

# CERTIFICATE OF ACCREDITATION



**Trescal Holding New Zealand Ltd**  
Trading as CPS (NZ) Limited

**Client Number 927**

38J Angle Street, Onehunga, Auckland, 1061

**Telephone 09 636-4999**

**www.cps.co.nz**

**Authorised Representative**

Kirsty Russell  
Laboratory Manager

**Programme**

Metrology & Calibration Laboratory

**Accreditation Number 271**

**Initial Accreditation Date 18 December 1985**

**Conformance Standard**

ISO/IEC 17025:2017

General requirements for the competence of testing and calibration laboratories

**Laboratory Services Summary**

**CPS Labs: Onehunga, Auckland**

- 5.22 Precision Laboratory Balances
- 5.23 Industrial Balances
- 5.41 Barometric Indicators or Transducers
- 5.42 Differential Pressure Measuring Devices (including Manometers)
- 5.43 Pressure Gauge Testers and Pressure Balances
- 5.44 Pressure and Vacuum
- 5.45 Pressure Equipment Tests
- 5.61 Temperature Measuring Equipment

**CPS Labs: Penrose, Auckland**

- 5.28 Flow Measuring Devices
- 5.31 Volumetric Equipment
- 5.35 Hygrometry
- 5.42 Differential Pressure Measuring Devices (including Manometers)
- 5.55 Speed Measuring Devices
- 5.61 Temperature Measuring Equipment
- 5.88 Calibrators for Instrumentation
- 5.89 Indicating Instruments and Recording Instruments
- 5.91 Time and Frequency
- 5.93 Signal Sources

**CPS Labs: Bell Block, New Plymouth**

- 5.44 Pressure and Vacuum

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 1 of 53

## CERTIFICATE OF ACCREDITATION



5.45 Pressure Equipment Tests  
5.61 Temperature Measuring Equipment

### CPS Labs/Calibration Connect: Riccarton, Christchurch

5.50 Torque Measuring Equipment  
5.88 Calibrators for Instrumentation  
5.89 Indicating Instruments and Recording Instruments  
5.91 Time and Frequency

### Key Technical Personnel

#### CPS Labs: Onehunga, Auckland

Jane Robinson 5.44  
Kirsty Russell 5.22, 5.23, 5.41, 5.42, 5.43, 5.44, 5.45, 5.61

#### CPS Labs: Penrose, Auckland

Mauray Ganter 5.28, 5.31, 5.35, 5.42, 5.55, 5.61, 5.88, 5.89, 5.91, 5.93  
John He 5.28, 5.31, 5.35, 5.42, 5.55, 5.61, 5.88, 5.89, 5.91, 5.93  
Bernhard Kriel 5.28, 5.31, 5.35, 5.42, 5.55, 5.61, 5.88, 5.89, 5.91, 5.93

#### CPS Labs: Bell Block, New Plymouth

Michael Feigler 5.44  
Jane Robinson 5.44  
Kirsty Russell 5.44, 5.45, 5.61

#### CPS Labs/Calibration Connect: Riccarton, Christchurch

Richard Ettema 5.50, 5.88, 5.89, 5.91  
Jerome Fryer 5.50, 5.88, 5.89, 5.91

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 2 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

Calibration and Measurement Capability (CMC) uncertainties are expressed as an expanded uncertainty corresponding to a level of confidence of 95 % <sup>Note1</sup>

Measurement results are traceable to the International System of Units (SI) via an unbroken chain of comparisons to the New Zealand National Standards or to the National Standards of other Signatories to the CIPM MRA

Many calibrations of working instruments can be carried out on-site. Refer to the specific class of test information below for further information

Measurand

Parameters

CMC Uncertainty

## CPS Labs: Onehunga, Auckland

Location: 38J Angle Street, Onehunga, Auckland 1061

### 5.22 Precision Laboratory Balances

Calibration of precision laboratory balances having a nominal measurement uncertainty equal to or less than 1 part in 100,000 of maximum capacity, in accordance with in-house methods based on MSL Technical Guide 25 and OIML R111-1 (on-site calibration service)

Ranges and CMC uncertainties as in 5.23

### 5.23 Industrial Balances

Calibration of industrial balances having a nominal measurement uncertainty larger than 1 part in 100,000 of maximum capacity, in accordance with in-house methods based on MSL Technical Guide 25 and OIML R111-1 (on-site calibration service)

1 mg to 5 g  
5 g to 10 g  
10 g to 1 kg  
1 kg to 5 kg

10 µg  
11 µg  
1 µg/g  
1.6 µg/g

### 5.41 Barometric Indicators or Transducers

Aneroid barometers (including digital barometers) in accordance with an in-house method by comparison with reference devices

80 kPa to 120 kPa

0.23 Pa + 0.0014 % reading

### 5.42 Differential Pressure Measuring Devices (including Manometers)

- (a) Diaphragm types
- (b) Liquid column types, inclined and vertical

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 3 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

- (c) Transducers and transmitters
- (d) Other types – Pressure recorders

In accordance with an in-house method by comparison with reference devices

### Gauge mode

|                           |                                           |
|---------------------------|-------------------------------------------|
| -100 kPa to -15 kPa       | 0.019 kPa or <sup>1</sup> 0.008 % reading |
| -15 kPa to -7.5 kPa       | 1.5 Pa or <sup>1</sup> 0.03 % reading     |
| -7.5 kPa to +4 kPa        | 0.042 Pa or <sup>1</sup> 0.01 % reading   |
| 4 kPa to 350 kPa          | 0.23 Pa + 0.0014 % reading                |
| 350 kPa to 1778 kPa       | 2 Pa + 0.005 % reading                    |
| 1778 kPa to 20,000 kPa    | 0.018 kPa + 0.0041 % reading              |
| 20,000 kPa to 200,000 kPa | 0.19 kPa + 0.0049 % reading               |

Calibrations in the following ranges are available onsite (gauge mode)

|                       |                                        |
|-----------------------|----------------------------------------|
| -95 kPa to 100 kPa    | 0.25 Pa or <sup>1</sup> 0.06 % reading |
| 100 kPa to 70,000 kPa | 0.06 % reading                         |

or<sup>1</sup> = whichever is greater

### 5.43 Pressure Gauge Testers and Pressure Balances

Pressure calibrators and testers in accordance with an in-house method by comparison with reference devices

### Gauge mode

|                     |                                           |
|---------------------|-------------------------------------------|
| -100 kPa to -15 kPa | 0.019 kPa or <sup>1</sup> 0.008 % reading |
| -15 kPa to -7 kPa   | 1.5 Pa or <sup>1</sup> 0.03 % reading     |
| -7 kPa to +4 kPa    | 0.042 Pa or <sup>1</sup> 0.01 % reading   |
| 4 kPa to 350 kPa    | 0.23 Pa + 0.0014 % reading                |

or<sup>1</sup> = whichever is greater

### Gauge mode or absolute mode

|                           |                              |
|---------------------------|------------------------------|
| 350 kPa to 1778 kPa       | 2 Pa + 0.005 % reading       |
| 1778 kPa to 20,000 kPa    | 0.018 kPa + 0.0041 % reading |
| 20,000 kPa to 200,000 kPa | 0.19 kPa + 0.0049 % reading  |

### Absolute mode

|                  |                            |
|------------------|----------------------------|
| 7 kPa to 350 kPa | 0.23 Pa + 0.0014 % reading |
|------------------|----------------------------|

### 5.44 Pressure and Vacuum

- (a) Pressure gauges
- (b) Vacuum gauges
- (c) Pressure transducers
- (d) Pressure recorders

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 4 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

Accuracy classes: 0.1, 0.25, 0.6, 1.0, 1.6, 2.5, 4.0 in accordance with AS 1349:1986 and BS EN 837-1:1998;  
gauges of accuracy 4A, 3A, 2A, 1A and below as defined in ASME B40.100-2013  
By comparison with reference devices

