

technical guide

Working Thermometers
Calibration Procedures

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1 Introduction

It is fundamental to good laboratory practice that the calibrations of both working and reference thermometers be traceable to the New Zealand national standards of temperature and thus to SI units.

Laboratories achieve this by sending their reference thermometer(s) to an appropriate calibration agency. They then use the reference thermometer(s) to check their own working thermometers.

This IANZ Technical Guide describes a procedure that may be used for the comparison of working grade thermometers with calibrated reference thermometers. In addition, procedures for ice-point checks on reference thermometers and single-point checks on working thermometers are also described.

2 Thermometer Calibration Schedule

Good laboratory practice with regard to the calibration of liquid-in-glass thermometers is as follows:

Type	Calibration Schedule
Reference	<p>Initial complete calibration, traceable to national standard of temperature.</p> <p>Further complete calibrations at five-yearly intervals thereafter.</p> <p>Ice-point check six months after initial calibration and at six-monthly intervals thereafter.</p>
Working	<p>Initial check against a calibrated reference thermometer followed by further single-point checks at six-monthly intervals.</p> <p><i>Note: The single point may be the ice-point.</i></p> <p>Working thermometers need only be checked over their whole range if they are routinely used over a wide temperature range. In general, biological testing and chemical testing laboratories use particular thermometers over only a narrow range or at a single temperature. As long as the thermometers are not interchanged, a scale check at the particular temperature at which each is used can be made instead of the six-monthly ice-point check. Any thermometer used over a range greater than 5 °C should be subjected to checks at several points within the range of use.</p>

3 Construction of Thermometers

A liquid-in-glass thermometer comprises a bulb, a fine capillary and one or more expansion chambers at the top of the column. There may also be an expansion chamber between the ice point and the beginning of the scale. To give the required sensitivity, the bulb of a reference thermometer is extremely thin (less than 0.5 mm) so careful handling is imperative.

When a thermometer is first made, the glass is in a highly stressed state. This stress slowly relaxes in time causing the bulb to contract. This pushes the mercury higher up the capillary and causes the ice point to rise. There is a consequent change to all other scale points. Such “ageing” of the bulb is fairly rapid immediately after manufacture but gradually slows down with time. An ice-point check every six months, which is required by most thermometer calibration schedules, is a good monitor of the bulb contraction. In general, any rise detected can be subtracted linearly along the entire scale of the thermometer.

Heating a thermometer to its maximum temperature and then reducing it to ambient temperature causes a temporary depression of the ice point through bulb expansion. This may take several days to relax.

A total immersion thermometer is one that is designed to be immersed in the medium being monitored to the level of the current reading. A partial immersion thermometer is designed to be immersed to the depth of a specific mark on the stem (usually at 76 mm or 100 mm).

4 Inspection and Repair of Thermometers

The first step in the calibration procedure is to visually check the thermometer for gross defects. Points to look for are non-uniform or missing graduations, missing numbers and improper etching. Next, the thermometric liquid should be checked for defects such as inclusions, a broken column or separated liquid in the expansion or contraction chamber. More stringent and extensive specifications are given in appropriate standards such as BS 593:1989 *Specifications for Laboratory Thermometers* and BS 1900:1976 *Specification for Secondary Reference Thermometers*.

Gas inclusions and broken columns are best removed by carefully cooling the bulb of the thermometer in a thermos flask of either ice and methanol, dry ice and methanol or liquid nitrogen, depending on the temperature range of the thermometer. This will draw all the liquid into the bulb and enable the gas inclusion to be expelled or the broken thread rejoined. Avoid rapid cooling which may freeze the liquid in the thermometer and break the bulb. If the broken thread sticks, tap the thermometer gently. Separation of the column of a reference thermometer can occur in transit and requires the same treatment for repair. Spirit left in the expansion chamber or near the top of the thermometer can be gently heated to distil it off.

5 Selection of a Reference Thermometer

The selection of an appropriate reference thermometer will be influenced by the range of temperature measurements that are to be made and the uncertainty of measurement that it is required to achieve.

Table 1 lists a number of thermometers complying with the requirements of BS 593:1989. Those for which the designation includes /TOTAL are total immersion thermometers. Those for which the designation includes /100 are partial immersion thermometers (immersion to 100 mm).

