Australian Government

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 RN131688

Description of standard of measurement:	Leica TS30 electronic distance measuring instrument
Permanent distinguishing marks:	Serial No: 364182
Date of verification:	15 August 2013
This certificate is given for a period until:	15 August 2014
Value(s) of standard of measurement:	As stated in Report RN131688 of the National Measurement Institute
Uncertainty of value(s):	As stated in Report RN131688 of the National Measurement Institute

Values and uncertainties of relevant influence factors:

As stated in Report RN131688 of the National Measurement Institute

Signature: Peter Cox **Date:** 29 August 2013

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 RN131688 of the National Measurement Institute forms part of this Certificate.

noted 2/9/2013

Australian Government

National Measurement Institute

MEASUREMENT REPORT ON

Leica TS30 Electronic Distance Measuring Instrument serial number: 364182

NATA
WORLD RECOGNISED ACCREDITATION

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: **RN131688** *File:* **CB/13/0209** *Checked:* AB *Date:* **26 August 2013**

For:	Landgate, Head Office 1 Midland Square Morrison Road (cnr Gt Northern Hwy) MIDLAND WA 6056
Reference:	Quotation number Q131688, dated 7 June 2013
Description:	TS30 electronic distance measuring instrument
Manufacturer:	Leica
Serial Number:	364182
Date(s) of Test:	14 August 2013 to 15 August 2013

Scale Factor

The scale factor was measured by comparison to the 10MHz reference signal generated by the Australian National Frequency Standard. After aligning the output beam to a photo-detector, the Device Under Test (DUT) was left switched off for a period of not less than 5 hours. The DUT was then switched on and set to display its internal modulation frequency. From the time of switch on, measurements of the modulation frequency were recorded at approximately 1 minute intervals for a period of not less than 25 minutes. The rate of change of frequency was observed to be slightly greater immediately after switch-on and the first reading was consequently excluded from the analysis. The result and uncertainty of measurement are summarised in Table 1.

Table 1: Modulation Frequency Measurement Results

Average DUT indicated frequency (MHz)	Average measured frequency (MHz)	Average error (x 10^{-6}) See Note 6	Uncertainty (x 10^{-6}) See Note 7	Coverage Factor k
100.383603	100.3836286	-0.26	± 0.14	2.1

The result shows that the indicated DUT distance measurement should be decreased by 0.26×10^{-6} of the displayed value.

Calibration on Baseline

A functional test of the DUT was performed on the NMI 7 pillar, 649 m baseline. A total of 21 different pillar-to-pillar distances were measured using a Leica GPH1P reflector. After applying the frequency correction as given in Table 1 and correcting for the ambient atmospheric conditions (temperature, pressure and relative humidity), the measured slope distances were referred to a common axis and height. A least squares analysis was performed on the data using the Gauss-Markov model as recommended 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).* The residual errors are shown in Figure 1. The DUT settings used at the time of the measurements are given in Table 2.