**Gauge mode**

|                     |                                           |
|---------------------|-------------------------------------------|
| -100 kPa to -15 kPa | 0.019 kPa or <sup>1</sup> 0.008 % reading |
| -15 kPa to -7.5 kPa | 1.5 Pa or <sup>1</sup> 0.03 % reading     |
| -7.5 kPa to +4 kPa  | 0.042 Pa or <sup>1</sup> 0.01 % reading   |
| 4 kPa to 350 kPa    | 0.23 Pa + 0.0014 % reading                |

**Gauge mode or absolute mode**

|                           |                              |
|---------------------------|------------------------------|
| 350 kPa to 1778 kPa       | 2 Pa + 0.005 % reading       |
| 1778 kPa to 20,000 kPa    | 0.018 kPa + 0.0041 % reading |
| 20,000 kPa to 200,000 kPa | 0.19 kPa + 0.0049 % reading  |

**Absolute mode**

|                  |                            |
|------------------|----------------------------|
| 7 kPa to 350 kPa | 0.23 Pa + 0.0014 % reading |
|------------------|----------------------------|

Calibrations in the following ranges are available onsite (gauge mode)

|                       |                                        |
|-----------------------|----------------------------------------|
| -95 kPa to 100 kPa    | 0.25 Pa or <sup>1</sup> 0.06 % reading |
| 100 kPa to 70,000 kPa | 0.06 % reading                         |

or<sup>1</sup> = whichever is greater

Maximum vacuum achievable is subject to ambient barometric pressure

**5.45 Pressure Equipment Tests**

(e) Pressure relief valve tests

The testing of Pressure Relief Valves and Pressure Switches up to 120000 kPa, in accordance with in-house methods, on-site or in the laboratory

**5.61 Temperature Measuring Equipment**

- (a) Rare metal thermocouples
- (b) Base metal thermocouples
- (c) Platinum (and other metallic) resistance thermometers
- (e) Thermistors and other semi-conductor thermometers
- (f) Liquid-in-glass thermometers
- (g) Clinical thermometers
- (j) Radiation thermometers
- (k) Vapour pressure thermometers
- (l) Filled metal systems
- (m) Bimetallic systems

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 5 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory

Accreditation Number 271

**SCOPE OF ACCREDITATION**

- (n) Digital quartz frequency units
- (o) Indicators, recorders and controllers
- (p) Other direct reading temperature measuring systems

Range applies to all of the above, except (j) (see further below), including digital thermometers and single position calibration of dry well calibrators

|                   |          |
|-------------------|----------|
| Ice-point         | 0.01 °C  |
| -100 °C to -60 °C | 0.080 °C |
| -60 °C to -20 °C  | 0.028 °C |
| -20 °C to 200 °C  | 0.015 °C |
| 200 °C to 660 °C  | 0.17 °C  |

On-site temperature calibration is offered over the ranges below

|                  |          |
|------------------|----------|
| Ice-point        | 0.01 °C  |
| -30 °C to -20 °C | 0.10 °C  |
| -20 °C to 80 °C  | 0.03 °C  |
| 80 °C to 150 °C  | 0.046 °C |
| 150 °C to 350 °C | 0.51 °C  |

Radiation thermometers, including infrared thermometers and infrared imaging cameras

|                  |         |
|------------------|---------|
| -15 °C to 0 °C   | 1.0 °C  |
| 0 °C to 130 °C   | 0.24 °C |
| 130 °C to 500 °C | 0.75 °C |

Electrical calibration of temperature calibrators (resistance and thermocouples) as in 5.88 (i)

Electrical simulation or measurement of temperature (resistance and thermocouples), including transducers and transmitters with electrical 4-20 mA, 1-10 Vdc and 1-5 Vdc outputs, as in 5.89 (q)

**CPS Labs: Penrose, Auckland**

**Location: 101A Station Road, Penrose, Auckland 1061**

**5.28 Flow Measuring Devices**

By comparison with reference instrument to an in-house method based on manufacturer recommendations and/or customer requirements using a wind tunnel

- (a) Anemometers

Vane type

|                     |           |
|---------------------|-----------|
| 0.25 m/s to 0.5 m/s | 0.031 m/s |
| 0.5 m/s to 0.7 m/s  | 0.04 m/s  |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 6 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory

Accreditation Number 271

### SCOPE OF ACCREDITATION

0.7 m/s to 4.5 m/s

0.06 m/s

4.5 m/s to 18.5 m/s

0.07 m/s to 0.19 m/s\*

\*increasing approximately linearly with increasing measurand

Hot wire type

0.2 m/s to 2 m/s

$-0.29\sqrt{x^3} + 0.70x - 0.46\sqrt{x} + 0.12$   
m/s\*

2 m/s to 17 m/s

0.0060x+0.018 m/s\*

\* Where x = measured air flow

(l) Other devices

Pitot tubes

Standard types (1.0 m/s to 17 m/s)

0.07 m/s or 1.6 % of reading  
whichever is greater

Type S (1.0 m/s to 17 m/s)

### 5.31 Volumetric Equipment

By comparison with reference instrument to an in-house method based on manufacturer recommendations and/or customer requirements using a wind tunnel

(b) Examination of other types of volumetric apparatus (including gas meters)

Air samplers relating to (ISO/CD 14698-1)

Nominal 100 L/min

1.1 L

### 5.35 Hygrometry

By comparison with a reference hygrometer in a controlled climatic chamber to an in-house method based on manufacturer recommendations and/or customer requirements

(a) Humidity measuring devices

Relative humidity, all CMC values in %rh

| Relative Humidity | Temperature |       |       |       |       |
|-------------------|-------------|-------|-------|-------|-------|
|                   | 10 °C       | 20 °C | 25 °C | 40 °C | 47 °C |
| 7 %rh             | 1.6         | 1.3   | 1.2   | 1.3   | 1.2   |
| 15 %rh            | 2.1         | 1.4   | 1.1   | 1.4   | 1.3   |
| 20 %rh            | 2.3         | 1.4   | 1.0   | 1.4   | 1.4   |
| 25 %rh            | 2.5         | 1.5   | 1.0   | 1.5   | 1.5   |
| 35 %rh            | 3.0         | 1.6   | 0.9   | 1.6   | 1.7   |
| 45 %rh            | 3.5         | 1.7   | 0.7   | 1.7   | 1.9   |
| 50 %rh            | 3.8         | 1.7   | 0.7   | 1.7   | 2.0   |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 7 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory

Accreditation Number 271

**SCOPE OF ACCREDITATION**

|        |     |     |     |     |     |
|--------|-----|-----|-----|-----|-----|
| 55 %rh | 4.0 | 1.8 | 0.6 | 1.8 | 2.1 |
| 75 %rh | 5.0 | 2.2 | 0.7 | 1.4 | 1.7 |
| 95 %rh | -   | 2.5 | 0.8 | 1.4 | 1.7 |

Air temperature, all CMC values in °C

| Temperature | Relative Humidity |        |        |        |        |
|-------------|-------------------|--------|--------|--------|--------|
|             | 7 %rh             | 25 %rh | 50 %rh | 75 %rh | 95 %rh |
| 10 °C       | 0.27              | 0.28   | 0.30   | 0.29   | -      |
| 14 °C       | 0.23              | 0.24   | 0.26   | 0.25   | -      |
| 16 °C       | 0.21              | 0.22   | 0.24   | 0.23   | -      |
| 20 °C       | 0.17              | 0.18   | 0.19   | 0.19   | 0.20   |
| 24 °C       | 0.13              | 0.14   | 0.15   | 0.15   | 0.16   |
| 25 °C       | 0.12              | 0.13   | 0.14   | 0.15   | 0.15   |
| 30 °C       | 0.13              | 0.14   | 0.14   | 0.15   | 0.15   |
| 36 °C       | 0.17              | 0.16   | 0.16   | 0.15   | 0.15   |
| 44 °C       | 0.21              | 0.20   | 0.17   | 0.16   | 0.15   |
| 47 °C       | 0.23              | 0.21   | 0.18   | 0.16   | 0.16   |