Table 1 Thermometers complying with BS 593:1989

Designation	Range (°C)	Graduated to (°C)	Max Error Allowed (°C)	Least Uncertainty of Test (°C)
A40C/TOTAL	0 TO +40	0.1	0.2	± 0.02
A70C/TOTAL	-0.5 to +0.5 and 40 to 70	0.1	0.2	± 0.02
A100C/TOTAL	-0.5 to +0.5 and 70 to 100	0.1	0.2	± 0.02
A130C/TOTAL	+0.5 to +0.5 and 100 to 130	0.1	0.2	± 0.05

Designation	Range (°C)	Graduated to (°C)	Max Error Allowed (°C)	Least Uncertainty of Test (°C)
A40C/100	0 to +40	0.1	0.4	± 0.05
A70C/100	-0.5 to +0.5 and 40 to 70	0.1	0.4	± 0.05
A100C/100	-0.5 to +0.5 and 70 to 100	0.1	0.4	± 0.05
A130C/100	-0.5 to +0.5 and 100 to 130	0.1	0.4	± 0.1

Note: This table is not complete and BS 593 should be consulted for the full range of thermometers specified.

BS 1900:1976 provides similar information about secondary reference thermometers whilst ASTM E1 provides details of ASTM and IP thermometers. If an uncertainty of calibration of less than 0.02 °C is required, then a BS 1900 thermometer must be used.

Let us suppose that a laboratory intends to purchase a reference thermometer with which to calibrate a group of its own working thermometers. The reference thermometers must first be submitted to an appropriate calibration agency to be calibrated.

The working thermometers in question will be used to measure the temperature of a water bath set at 44.5 °C. They must be calibrated with an uncertainty of ± 0.2 °C.

In general, the uncertainty of calibration of the reference thermometer should be a factor of five smaller than the uncertainty of calibration that is required for the working thermometer. In this case, as an uncertainty of calibration of ± 0.2 °C is required for the working thermometer, the uncertainty of the reference thermometer's calibration must be ± 0.04 °C (0.2x1/5).

A good quality reference thermometer can generally be calibrated with an uncertainty of one fifth of a scale division so if an uncertainty of ± 0.04 °C is required this implies that the reference thermometer must have scale divisions of 0.2 °C (0.04x5).

For the application under consideration, therefore, a reference thermometer covering the region of 44.5 °C with graduations of at least 0.2 °C is required. The BS 593 thermometer A70C/TOTAL listed above meets this specification.

In summary, a reference thermometer must have scale divisions equal to, or less than, the uncertainty of measurement required in the calibration of the working thermometer with which it is to be compared.

6 Ice Point Checks

Checks on the relaxation changes in both a reference and working thermometer should be made every six months on the ice point (0 °C mark) of the thermometer. The ice point check need not, however, be made on a working thermometer used continually at one temperature (say 37 °C). Such a thermometer would be more appropriately checked at this temperature every six months against a single reference thermometer (which itself would still require the ice point check).

An ice point is made with distilled water frozen in clean trays in a freezer. It is preferable for the ice to be shaved in a food processor or purpose built shaver (low cost ice shavers are available from some department stores). Alternatively, the ice is crushed in a clean cloth with a mallet or a hammer and put into a thermos flask deep enough to immerse the thermometer to the correct level. Distilled water is then added until the whitish ice colour disappears and clear ice remains. Excess water should then be drained off but the whitish colour should not return.

The ice point reading can now be taken providing test thermometers are inserted to the 0 °C mark or partial immersion mark, whichever is appropriate. Read the thermometer with a magnifying eyepiece and record the reading. Repeat that measurement at least twice (preferably with another observer). An ice point used for extended periods should have the excess water drained off occasionally.

Any change in the temperature correction at the ice point, which has occurred between the current calibration and the initial calibration of the thermometer made by the external calibration agency, should be applied at all other calibrated points.

For example, a laboratory may perform an ice point check on a reference thermometer which was subjected to a complete calibration at the time it was purchased.

The initial calibration report may have indicated the following results:

Thermometer Reading (°C)	Correction (°C)
-0.04	+0.04
5.00	+0.04
10.00	+0.06
15.00	+0.02
20.00	+0.06
25.00	+0.08
30.00	+0.06
35.00	+0.04
40.00	+0.04

To obtain the correct temperature the correction must be added to (or subtracted from if negative) the thermometer reading.