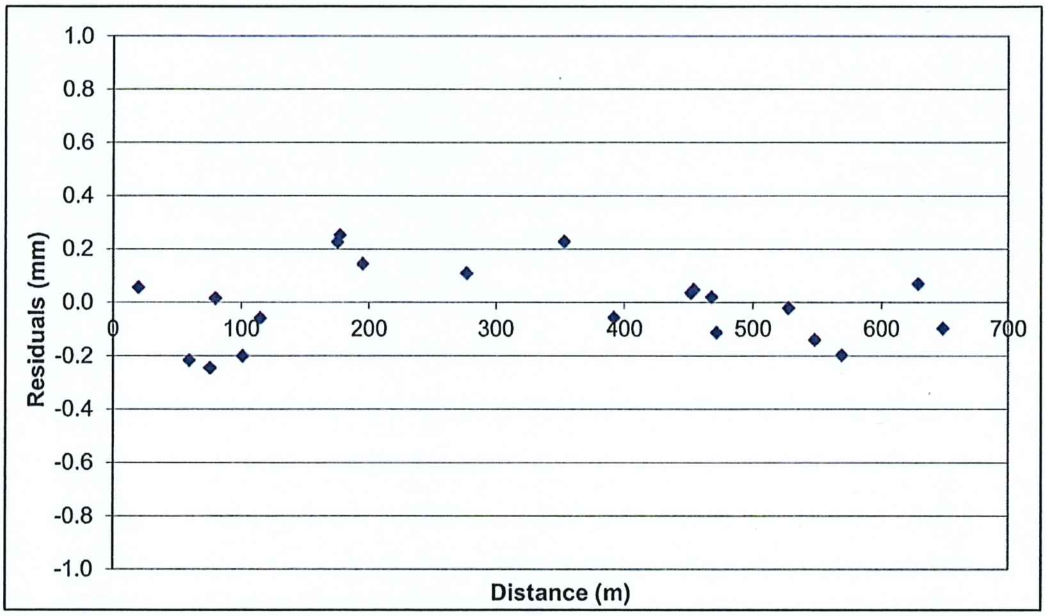

Figure 1: Residuals from least squares analysis

Table 2: DUT Settings

Parameter	Setting
EDM Type:	Reflector (IR)
EDM Mode:	Precise
Reflector:	Leica circular prism
Additive constant:	0.0 mm
ATR:	On
ATR settings:	Normal
Temperature:	12 °C
Pressure:	1013.3 mbar
Relative Humidity:	60%
Atmospheric ppm:	0.0
Geometric ppm:	0.0
Refractive Correction:	On
Refractive Coefficient (k):	0.13

Uncertainty

The standard deviation of the residuals for the 21 intervals was 0.15 mm. The additive constant was + 0.48 mm with an uncertainty of ± 0.17 mm. The uncertainty for measured distances, L, between 20 m and 649 m was obtained by fitting a linear equation to the calculated uncertainties for the pillar-to-pillar intervals. The linear uncertainty relationship is shown below in Equation (1).

$$\mathrm{U}(L) = \pm \left(0.21\ \mathrm{mm} + 0.35 \times 10^{-6} L\right) \quad \text{for } L \text{ in millimetres} \tag{1}$$

Fitting a quadratic equation is necessary if the range is to be extended beyond 649 m. In this case the uncertainty can be determined from Equation (2).

$$\mathrm{U}(L) = \pm \sqrt{0.23^2\ \mathrm{mm} + \left(0.56 \times 10^{-6} L\right)^2} \quad \text{for } L \text{ in millimetres} \tag{2}$$

The coverage factor associated with the above uncertainties is, k = 2.1.

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%. 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. Laboratory temperature during the frequency measurements was within the range (20.0 ± 0.5) °C.
3. Baseline measurements were carried out early in the morning under clear and sunny conditions. Ambient atmospheric conditions during the measurements varied as follows: air temperature (12.9 ± 4) °C, air pressure (1011.1 ± 1.3) hPa and relative humidity (41 ± 15) %.
4. The measured baseline distances were corrected for ambient atmospheric conditions using a nominal carrier wavelength of 658 nm.
5. The measurements were performed following Test Method PM-LEN-8.2.26-DV4-EDM Long of the Length Project quality manual.
6. The average error in Table 1 is expressed as a proportion of the average DUT indicated frequency, and is equal to:

$$\text{average error} = \frac{\text{average DUT indicated frequency} - \text{average measured frequency}}{\text{average DUT indicated frequency}}$$

7. The measurement uncertainty in Table 1 is expressed as a proportion of the average DUT indicated frequency.
8. The calibration was conducted at the National Measurement Institute (NMI) Physical Metrology Branch, Bradfield Road, West Lindfield, NSW, 2070.

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Peter Cox

Mr Peter Cox
for Dr P T H Fisk
Chief Metrologist

Simon D

Mr Simon Dignan
NATA approved signatory
Length

Stephen Quigg

Mr Stephen Quigg
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Time & Frequency