**5.42 Differential Pressure Measuring Devices (including Manometers)**

By comparison with reference calibrator to an in-house method based on manufacturer recommendations and/or customer requirements

- (a) Diaphragm types
- (b) Liquid column types, inclined and vertical
- (c) Transducers and transmitters
- (d) Other types

0.05 Pa to 2000 Pa  
2000 Pa to 2242 Pa

0.014 % + 0.08 Pa  
0.9 Pa

**5.55 Speed Measuring Devices**

- (a) Tachometers

Optical tachometers in accordance with an in-house method based on manufacturer's recommendations and/or customer requirements

30 rpm to 8999 rpm  
9000 rpm to 90000 rpm

0.0003 % + 0.03 rpm  
0.0003 % + 0.60 rpm

**5.61 Temperature Measuring Equipment**

- (a) Rare metal thermocouples

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 8 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory

Accreditation Number 271

### SCOPE OF ACCREDITATION

- (b) Base metal thermocouples
- (c) Platinum (and other metallic) resistance thermometers
- (e) Thermistors and other semi-conductor thermometers
- (k) Vapour pressure thermometers
- (l) Filled metal systems
- (m) Bimetallic systems
- (n) Digital quartz frequency units
- (o) Indicators, recorders and controllers
- (p) Other direct reading temperature measuring systems

By comparison with reference instruments in a temperature bath to an in-house method based on manufacturer recommendations and/or customer requirements

-40 °C to 55 °C

55 °C to 125 °C

$73 \times 10^{-6}T + 0.019 \text{ °C}$

$68 \times 10^{-6}T + 0.019 \text{ °C}$

where T = temperature

Indicators, recorders, and controllers by electrical simulation using a multifunction calibrator

#### Rare metal thermocouples

##### Type B

600 °C to 800 °C

1.2 °C

800 °C to 1000 °C

1.0 °C

1000 °C to 1550 °C

0.81 °C

1550 °C to 1820 °C

0.74 °C

##### Type R

0 °C to 250 °C

1.1 °C

250 °C to 400 °C

0.87 °C

400 °C to 1000 °C

0.77 °C

1000 °C to 1767 °C

0.67 °C

##### Type S

0 °C to 250 °C

1.2 °C

250 °C to 1000 °C

0.87 °C

1000 °C to 1400 °C

0.73 °C

1400 °C to 1767 °C

0.63 °C

#### Base Metal Thermocouples

##### Type C

0 °C to 150 °C

0.58 °C

150 °C to 650 °C

0.46 °C

650 °C to 1000 °C

0.45 °C

1000 °C to 1800 °C

0.54 °C

1800 °C to 2316 °C

0.74 °C

##### Type E

-250 °C to -100 °C

0.33 °C

-100 °C to -25 °C

0.17 °C

-25 °C to 350 °C

0.12 °C

350 °C to 650 °C

0.11 °C

650 °C to 1000 °C

0.12 °C

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 9 of 53

## CERTIFICATE OF ACCREDITATION



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|        |                   |         |
|--------|-------------------|---------|
| Type J | 210 °C to -100 °C | 0.22 °C |
|        | -100 °C to -30 °C | 0.19 °C |
|        | -30 °C to 150 °C  | 0.11 °C |
|        | 150 °C to 760 °C  | 0.15 °C |
|        | 760 °C to 1200 °C | 0.15 °C |

|        |                    |         |
|--------|--------------------|---------|
| Type K | -200 °C to -100 °C | 0.37 °C |
|        | -100 °C to -25 °C  | 0.25 °C |
|        | -25 °C to 120 °C   | 0.32 °C |
|        | 120 °C to 1000 °C  | 0.21 °C |
|        | 1000 °C to 1372 °C | 0.24 °C |

|        |                    |         |
|--------|--------------------|---------|
| Type L | -200 °C to -100 °C | 0.16 °C |
|        | -100 °C to 800 °C  | 0.17 °C |
|        | 800 °C to 900 °C   | 0.15 °C |

|        |                   |         |
|--------|-------------------|---------|
| Type N | 200 °C to -100 °C | 0.59 °C |
|        | -100 °C to -25 °C | 0.33 °C |
|        | -25 °C to 120 °C  | 0.31 °C |
|        | 120 °C to 410 °C  | 0.25 °C |
|        | 410 °C to 1300 °C | 0.23 °C |

|        |                    |         |
|--------|--------------------|---------|
| Type T | -250 °C to -150 °C | 0.56 °C |
|        | -150 °C to 0 °C    | 0.28 °C |
|        | 0 °C to 120 °C     | 0.20 °C |
|        | 120 °C to 400 °C   | 0.15 °C |

|        |                 |         |
|--------|-----------------|---------|
| Type U | -200 °C to 0 °C | 0.30 °C |
|        | 0 °C to 600 °C  | 0.15 °C |

Platinum (and other metallic) resistance thermometers (Source 3W or 4W)

|              |                   |                      |
|--------------|-------------------|----------------------|
| Pt 385 100 Ω | -200 °C to -80 °C | 0.007 °C to 0.015 °C |
|              | -80 °C to 0 °C    | 0.015 °C to 0.02 °C  |
|              | 0 °C to 100 °C    | 0.02 °C to 0.03 °C   |
|              | 100 °C to 300 °C  | 0.03 °C to 0.05 °C   |
|              | 300 °C to 400 °C  | 0.05 °C to 0.06 °C   |
|              | 400 °C to 630 °C  | 0.06 °C to 0.08 °C   |
|              | 630 °C to 800 °C  | 0.08 °C to 0.09 °C   |

|               |                   |                      |
|---------------|-------------------|----------------------|
| Pt 385 1000 Ω | -200 °C to -80 °C | 0.007 °C to 0.015 °C |
|               | -80 °C to 0 °C    | 0.015 °C to 0.018 °C |
|               | 0 °C to 100 °C    | 0.018 °C to 0.03 °C  |
|               | 100 °C to 260 °C  | 0.03 °C to 0.04 °C   |
|               | 260 °C to 300 °C  | 0.04 °C to 0.05 °C   |
|               | 300 °C to 400 °C  | 0.04 °C to 0.05 °C   |
|               | 400 °C to 600 °C  | 0.05 °C to 0.07 °C   |

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 10 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                        |                    |                      |
|------------------------|--------------------|----------------------|
|                        | 600 °C to 630 °C   | 0.07 °C to 0.08 °C   |
| Pt 3916 Ω              | -200 °C to -190 °C | 0.007 °C             |
|                        | -190 °C to -80 °C  | 0.007 °C to 0.015 °C |
|                        | -80 °C to 0 °C     | 0.015 °C to 0.02 °C  |
|                        | 0 °C to 100 °C     | 0.02 °C to 0.03 °C   |
|                        | 100 °C to 260 °C   | 0.03 °C to 0.04 °C   |
|                        | 260 °C to 300 °C   | 0.04 °C to 0.05 °C   |
|                        | 300 °C to 400 °C   | 0.05 °C              |
|                        | 400 °C to 600 °C   | 0.05 °C to 0.07 °C   |
|                        | 600 °C to 630 °C   | 0.07 °C              |
| Pt 3926 Ω              | -200 °C to -80 °C  | 0.007 °C to 0.015 °C |
|                        | -80 °C to 0 °C     | 0.015 °C to 0.02 °C  |
|                        | 0 °C to 100 °C     | 0.02 °C to 0.03 °C   |
|                        | 100 °C to 300 °C   | 0.03 °C to 0.05 °C   |
|                        | 300 °C to 400 °C   | 0.05 °C              |
|                        | 400 °C to 630 °C   | 0.05 °C to 0.07 °C   |
| PtNi 385 120 Ω (Ni120) | -80 °C to 0 °C     | 0.008 °C to 0.012 °C |
|                        | 0 °C to 100 °C     | 0.008 °C to 0.017 °C |
|                        | 100 °C to 260 °C   | 0.017 °C to 0.012 °C |

## 5.88 Calibrators for Instrumentation

By comparison with reference instrument to an in-house method based on manufacturer recommendations and/or customer requirements. Note that CMC Uncertainties only include reference device uncertainties and reported measurement uncertainty for a customer's calibrator is likely to be larger.