The laboratory might obtain three ice point readings as follows:

-0.02 °C; -0.02 °C; -0.02 °C

The new ice point reading is the average of the above, i.e. $-0.02\text{ }^{\circ}\text{C}$. The thermometer is, therefore, reading low by $0.02\text{ }^{\circ}\text{C}$ and so the correction to be applied is $+0.02\text{ }^{\circ}\text{C}$. This compares with the earlier calibration which gave a correction at $0\text{ }^{\circ}\text{C}$ of $+0.04\text{ }^{\circ}\text{C}$. Corrections at all other temperature reported by the calibration agency must now be altered by $(0.02 - 0.04)$ i.e. $-0.02\text{ }^{\circ}\text{C}$, thus:

Thermometer Reading ($^{\circ}\text{C}$)	Correction ($^{\circ}\text{C}$)
-0.02	+0.02
5.00	+0.02
10.00	+0.04
15.00	+0.00
20.00	+0.04
25.00	+0.06
30.00	+0.04
35.00	+0.02
40.00	+0.02

Ice points made with reasonable care should reproduce $0\text{ }^{\circ}\text{C} \pm 0.05\text{ }^{\circ}\text{C}$ or better.

7 Uncertainty of Measurement

With the introduction of ISO/IEC 17025 there is now a requirement for all laboratories, testing laboratories as well as calibration laboratories, to determine the uncertainty of each of their measurements. Obviously for equipment being used to make measurements in testing, the starting point for this determination will be an awareness of the uncertainty contribution provided from each measuring instrument. Accredited metrology laboratories are required to report the uncertainty for their calibrations and all IANZ endorsed calibration certificates will provide this information. As appropriate, this data can be directly used in the testing laboratory's own determination of uncertainty of measurement in testing.

When a testing laboratory chooses to carry out its own in-house calibration, the uncertainty of that calibration will need to be determined using appropriate methods. Depending on the degree of rigor required, there are a number of different approaches to this. Various guidance documents are available and testing laboratories should adopt methods appropriate for their purposes.

8 Comparison of Working Thermometers with Reference Thermometers

8.1 General Procedure

The working thermometer and the reference thermometer with which it is to be compared are held side-by-side in a temperature controlled water (or oil) bath. The bath is allowed to stabilise at the required calibration temperature before the readings of the thermometers are compared.

If it is required to compare the thermometers at a particular temperature ($37\text{ }^{\circ}\text{C}$ say), then the two sets of readings are taken to either side of the required temperatures ($36.5\text{ }^{\circ}\text{C}$ and $37.5\text{ }^{\circ}\text{C}$). These two sets of readings are averaged to find the correction to the working thermometer's reading at the required temperature.

If the working thermometer is only being checked at one point for its regular six-monthly check then only one set of readings is required. If the thermometer is being subjected to an initial check before being put into use then readings should be taken at approximately ten degree intervals along its scale.

The procedures outlined below presume that up to four working thermometers are being checked at one time. They are equally valid, however, for checks on fewer than four. The calibration of more than four thermometers at one time is not recommended.

8.2 Uncertainty of Calibration Greater than $\pm 0.5\text{ }^{\circ}\text{C}$

8.2.1 Equipment

- (a) A well-stirred, temperature-controlled water bath which is stable to at least half the required uncertainty in the calibration of the working thermometer. A very slowly rising temperature is desirable but in no case should the temperature be falling during calibration as sticking of the liquid in the thermometer capillary will lead to errors. Spatial temperature gradients (both vertical and horizontal) within the area of the bath being used for comparison should be checked before calibration begins. These must be less than one quarter of the uncertainty of calibration required.
- (b) At least one reference thermometer, the uncertainty of calibration of which is, at most, one-fifth of the uncertainty of calibration required for the thermometer under test. The reference thermometer(s) must be calibrated by an appropriate agency (see Appendix I). The reference(s) should be of the partial immersion type if the working thermometers are partial immersion and/or if the depth of immersion in the comparison bath is limited.
Note: In Table 1 the calibration uncertainty of partial immersion thermometers is generally greater than that for total immersion thermometers covering the same range.
- (c) A magnifying eyepiece to reduce parallax errors and improve readability.
- (d) A flat plate, drilled to take both reference and working thermometers, which can be clamped over the bath. O-rings or rubber grommets can be used to hold the thermometers at the correct height in the plate.

8.2.2 Procedure

Note: In general, no attempt should be made to calibrate a working thermometer (in-house) to an uncertainty of less than half a scale division.

