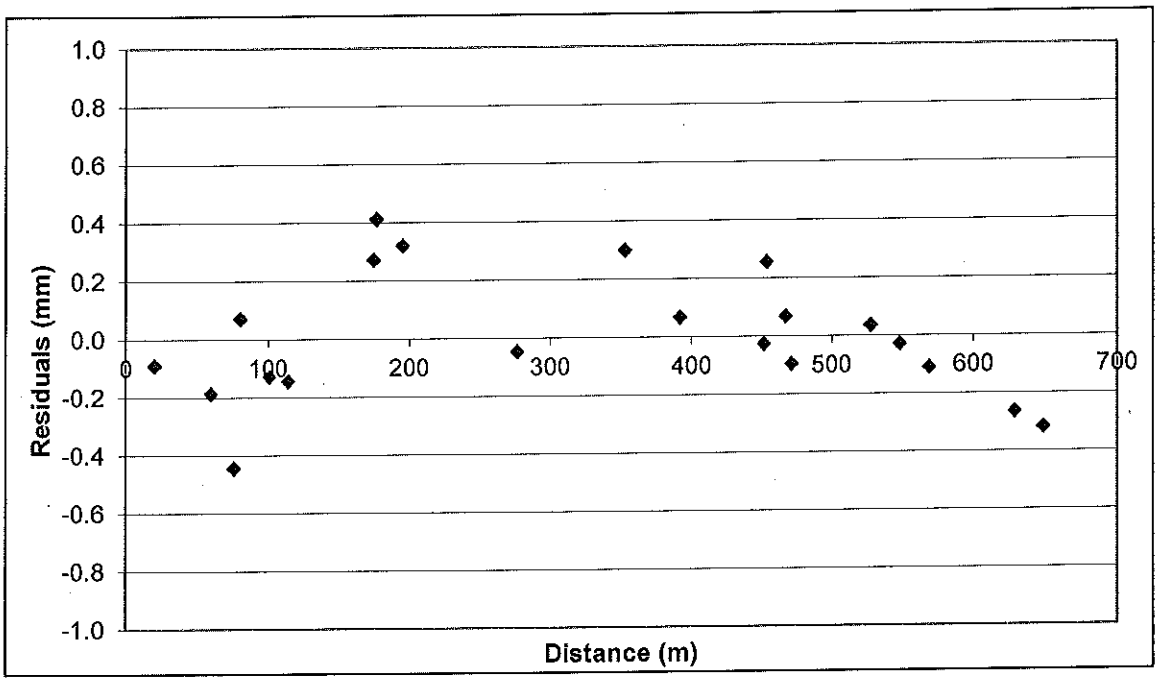

Figure 1: Residuals from least squares analysis

Table 2: Instrument Settings

Parameter	Value	Parameter	Value
EDM type:	Reflector (IR)	ATR settings:	OFF
EDM mode:	Standard	Automation:	-
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:	0.1		

The results indicate that the instrument is within the manufacturer's accuracy specification for distance measurement using a prism reflector.

Uncertainty

The uncertainty of measurement is given by Equation (1) and was obtained by fitting a quadratic equation to the calculated uncertainties for the measured pillar-to-pillar intervals.

$$U(L) = \pm\sqrt{0.39^2 \text{ mm} + \left(0.8\times10^{-3} L\right)^2} \quad \text{for } L \text{ in metres} \tag{1}$$

The coverage factor associated with the above uncertainty is, k = 2.0.

Notes

1. The uncertainties stated in this Report have been calculated in accordance with the principles in *JCGM 100:2008 – Evaluation of measurement data – Guide to the expression of uncertainty in measurement*, and give intervals estimated to have a level of confidence of 95%. Unless otherwise stated, a coverage factor (k) of 2.0 has been used. The uncertainties apply at the time of measurement only and take 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 specifications.
2. The instrument's modulated frequency was measured at intervals of 1 minute by switching the instrument into Test mode for periods of approximately 10 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. Measurements were continued for a period of approximately 26 minutes. During this time, the ambient laboratory temperature was within the range (19.7 ± 0.2) °C.
3. The calibration was performed following the procedures given in Test Method PM-LEN-8.2.26-V5-EDM Long of the Melbourne Physical Metrology site operations manual. The method is based on the full test procedure and the statistical tests (a) and (c) given 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).*
4. After acclimatization to the ambient conditions and prior to testing on the NMI baseline, the instrument parameters: *l, t, i, c,* and *a* were determined according to the manufacturer's instructions using the instrument's built-in self-adjustment routines.
5. Baseline measurements were carried out early in the morning under wet and overcast conditions. Ambient atmospheric conditions during the measurements varied as follows: air temperature (15.5 ± 2) °C, air pressure (1003.8 ± 1.1) hPa and relative humidity (93 ± 7) %.
6. The measured baseline distances were corrected for ambient atmospheric conditions using a nominal carrier wavelength of 658 nm.
7. The calibration was conducted at the National Measurement Institute (NMI) Physical Metrology Branch, Bradfield Road, West Lindfield, NSW, 2070.

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Mr Peter Cox
for Dr P T H Fisk
Chief Metrologist

Mr Peter Cox
NMI approved signatory
Length

Mr Stephen Quigg
NMI approved signatory
Time & Frequency