### (a) DC voltage

|                     |                            |
|---------------------|----------------------------|
| ± (0.010 to 200) mV | 5 ppm + 2 ppm of range     |
| ± (0.2 to 2) V      | 3.5 ppm + 0.5 ppm of range |
| ± (2 to 20) V       | 3.5 ppm + 2 ppm of range   |
| ± (20 to 200) V     | 5.5 ppm + 0.2 ppm of range |
| ± (200 to 1050) V   | 5.5 ppm + 3 ppm of range   |

### (b) AC voltage

|        |                   |                            |
|--------|-------------------|----------------------------|
| 200 mV | 20 Hz to 57 Hz    | 140 ppm + 70 ppm of range  |
|        | 57 Hz to 1 kHz    | 115 ppm + 20 ppm of range  |
|        | 1 kHz to 3 kHz    | 135 ppm + 20 ppm of range  |
|        | 3 kHz to 10 kHz   | 135 ppm + 20 ppm of range  |
|        | 10 kHz to 30 kHz  | 340 ppm + 20 ppm of range  |
|        | 30 kHz to 60 kHz  | 340 ppm + 40 ppm of range  |
|        | 60 kHz to 100 kHz | 765 ppm + 100 ppm of range |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page **11** of **53**



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                            |                    |                             |
|----------------------------|--------------------|-----------------------------|
| 2 V                        | 20 Hz to 57 Hz     | 115 ppm + 12 ppm of range   |
|                            | 57 Hz to 1 kHz     | 90 ppm + 12 ppm of range    |
|                            | 1 kHz to 3 kHz     | 100 ppm + 10 ppm of range   |
|                            | 3 kHz to 10 kHz    | 200 ppm + 15 ppm of range   |
| 20 V                       | 10 kHz to 30 kHz   | 220 ppm + 15 ppm of range   |
|                            | 30 kHz to 60 kHz   | 400 ppm + 70 ppm of range   |
|                            | 60 kHz to 100 kHz  | 900 ppm + 5500 ppm of range |
|                            | 100 kHz to 500 kHz | 1 % + 1 % of range          |
| 200 V                      | 500 kHz to 1 MHz   | 1 % + 1 % of range          |
|                            | 20 Hz to 57 Hz     | 90 ppm + 37 ppm of range    |
|                            | 57 Hz to 1 kHz     | 100 ppm + 10 ppm of range   |
|                            | 1 kHz to 3 kHz     | 90 ppm + 10 ppm of range    |
| 1000 V                     | 3 kHz to 10 kHz    | 110 ppm + 10 ppm of range   |
|                            | 10 kHz to 30 kHz   | 150 ppm + 15 ppm of range   |
|                            | 30 kHz to 60 kHz   | 350 ppm + 75 ppm of range   |
|                            | 60 kHz to 100 kHz  | 900 ppm + 900 ppm of range  |
| (c) DC current             | 100 kHz to 500 kHz | 1 % + 1 % of range          |
|                            | 500 kHz to 1 MHz   | 1 % + 1 % of range          |
|                            | 20 Hz to 57 Hz     | 100 ppm + 350 ppm of range  |
|                            | 57 Hz to 1 kHz     | 90 ppm + 300 ppm of range   |
| ± 200 µA                   | 1 kHz to 3 kHz     | 90 ppm + 12 ppm of range    |
|                            | 3 kHz to 10 kHz    | 110 ppm + 12 ppm of range   |
|                            | 10 kHz to 30 kHz   | 150 ppm + 15 ppm of range   |
|                            | 30 kHz to 60 kHz   | 350 ppm + 75 ppm of range   |
| ± 2 mA                     | 60 kHz to 100 kHz  | 570 ppm + 100 ppm of range  |
|                            | 57 Hz to 1 kHz     | 115 ppm + 0.6 % of range    |
|                            | 1 kHz to 3 kHz     | 115 ppm + 75 ppm of range   |
|                            | 3 kHz to 10 kHz    | 115 ppm + 39 ppm of range   |
| ± 20 mA                    | 10 kHz to 30 kHz   | 180 ppm + 2 % of range      |
|                            | 10 Hz to 305 Hz    | 12 ppm + 4 ppm of range     |
|                            | 305 Hz to 1 kHz    | 12 ppm + 4 ppm of range     |
|                            | 1 kHz to 3 kHz     | 14 ppm + 65 ppm of range    |
| ± 200 mA                   |                    | 48 ppm + 70 ppm of range    |
|                            |                    | 185 ppm + 300 ppm of range  |
|                            |                    | 400 ppm + 900 ppm of range  |
|                            |                    |                             |
| ± 2 A                      |                    |                             |
|                            |                    |                             |
|                            |                    |                             |
|                            |                    |                             |
| ± 20 A                     |                    |                             |
|                            |                    |                             |
|                            |                    |                             |
|                            |                    |                             |
| (d) AC current             |                    |                             |
|                            |                    |                             |
|                            |                    |                             |
|                            |                    |                             |
| 200 µA                     |                    |                             |
|                            |                    |                             |
|                            |                    |                             |
|                            |                    |                             |
| 500 ppm + 100 ppm of range |                    |                             |
|                            |                    |                             |
|                            |                    |                             |
|                            |                    |                             |
| 500 ppm + 100 ppm of range |                    |                             |
|                            |                    |                             |
|                            |                    |                             |
|                            |                    |                             |
| 500 ppm + 100 ppm of range |                    |                             |
|                            |                    |                             |
|                            |                    |                             |
|                            |                    |                             |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 12 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                |                 |                             |
|----------------|-----------------|-----------------------------|
|                | 3 kHz to 5 kHz  | 500 ppm + 100 ppm of range  |
|                | 5 kHz to 10 kHz | 500 ppm + 100 ppm of range  |
| 2 mA           | 10 Hz to 305 Hz | 310 ppm + 100 ppm of range  |
|                | 305 Hz to 1 kHz | 300 ppm + 100 ppm of range  |
|                | 1 kHz to 3 kHz  | 300 ppm + 100 ppm of range  |
|                | 3 kHz to 5 kHz  | 300 ppm + 100 ppm of range  |
|                | 5 kHz to 10 kHz | 700 ppm + 200 ppm of range  |
| 20 mA          | 10 Hz to 305 Hz | 300 ppm + 100 ppm of range  |
|                | 305 Hz to 1 kHz | 300 ppm + 100 ppm of range  |
|                | 1 kHz to 3 kHz  | 300 ppm + 100 ppm of range  |
|                | 3 kHz to 5 kHz  | 300 ppm + 100 ppm of range  |
|                | 5 kHz to 10 kHz | 700 ppm + 200 ppm of range  |
| 200 mA         | 10 Hz to 305 Hz | 300 ppm + 100 ppm of range  |
|                | 305 Hz to 1 kHz | 290 ppm + 100 ppm of range  |
|                | 1 kHz to 3 kHz  | 290 ppm + 100 ppm of range  |
|                | 3 kHz to 5 kHz  | 290 ppm + 100 ppm of range  |
|                | 5 kHz to 10 kHz | 0.5 % + 200 ppm of range    |
| 2 A            | 10 Hz to 305 Hz | 620 ppm + 350 ppm of range  |
|                | 305 Hz to 1 kHz | 620 ppm + 100 ppm of range  |
|                | 1 kHz to 3 kHz  | 700 ppm + 100 ppm of range  |
|                | 3 kHz to 5 kHz  | 730 ppm + 100 ppm of range  |
|                | 5 kHz to 10 kHz | 0.2 % + 100 ppm of range    |
| 20 A           | 10 Hz to 305 Hz | 820 ppm + 200 ppm of range  |
|                | 305 Hz to 1 kHz | 820 ppm + 200 ppm of range  |
|                | 1 kHz to 3 kHz  | 1500 ppm + 200 ppm of range |
|                | 3 kHz to 5 kHz  | 0.25 % + 210 ppm of range   |
|                | 5 kHz to 10 kHz | 0.25 % + 500 ppm of range   |
| (e) Resistance |                 |                             |
| Normal         |                 |                             |
| 2 Ω            | 4W              | 17 ppm + 4 pm of range      |
| 20 Ω           | 4W              | 10 ppm + 1.5 pm of range    |
| 200 Ω          | 4W              | 8 ppm + 17 pm of range      |
| 2 kΩ           | 4W              | 8 ppm + 1 pm of range       |
| 20 kΩ          | 4W              | 8 ppm + 1 pm of range       |
| 200 kΩ         | 4W              | 8 ppm + 1 pm of range       |
| 2 MΩ           | 4W              | 9 ppm + 14 pm of range      |
| 20 MΩ          | 2W              | 20 ppm + 790 pm of range    |
| 200 MΩ         | 2W              | 120 ppm + 0.4 % of range    |
| 2 GΩ           | 2W              | 0.15 % + 3.7 % of range     |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 13 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