Let us presume that a working thermometer is to be compared with a reference thermometer at a particular temperature (37 °C say). Insert the reference thermometer into the supporting plate with no more than four working thermometers in the order Reference, Test 1, Test 2, Test 3, Test 4. Stabilise the bath temperature to just below 37 °C (36.5 °C say).

Thermometers should be immersed to the reading if they are of the total immersion type or to the appropriate mark (e.g. 76 mm) if partial immersion.

Thermometers should remain vertical and the water bath level should be increased if immersion is insufficient.

If total immersion thermometers are used at partial immersion, their readings will require correction (see 8.4).

When the bath temperature is stable (or increasing slowly), read the thermometers in the following order (tapping each thermometer gently, first):

Ref 1 2 3 4 4 3 2 1 Ref

and record the thermometer readings as they are made.

Repeat the measurements at a temperature above 37 °C (say 37.5 °C). Similar checks should be made at least every 10 °C of the scale if the thermometer is to be used over a wide range of temperatures.

8.2.3 Calculation of Corrections

Average the two sets of readings for each of the five thermometers as shown below. Correct the reference thermometer reading from its calibration certificate, allowing for any change in the ice point as shown previously. It may be necessary to interpolate the correction to the reference thermometer reading for the actual bath temperature chosen i.e. If the correction to the reference thermometer at 35 °C is + 0.01 °C and at 40 °C the correction is + 0.03 °C, then at 37 °C the correction will be +0.02 °C.

Subtract the corrected reference thermometer average reading from the average readings of the working thermometers to obtain the error in each thermometer. The correction is found by changing the sign of each error, as shown in Tables 2 and 3.

Table 2 Calibration at 36.5 °C

	Reference	T1	T2	T3	T4
Reading 1 (°C)	36.65	36.5	36.7	36.6	37.0
Reading 2 (°C)	36.70	36.6	36.7	36.6	37.0
Average	36.68	36.55	36.7	36.6	37.0
Correction to reference from calibration certificate +0.02 °C	<u>+0.02</u>				
Therefore average temperature in bath at calibration =	36.70				
Subtract average bath temperature from average test thermometer reading to obtain error in test thermometers		(-36.70)	(-36.70)	(-36.70)	(-36.70)
		-0.15	0.00	-0.10	+0.30
Correction (1) to test Thermometers (change sign)		+0.15	0.00	+0.10	-0.30

Repeat this procedure for the results of the second test carried out at 37.5 °C.

Table 3 Calibration at 37.5 °C

	Reference	T1	T2	T3	T4
Reading 1 (°C)	37.45	37.3	37.4	37.3	37.5
Reading 2 (°C)	37.48	37.3	37.4	37.3	37.5
Average	37.46	37.3	37.4	37.3	37.5
Correction to reference thermometer	+0.02				
Temperature in bath	37.48				
		(-37.48)	(-37.48)	(-37.48)	(-37.48)
Error in test thermometers		-0.18	-0.08	-0.18	+0.02
Correction (2) to test thermometers		+0.18	+0.08	+0.18	-0.02
Correction (1) to test thermometers from above		+0.15	0.00	+0.10	-0.30
Average of corrections (1) and (2) to test thermometers at 37 °C		+0.16	+0.04	+0.14	-0.16
Round to nearest 0.1 °C (readability of thermometer)		+0.2	0.0	+0.1	-0.2

The procedure outlined above should be carried out at each point on the working thermometer's scale that is to be calibrated.

The corrections to a thermometer being used over a wide range of temperatures can be plotted against temperature to produce a calibration curve. This procedure facilitates interpolation of corrections at intermediate temperatures.

8.3 Uncertainty of Calibration between $\pm 0.5\text{ }^{\circ}\text{C}$ and $\pm 0.1\text{ }^{\circ}\text{C}$

8.3.1 Equipment

- (a) A well stirred temperature-controlled water bath which is stable to at least half the uncertainty of the calibration required. A very slowly rising temperature is desirable but in no case should the temperature be falling during calibration as sticking of the mercury will lead to calibration errors. Spatial gradients within the area of the bath being used for comparison should be checked before calibration begins and must be less than half the uncertainty of test required.
- (b) Two calibrated reference thermometers, the uncertainty of calibration of which should be at most $\frac{1}{4}$ of that of the uncertainty of calibration required for the thermometer under test. The reference thermometer(s) must be calibrated by an appropriate agency (see Appendix I). The reference(s) should be of the partial immersion type if the working thermometers are partial immersion and/or if the depth of immersion in the comparison bath is limited.
Note: In Table 1 the calibration uncertainty of partial immersion thermometers is generally greater than that for total immersion thermometers covering the same range.
- (c) A magnifying eyepiece to reduce parallax errors and improve readability.
- (d) A flat plate, drilled to take both reference and working thermometers, which can be clamped over the bath. O-rings or rubber grommets can be used to hold the thermometers in the plate at the correct height.