**Lo Current Mode**

|                |    |                        |
|----------------|----|------------------------|
| 2 $\Omega$     | 4W | 17 ppm + 3 pm of range |
| 20 $\Omega$    | 4W | 10 ppm + 2 pm of range |
| 200 $\Omega$   | 4W | 8 ppm + 1 pm of range  |
| 2 k $\Omega$   | 4W | 8 ppm + 1 pm of range  |
| 20 k $\Omega$  | 4W | 8 ppm + 1 pm of range  |
| 200 k $\Omega$ | 4W | 8 ppm + 2 pm of range  |

**High Voltage Mode**

|                |    |                          |
|----------------|----|--------------------------|
| 20 M $\Omega$  | 2W | 17 ppm + 62 ppm of range |
| 200 M $\Omega$ | 2W | 65 ppm + 60 ppm of range |
| 2 G $\Omega$   | 2W | 180 ppm + 1 % of range   |
| 20 G $\Omega$  | 2W | 1500 ppm + 1 % of range  |

**5.89 Indicating Instruments and Recording Instruments**

By comparison with reference calibrator to an in-house method based on manufacturer recommendations and/or customer requirements. CMC Uncertainties only include reference device uncertainties and reported measurement uncertainty for a customer's calibrator is likely to be larger.

**(a) DC voltmeters**

|                                    |                       |
|------------------------------------|-----------------------|
| 0 mV to $\pm 329.9999$ mV          | 0.005 % + 7 $\mu$ V   |
| 0 V to $\pm 3.299999$ V            | 0.004 % + 32 $\mu$ V  |
| 0 V to $\pm 32.99999$ V            | 0.004 % + 270 $\mu$ V |
| $\pm (30 \text{ to } 329.9999)$ V  | 0.004 % + 3.8 mV      |
| $\pm (330 \text{ to } 1020.000)$ V | 0.004 % + 14 mV       |

**(b) AC voltmeters**

|                     |                    |                      |
|---------------------|--------------------|----------------------|
| 1.0 mV to 32.999 mV | 9.5 Hz to 10 Hz    | 0.12 % + 40 $\mu$ V  |
|                     | 10 Hz to 57 Hz     | 0.09 % + 24 $\mu$ V  |
|                     | 57 Hz to 1 kHz     | 0.08 % + 22 $\mu$ V  |
|                     | 1 kHz to 10 kHz    | 0.11 % + 22 $\mu$ V  |
|                     | 10 kHz to 20 kHz   | 0.13 % + 22 $\mu$ V  |
|                     | 20 kHz to 50 kHz   | 0.16 % + 32 $\mu$ V  |
|                     | 50 kHz to 100 kHz  | 0.22 % + 57 $\mu$ V  |
|                     | 100 kHz to 450 kHz | 0.53 % + 110 $\mu$ V |
| 33 mV to 329.999 mV | 9.5 Hz to 10 Hz    | 0.04 % + 180 $\mu$ V |
|                     | 10 Hz to 57 Hz     | 0.04 % + 75 $\mu$ V  |
|                     | 57 Hz to 1 kHz     | 0.03 % + 38 $\mu$ V  |
|                     | 1 kHz to 10 kHz    | 0.02 % + 68 $\mu$ V  |
|                     | 10 kHz to 20 kHz   | 0.03 % + 57 $\mu$ V  |
|                     | 20 kHz to 50 kHz   | 0.06 % + 88 $\mu$ V  |
|                     | 50 kHz to 100 kHz  | 0.13 % + 140 $\mu$ V |
|                     | 100 kHz to 500 kHz | 0.28 % + 260 $\mu$ V |

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 14 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                     |                    |                      |
|---------------------|--------------------|----------------------|
| 0.33 V to 3.29999 V | 9.5 Hz to 10 Hz    | 0.04 % + 2.2 mV      |
|                     | 10 Hz to 57 Hz     | 0.04 % + 600 $\mu$ V |
|                     | 57 Hz to 1 kHz     | 0.03 % + 230 $\mu$ V |
|                     | 1 kHz to 10 kHz    | 0.02 % + 250 $\mu$ V |
|                     | 10 kHz to 20 kHz   | 0.03 % + 250 $\mu$ V |
|                     | 20 kHz to 50 kHz   | 0.05 % + 250 $\mu$ V |
|                     | 50 kHz to 100 kHz  | 0.13 % + 830 $\mu$ V |
|                     | 100 kHz to 450 kHz | 0.28 % + 1.1 mV      |
| 3.3 V to 32.9999 V  | 9.5 Hz to 10 Hz    | 0.04 % + 24 mV       |
|                     | 10 Hz to 57 Hz     | 0.04 % + 5.2 mV      |
|                     | 57 Hz to 1 kHz     | 0.03 % + 3.4 mV      |
|                     | 1 kHz to 10 kHz    | 0.02 % + 4.6 mV      |
|                     | 10 kHz to 20 kHz   | 0.04 % + 6.5 mV      |
|                     | 20 kHz to 50 kHz   | 0.07 % + 5.4 mV      |
| 33 V to 329.999 V   | 45 Hz to 1 kHz     | 0.04 % + 16 mV       |
|                     | 1 kHz to 10 kHz    | 0.05 % + 19 mV       |
|                     | 10 kHz to 18 kHz   | 0.06 % + 35 mV       |
|                     | 18 kHz to 50 kHz   | 0.08 % + 48 mV       |
|                     | 50 kHz to 100 kHz  | 0.14 % + 130 mV      |
| 330 V to 1020 V     | 45 Hz to 1 kHz     | 0.04 % + 34 mV       |
|                     | 1 kHz to 5 kHz     | 0.06 % + 31 mV       |
|                     | 5 kHz to 10 kHz    | 0.06 % + 760 mV      |

(c) DC ammeters

|                       |                       |
|-----------------------|-----------------------|
| $\pm$ (0 to 3.3) mA   | 0.01 % + 0.05 $\mu$ A |
| $\pm$ (3.3 to 33) mA  | 0.01 % + 0.25 $\mu$ A |
| $\pm$ (33 to 330) mA  | 0.01 % + 2.5 $\mu$ A  |
| $\pm$ (0.33 to 2.2) A | 0.038 % + 44 $\mu$ A  |
| $\pm$ (2.2 to 11) A   | 0.06 % + 500 $\mu$ A  |
| $\pm$ (11 to 20) A    | 0.1 % + 750 $\mu$ A   |

DC Clamp meters using the Fluke 50:1 current coil

|                       |        |
|-----------------------|--------|
| $\pm$ (11 to 16.5) A  | 0.51 % |
| $\pm$ (16.5 to 110) A | 0.51 % |
| $\pm$ (110 to 550) A  | 0.51 % |
| $\pm$ (550 to 1000) A | 0.51 % |

(d) AC ammeters

|                              |                |                      |
|------------------------------|----------------|----------------------|
| 29 $\mu$ A to 329.99 $\mu$ A | 10 Hz to 57 Hz | 0.13 % + 0.2 $\mu$ A |
|------------------------------|----------------|----------------------|

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 15 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                       |                  |                       |
|-----------------------|------------------|-----------------------|
|                       | 57 Hz to 1 kHz   | 0.10 % + 0.1 $\mu$ A  |
|                       | 1 kHz to 5 kHz   | 0.13 % + 0.1 $\mu$ A  |
|                       | 5 kHz to 10 kHz  | 0.52 % + 0.2 $\mu$ A  |
| 0.33 mA to 3.29999 mA | 10 Hz to 57 Hz   | 0.13 % + 1.3 $\mu$ A  |
|                       | 57 Hz to 1 kHz   | 0.08 % + 0.37 $\mu$ A |
|                       | 1 kHz to 5 kHz   | 0.04 % + 0.33 $\mu$ A |
|                       | 5 kHz to 10 kHz  | 0.27 % + 1.4 $\mu$ A  |
| 3.3 to 32.9999 mA     | 10 Hz to 57 Hz   | 0.11 % + 13 $\mu$ A   |
|                       | 57 Hz to 1 kHz   | 0.04 % + 3 $\mu$ A    |
|                       | 1 kHz to 5 kHz   | 0.04 % + 3 $\mu$ A    |
|                       | 5 kHz to 10 kHz  | 0.11 % + 3 $\mu$ A    |
| 33 to 329.999 mA      | 10 Hz to 20 Hz   | 0.17 % + 2 $\mu$ A    |
|                       | 20 Hz to 45 Hz   | 0.12 % + 2 $\mu$ A    |
|                       | 45 Hz to 1 kHz   | 0.11 % + 2 $\mu$ A    |
|                       | 1 kHz to 5 kHz   | 0.13 % + 2 $\mu$ A    |
|                       | 5 kHz to 10 kHz  | 0.18 % + 2.3 $\mu$ A  |
|                       | 10 kHz to 30 kHz | 0.33 % + 3.1 $\mu$ A  |
| 0.33 A to 1.09999 A   | 10 Hz to 57 Hz   | 0.09 % + 380 $\mu$ A  |
|                       | 57 Hz to 1 kHz   | 0.04 % + 140 $\mu$ A  |
|                       | 1 kHz to 5 kHz   | 0.25 % + 490 $\mu$ A  |
|                       | 5 kHz to 10 kHz  | 1.45 % + 3500 $\mu$ A |
| 1.1 to 2.99999 A      | 10 Hz to 57 Hz   | 0.09 % + 810 $\mu$ A  |
|                       | 57 Hz to 1 kHz   | 0.05 % + 350 $\mu$ A  |
|                       | 1 kHz to 5 kHz   | 0.26 % + 560 $\mu$ A  |
|                       | 5 kHz to 10 kHz  | 1.20 % + 8200 $\mu$ A |
| 3 to 10.9999 A        | 500 Hz to 1 kHz  | 0.06 % + 2.2 mA       |
|                       | 1 kHz to 5 kHz   | 1.20 % + 14 mA        |
| 11 to 20.5 A          | 45 Hz to 65 Hz   | 0.09 % + 5 mA         |
|                       | 65 Hz to 500 Hz  | 0.11 % + 4.4 mA       |
|                       | 500 Hz to 1 kHz  | 0.12 % + 6 mA         |
|                       | 1 kHz to 5 kHz   | 1.22 % + 36 mA        |

Toroidal Coil AC Clamp meters using 1:1 current coil

|                    |                  |                       |
|--------------------|------------------|-----------------------|
| 0.33 to 3.29999 mA | 10 Hz to 20 Hz   | 0.18 % + 0.1 $\mu$ A  |
|                    | 20 Hz to 45 Hz   | 0.14 % + 0.1 $\mu$ A  |
|                    | 45 Hz to 1 kHz   | 0.14 % + 0.1 $\mu$ A  |
|                    | 1 kHz to 5 kHz   | 0.25 % + 0.15 $\mu$ A |
|                    | 5 kHz to 10 kHz  | 0.63 % + 0.2 $\mu$ A  |
|                    | 10 kHz to 30 kHz | 1.24 % + 0.3 $\mu$ A  |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page **16** of **53**



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                   |                  |                       |
|-------------------|------------------|-----------------------|
| 3.3 to 32.9999 mA | 10 Hz to 20 Hz   | 0.18 % + 0.12 $\mu$ A |
|                   | 20 Hz to 45 Hz   | 0.14 % + 0.12 $\mu$ A |
|                   | 45 Hz to 1 kHz   | 0.13 % + 0.12 $\mu$ A |
|                   | 1 kHz to 5 kHz   | 0.18 % + 0.2 $\mu$ A  |
|                   | 5 kHz to 10 kHz  | 0.40 % + 0.23 $\mu$ A |
|                   | 10 kHz to 30 kHz | 0.78 % + 0.5 $\mu$ A  |
| 33 to 329.999 mA  | 10 Hz to 20 Hz   | 0.17 % + 2 $\mu$ A    |
|                   | 20 Hz to 45 Hz   | 0.12 % + 2 $\mu$ A    |
|                   | 45 Hz to 1 kHz   | 0.11 % + 2 $\mu$ A    |
|                   | 1 kHz to 5 kHz   | 0.13 % + 2 $\mu$ A    |
|                   | 5 kHz to 10 kHz  | 0.18 % + 2.3 $\mu$ A  |
|                   | 10 kHz to 30 kHz | 0.33 % + 3.1 $\mu$ A  |
| 0.33 to 1.09999 A | 10 Hz to 45 Hz   | 0.17 % + 16 $\mu$ A   |
|                   | 45 Hz to 1 kHz   | 0.11 % + 16 $\mu$ A   |
|                   | 1 kHz to 5 kHz   | 0.48 % + 16 $\mu$ A   |
|                   | 5 kHz to 10 kHz  | 1.9 % + 39 $\mu$ A    |
| 1.1 to 2.99999 A  | 10 Hz to 45 Hz   | 0.17 % + 78 $\mu$ A   |
|                   | 45 Hz to 1 kHz   | 0.11 % + 78 $\mu$ A   |
|                   | 1 kHz to 5 kHz   | 0.48 % + 770 $\mu$ A  |
|                   | 5 kHz to 10 kHz  | 1.9 % + 3.8 mA        |
| 3 to 10.9999 A    | 45 Hz to 100 Hz  | 0.11 % + 1.6 mA       |
|                   | 100 Hz to 1 kHz  | 0.13 % + 1.6 mA       |
|                   | 1 kHz to 5 kHz   | 2.3 % + 1.6 mA        |
| 11 to 20.5 A      | 45 Hz to 100 Hz  | 0.14 % + 3.9 mA       |
|                   | 100 Hz to 1 kHz  | 0.15 % + 3.9 mA       |
|                   | 1 kHz to 5 kHz   | 2.3 % + 3.9 mA        |

Toroidal Coil AC clamp meters using the Fluke 50:1 current coil

|                 |                 |        |
|-----------------|-----------------|--------|
| 16.5 A to 500 A | 45 Hz to 440 Hz | 0.22 % |
| 500 A to 1025 A | 45 Hz to 440 Hz | 0.27 % |

Rogowski Coil Clamp meters using the Fluke 50:1 current coil

|                 |                 |        |
|-----------------|-----------------|--------|
| 16.5 A to 500 A | 45 Hz to 440 Hz | 0.28 % |
| 500 A to 1025 A | 45 Hz to 440 Hz | 0.30 % |