8.3.2 Procedure

Let us assume that a working thermometer is to be compared with a reference thermometer at a particular temperature ($37\text{ }^{\circ}\text{C}$ say). Insert the reference thermometers into the support plate with no more than four working thermometers in the order:

Reference 1, Test 1, Test 2, Test 3, Test 4, Reference 2

Stabilise the bath reading below $37\text{ }^{\circ}\text{C}$ (at $36.9\text{ }^{\circ}\text{C}$ for example).

The thermometers should be immersed to the reading if total immersion or to the appropriate mark (e.g. 76 mm) if partial immersion. Thermometers should remain vertical and the water bath level should be increased if immersion is insufficient; otherwise, the calibration of total immersion thermometers used at partial immersion will need to be corrected (see 7.4).

When the bath temperature is stable or slowly increasing, begin reading from left to right and back recording the readings as you go. Tap each thermometer gently before reading. The readings should be made in the following order:

Ref 1, Test 1, 2, 3, 4, Ref 2, Ref 2, Test 4, 3, 2, 1, Ref 1

Repeat the measurements at approximately $37.1\text{ }^{\circ}\text{C}$.

If the working thermometer is to be calibrated over a wide range such as $0\text{ }^{\circ}\text{C}$ to $50\text{ }^{\circ}\text{C}$, tests should be carried out at the ice point, $9.9\text{ }^{\circ}\text{C}$ and $10.1\text{ }^{\circ}\text{C}$, $19.9\text{ }^{\circ}\text{C}$ and $20.1\text{ }^{\circ}\text{C}$ etc, up to $50\text{ }^{\circ}\text{C}$.

8.3.3 Calculation of Corrections

Average the two sets of readings for each of the six thermometers and correct the reference thermometer readings using data from their calibration certificates. Presume that at $37\text{ }^{\circ}\text{C}$ the corrections required are $+0.02\text{ }^{\circ}\text{C}$ for Reference 1 and $+0.05\text{ }^{\circ}\text{C}$ for Reference 2. (These figures will probably have been interpolated from corrections given by the reference thermometers' calibration certificates at $35\text{ }^{\circ}\text{C}$ and $40\text{ }^{\circ}\text{C}$.)

The average of the two corrected reference thermometers' readings are now subtracted algebraically from the average for each test thermometer to give the error as shown in Tables 4 and 5.

Table 4 Calibration at 36.9 °C

	Ref 1	T1	T2	T3	T4	Ref 2
Reading 1 (°C)	36.88	36.8	36.8	36.7	37.0	36.85
Reading 2 (°C)	36.92	37.0	36.9	36.8	37.0	36.87
Averages	36.90	36.9	36.85	36.75	37.0	36.86
Reference correction from calibration certificate =	<u>+0.02</u>					<u>+0.05</u>
Reference Temperature (1)	36.92			Reference Temperature (2)		36.91
Average of references (Temperature in bath)	36.92					
Subtract average bath temperature from average test thermometer reading to obtain error in test thermometers		(-36.92)	(-36.92)	(-36.92)	(-36.92)	
		-0.02	-0.07	-0.17	+0.08	
Correction (1) to test thermometers (change sign)		+0.02	+0.07	+0.17	-0.08	

For the second test at 37.1 °C the calculations might be as follows:

Table 5 Calibration at 37.1 °C

	Ref 1	T1	T2	T3	T4	Ref 2
Reading 1 (°C)	37.08	37.1	37.1	37.3	37.2	37.05
Reading 2 (°C)	37.16	37.2	37.1	37.3	37.2	37.05
Averages	37.12	37.15	37.1	37.3	37.2	37.05
Correction to references from calibration certificates	<u>+0.02</u>					<u>+0.05</u>
Reference Temperature (1)	37.14				Reference Temperature (2)	37.10
Average of References (Temperature in bath)	37.12					
		(-37.12)	(-37.12)	(-37.12)	(-37.12)	
Error in test thermometers		+0.03	-0.02	+0.18	+0.08	
Correction (2) to test thermometers (Change sign)		-0.03	+0.02	-0.18	-0.08	
Correction (1) from above		+0.02	+0.07	+0.17	-0.08	
Average of corrections (1) and (2) to test thermometers at 37.0 °C		0.00	+0.04	0.00	-0.08	
Round to 0.1 °C (readability of thermometer)		<u>0.0</u>	<u>0.0</u>	<u>0.0</u>	<u>-0.1</u>	

The corrections to a thermometer being used over a wide range of temperatures can be plotted against temperature to produce a calibration curve. This facilitates interpolation of corrections at intermediate temperatures.

8.4 Correction of Total Immersion Thermometers used at Partial Immersion

If it is not possible to fill the comparison bath sufficiently to immerse a total immersion reference thermometer to the reading, then another small thermometer should be attached to the stem of the thermometer about one-third of the way up the exposed column. This will read (approximately) the average temperature of the emergent length of mercury (or spirit). A correction now needs to be applied to the thermometer reading because of the generally lower temperature of the mercury (or spirit) not immersed. This correction is given by:

$$kN (T_c - T_u)$$

Where k = 0.00016 for mercury
= 0.001 for spirit

N = the number of degrees of the scale exposed

T_c = the temperature of the calibration bath during the original calibration

T_u = the temperature of the exposed scale during this calibration (given by the small thermometer attached to the stem)

e.g. 1) Total immersion mercury in glass thermometer (0 °C - 100 °C divided to 0.5 °C) in a bath at 55 °C but immersed to the 30 °C mark.

k = 0.00016

N = 55 °C – 30 °C = 25 °C

T_c = 55 °C

T_u = 25 °C (say) on the small thermometer attached to the scale

Correction = 0.00016 x 25 (55-25)
= +0.12 °C
= +0.1 °C rounded to the readability of the thermometer

2) A total immersion mercury in glass thermometer (0 °C - 300 °C divided to 0.5 °C) in an oil bath at 105 °C but immersed at the 30 °C mark.

k = 0.00016

N = 105 °C – 30 °C = 75 °C

T_c = 105 °C

T_u = 40 °C (measured on the exposed scale)

Correction = 0.00016 x 75 (105-40)
= +0.78 °C
= +0.8 °C rounded

These corrections are made in addition to any scale corrections required by the calibration certificate.

9 Packing for Safe Transport

Reference thermometers for calibration should be carried by hand if at all possible, but failing that should be packed in such a way that the whole length of the thermometer is supported. This can be achieved by cutting slots in a solid slab of polystyrene foam or by supporting the thermometers between long slabs of foam rubber in a wooden box with a screw-on lid. Some calibrating agencies have shipping containers which can be procured for a deposit which is refundable on return of the box.

Appendix 1

Traceability to National Standards of Measurement (SI Units)

New Zealand

The Measurement Standards Laboratory of Industrial Research Limited (MSL) maintains the New Zealand National Standards of Measurement under authority enacted in the Scientific and Industrial Research Act 1989.

The laboratory can undertake calibration work to specific uncertainties defined by the laboratory in addition to the routine calibration services, which are detailed in Appendices B and C of the National Metrology Institutes' (NMI) mutual recognition arrangement. Enquiries should be directed to:

The Chief Metrologist
Measurement Standards Laboratory
Industrial Research Limited
PO Box 31310
Lower Hutt

Traceability to New Zealand's National Standards of Measurement for specific measurements can also be obtained via laboratories accredited by IANZ for such measurements. Information regarding these laboratories can be gained from the IANZ website (www.ianz.govt.nz) or by phoning the organisation direct.

Overseas

Traceability to SI units via national metrology institutes (NMI) is acceptable to IANZ. This may be obtained by calibration by an overseas NMI that is part of the international mutual recognition arrangement for NMIs. Alternatively, calibration by a laboratory accredited by an overseas laboratory accreditation body with which IANZ has a mutual recognition arrangement is also acceptable.

For a list of NMIs that are part of the agreement, contact the Chief Metrologist of MSL. For accreditation bodies belonging to the mutual recognition arrangements, information is available on www.ianz.govt.nz or by contacting IANZ.