Hall Effect DC-AC Clamp meters using the Fluke 50:1 current coil

|                 |                 |        |
|-----------------|-----------------|--------|
| 16.5 A to 500 A | 45 Hz to 440 Hz | 0.46 % |
| 500 A to 1025 A | 45 Hz to 440 Hz | 0.51 % |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 17 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

(i) Ohmmeters

Range 4-Wire

(for 2-Wire measurements add an additional uncertainty of 5  $\mu$ V per amp of stimulus current to the floor value)

|                                   |                           |
|-----------------------------------|---------------------------|
| 0 $\Omega$ to 11 $\Omega$         | 0.012 % + 0.001 $\Omega$  |
| 11 $\Omega$ to 33 $\Omega$        | 0.012 % + 0.0015 $\Omega$ |
| 33 $\Omega$ to 110 $\Omega$       | 0.009 % + 0.0014 $\Omega$ |
| 110 $\Omega$ to 330 $\Omega$      | 0.009 % + 0.002 $\Omega$  |
| 330 $\Omega$ to 1100 $\Omega$     | 0.009 % + 0.002 $\Omega$  |
| 1.1 k $\Omega$ to 3.3 k $\Omega$  | 0.009 % + 0.02 $\Omega$   |
| 3.3 k $\Omega$ to 11 k $\Omega$   | 0.009 % + 0.02 $\Omega$   |
| 11 k $\Omega$ to 33 k $\Omega$    | 0.009 % + 0.2 $\Omega$    |
| 33 k $\Omega$ to 110 k $\Omega$   | 0.011 % + 0.02 $\Omega$   |
| 110 k $\Omega$ to 330 k $\Omega$  | 0.009 % + 2 $\Omega$      |
| 330 k $\Omega$ to 1.1 M $\Omega$  | 0.012 % + 2 $\Omega$      |
| 1.1 M $\Omega$ to 3.3 M $\Omega$  | 0.012 % + 27 $\Omega$     |
| 3.3 M $\Omega$ to 11 M $\Omega$   | 0.05 % + 50 $\Omega$      |
| 11 M $\Omega$ to 33 M $\Omega$    | 0.08 % + 2.5 k $\Omega$   |
| 33 M $\Omega$ to 110 M $\Omega$   | 0.39 % + 3 k $\Omega$     |
| 110 M $\Omega$ to 330 M $\Omega$  | 0.4 % + 100 k $\Omega$    |
| 330 M $\Omega$ to 1100 M $\Omega$ | 1.2 % + 240 k $\Omega$    |

### 5.91 Time and Frequency

By comparison with reference instrument to an in-house method based on manufacturer recommendations and/or customer requirements

(a) Frequency meters

|                         |                 |                 |
|-------------------------|-----------------|-----------------|
| 0.01 Hz to 119.99 Hz    | 0.01 Hz         | 20 ppm + 1 mHz  |
| 120.0 Hz to 1199.9 Hz   | 0.1 Hz          | 20 ppm + 1 mHz  |
| 1.2 kHz to 11999 kHz    | 1 Hz            | 20 ppm + 1 mHz  |
| 12 kHz to 119.99 kHz    | 10 Hz           | 20 ppm + 15 mHz |
| 120.0 kHz to 1199.9 kHz | 100 Hz          | 20 ppm + 15 mHz |
| 1.2 MHz to 2.000 MHz    | 1 kHz           | 20 ppm + 15 mHz |
| 10 MHz                  | fixed sine wave | 1.0 Hz          |

(c) Counters

Period Measurement Square Wave AC Input range (1 mV to 3.3 V, 50 % duty cycle)

|                      |                |
|----------------------|----------------|
| 0.5 $\mu$ s to 100 s | 0.8 % + 100 ns |
|----------------------|----------------|

(f) Stroboscopes

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 18 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

Specific frequency values

1 Hz to 100 kHz

0.002 Hz to 0.02 Hz (increases  
with increasing measurand)

### 5.93 Signal Sources

By comparison with reference instrument to an in-house method based on manufacturer recommendations and/or customer requirements

(e) Other characteristics

Signal Generators Frequency – Square or Sine Wave

71 mV to 30 V p-p

2 Hz to 500 kHz

$0.001 \times 106/f$ , where f is the  
measured frequency in Hz

## CPS Labs: Bell Block, New Plymouth

Location: Unit 8, 16 Cory John Place, Bell Block, New Plymouth 4312

### 5.44 Pressure and Vacuum

- (a) Pressure gauges
- (b) Vacuum gauges
- (c) Pressure transducers
- (d) Pressure recorders

Accuracy classes: 0.1, 0.25, 0.6, 1.0, 1.6, 2.5, 4.0 in accordance with AS 1349:1986 and BS EN 837-1:1998; gauges of accuracy 4A, 3A, 2A, 1A and below as defined in ASME B40.100-2013

By comparison with reference devices

Gauge mode

-100 kPa to -15 kPa  
-15 kPa to -7.5 kPa  
-7.5 kPa to +4 kPa  
4 kPa to 350 kPa

0.019 kPa or<sup>1</sup> 0.008 % reading  
1.5 Pa or<sup>1</sup> 0.03 % reading  
0.042 Pa or<sup>1</sup> 0.01 % reading  
0.23 Pa + 0.0014 % reading

Gauge mode or absolute mode

350 kPa to 1778 kPa  
1778 kPa to 20,000 kPa  
20,000 kPa to 200,000 kPa

2 Pa + 0.005 % reading  
0.018 kPa + 0.0041 % reading  
0.19 kPa + 0.0049 % reading

Absolute mode

7 kPa to 350 kPa

0.23 Pa + 0.0014 % reading

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 19 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

Calibrations in the following ranges are available onsite (gauge mode)

|                                        |                                        |
|----------------------------------------|----------------------------------------|
| -95 kPa to 100 kPa                     | 0.25 Pa or <sup>1</sup> 0.06 % reading |
| 100 kPa to 70,000 kPa                  | 0.06 % reading                         |
| or <sup>1</sup> = whichever is greater |                                        |

Maximum vacuum achievable is subject to ambient barometric pressure

#### 5.45 Pressure Equipment Tests

(e) Pressure relief valve tests

The testing of Pressure Relief Valves and Pressure Switches up to 120000 kPa, in accordance with in-house methods, on-site or in the laboratory

#### 5.61 Temperature Measuring Equipment

- (a) Rare metal thermocouples
- (b) Base metal thermocouples
- (c) Platinum (and other metallic) resistance thermometers
- (e) Thermistors and other semi-conductor thermometers
- (f) Liquid-in-glass thermometers
- (g) Clinical thermometers
- (k) Vapour pressure thermometers
- (l) Filled metal systems
- (m) Bimetallic systems
- (n) Digital quartz frequency units
- (o) Indicators, recorders and controllers
- (p) Other direct reading temperature measuring systems

Range applies to all of the above including digital thermometers and single position calibration of dry well calibrators

|                   |          |
|-------------------|----------|
| Ice-point         | 0.01 °C  |
| -100 °C to -60 °C | 0.080 °C |
| -60 °C to -20 °C  | 0.028 °C |
| -20 °C to 200 °C  | 0.015 °C |
| 200 °C to 660 °C  | 0.17 °C  |

On-site temperature calibration is offered over the ranges below

|                  |          |
|------------------|----------|
| Ice-point        | 0.01 °C  |
| -30 °C to -20 °C | 0.10 °C  |
| -20 °C to 80 °C  | 0.03 °C  |
| 80 °C to 150 °C  | 0.046 °C |
| 150 °C to 350 °C | 0.51 °C  |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 20 of 53



Trescal Holding New Zealand Ltd  
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**SCOPE OF ACCREDITATION**

Accreditation Number 271

## CPS Labs/Calibration Connect: Riccarton, Christchurch

**Location: 11A Leslie Hills Drive, Riccarton, Christchurch, 8011**

### 5.50 Torque Measuring Equipment

- (a) Hand torque tools (including wrenches and screwdriver types)
- (b) Torque multipliers and powered torque tools

Calibration in accordance with the performance requirements of ISO 6789:2003, ISO 5393:1994, or manufacturer's specification, on-site or in the laboratory

|                      |                  |
|----------------------|------------------|
| 0.1 N.m to 1 N.m     | 0.51 % to 3.0 %  |
| 1 N.m to 10 N.m      | 0.21 % to 0.72 % |
| 10 N.m to 100 N.m    | 0.21 % to 0.33 % |
| 100 N.m to 1000 N.m  | 0.25 % to 0.30 % |
| 1000 N.m to 1500 N.m | 0.28 %           |

### 5.88 Calibrators for Instrumentation

By comparison with reference instrument to an in-house method based on manufacturer recommendations and/or customer requirements

|                |                            |
|----------------|----------------------------|
| (a) DC voltage |                            |
| 200 mV range   |                            |
| 0 mV           | 0.2 $\mu$ V                |
| 29.9 mV        | 12 $\mu$ V/V + 0.2 $\mu$ V |
| 100 mV         | 9.4 $\mu$ V/V              |
| 190 mV         | 9.6 $\mu$ V/V              |
| 2 V range      |                            |
| 0.2 V          | 4.6 $\mu$ V/V              |
| 0.329 V        | 3.5 $\mu$ V/V              |
| 1 V            | 3.1 $\mu$ V/V              |
| 1.9 V          | 2.9 $\mu$ V/V              |
| 20 V range     |                            |
| 2 V            | 3.7 $\mu$ V/V              |
| 3.29 V         | 3.7 $\mu$ V/V              |
| 5 V            | 3.9 $\mu$ V/V              |
| 10 V           | 3.9 $\mu$ V/V              |
| 15 V           | 3.9 $\mu$ V/V              |
| 19 V           | 3.9 $\mu$ V/V              |

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 21 of 53

## CERTIFICATE OF ACCREDITATION



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|             |                     |
|-------------|---------------------|
| 200 V range |                     |
| 20 V        | 2.9 $\mu\text{V/V}$ |
| 32.9 V      | 2.8 $\mu\text{V/V}$ |
| 50 V        | 2.7 $\mu\text{V/V}$ |
| 100 V       | 2.6 $\mu\text{V/V}$ |
| 190 V       | 2.6 $\mu\text{V/V}$ |

|              |                     |
|--------------|---------------------|
| 1000 V range |                     |
| 200 V        | 2.8 $\mu\text{V/V}$ |
| 329 V        | 2.8 $\mu\text{V/V}$ |
| 334 V        | 2.8 $\mu\text{V/V}$ |
| 900 V        | 2.5 $\mu\text{V/V}$ |
| 1020 V       | 2.5 $\mu\text{V/V}$ |

Hewlett Packard 3458A Multimeter Reference Instrument

|                |                                        |
|----------------|----------------------------------------|
| 0 mV to 120 mV | 4 $\mu\text{V/V}$ + 300 nV             |
| 0 V to 1.2 V   | 6 $\mu\text{V/V}$ + 300 nV             |
| 0 V to 12 V    | 6 $\mu\text{V/V}$ + 1 $\mu\text{V}$    |
| 0 V to 120 V   | 8 $\mu\text{V/V}$ + 60 $\mu\text{V}$   |
| 0 V to 1050 V  | 10 $\mu\text{V/V}$ + 100 $\mu\text{V}$ |

Fluke 8846A Multimeter Reference Instrument

|                |                                        |
|----------------|----------------------------------------|
| 0 mV to 100 mV | 26 $\mu\text{V/V}$ + 3.5 $\mu\text{V}$ |
| 0 V to 1 V     | 12 $\mu\text{V/V}$ + 7 $\mu\text{V}$   |
| 0 V to 10 V    | 18 $\mu\text{V/V}$ + 50 $\mu\text{V}$  |
| 0 V to 100 V   | 26 $\mu\text{V/V}$ + 600 $\mu\text{V}$ |
| 0 V to 1000 V  | 7 $\mu\text{V/V}$ + 10 mV              |

(b) AC voltage

All values in  $\mu\text{V/V}$

|     |    | 10 Hz | 20 Hz | 45 Hz | 200 Hz | 1 kHz | 3 kHz | 8 kHz | 10 kHz | 18 kHz | 20 kHz | 25 kHz | 50 kHz | 100 kHz | 450 kHz | 500 kHz | 1 MHz |  |
|-----|----|-------|-------|-------|--------|-------|-------|-------|--------|--------|--------|--------|--------|---------|---------|---------|-------|--|
| 2   | mV |       | 2300  |       | 1100   | 4400  |       |       |        |        |        | 4500   | 10000  |         |         |         |       |  |
| 3   | mV |       | 2300  | 270   | 460    |       |       |       |        | 4400   |        | 4500   | 10000  |         |         |         |       |  |
| 10  | mV |       |       |       | 310    | 460   |       |       |        |        | 1100   |        | 2700   |         |         |         |       |  |
| 20  | mV |       | 330   |       | 200    | 460   |       |       |        |        | 950    |        | 720    | 1700    |         |         |       |  |
| 30  | mV | 160   |       | 190   |        | 180   | 200   |       |        | 200    |        | 160    |        | 160     | 1500    |         |       |  |
| 300 | mV | 180   |       | 41    |        | 39    | 43    |       |        | 42     |        | 62     |        | 140     | 1700    |         |       |  |
| 3   | V  | 180   |       | 36    |        | 33    | 55    |       |        | 56     |        | 170    |        | 260     | 1900    |         | 7000  |  |
| 30  | V  | 190   |       | 44    |        | 36    | 47    |       |        | 170    |        | 220    |        | 300     |         |         |       |  |
| 200 | V  |       |       | 53    |        | 40    | 52    |       |        | 170    | 160    |        |        | 330     |         |         |       |  |

Operations Manager  
Authorisation:

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Issue 73

Date: 04/09/26

Page 22 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory

Accreditation Number 271

### SCOPE OF ACCREDITATION

|      |   |  |  |     |    |    |    |  |  |  |  |  |  |  |  |
|------|---|--|--|-----|----|----|----|--|--|--|--|--|--|--|--|
| 300  | V |  |  |     |    |    |    |  |  |  |  |  |  |  |  |
| 1000 | V |  |  | 130 | 40 | 48 | 83 |  |  |  |  |  |  |  |  |
| 1020 | V |  |  |     | 40 | 83 |    |  |  |  |  |  |  |  |  |

Hewlett Packard 3458A Multimeter Reference Instrument (RMS sinusoidal voltage given)

|                 |                   |                            |
|-----------------|-------------------|----------------------------|
| 1.2 mV to 12 mV | 1 Hz to 40 Hz     | 0.03 % + 3 $\mu$ V         |
|                 | 40 Hz to 1 kHz    | 0.02 % + 3 $\mu$ V         |
|                 | 1 kHz to 20 kHz   | 0.03 % + 1.1 $\mu$ V       |
|                 | 20 kHz to 300 kHz | 0.01 % + 1.1 $\mu$ V*      |
| 6 mV to 120 mV  | 1 Hz to 40 Hz     | 70 $\mu$ V/V + 4 $\mu$ V   |
|                 | 40 Hz to 1 kHz    | 20 $\mu$ V/V + 4 $\mu$ V   |
|                 | 1 kHz to 20 kHz   | 70 $\mu$ V/V + 2 $\mu$ V   |
|                 | 20 kHz to 2 MHz   | 0.016 % + 2 $\mu$ V*       |
| 0.06 V to 1.2 V | 1 Hz to 40 Hz     | 70 $\mu$ V/V + 40 $\mu$ V  |
|                 | 40 Hz to 1 kHz    | 40 $\mu$ V/V               |
|                 | 1 kHz to 20 kHz   | 20 $\mu$ V/V               |
|                 | 20 kHz to 2 MHz   | 20 $\mu$ V*                |
| 0.6 V to 12 V   | 1 Hz to 40 Hz     | 70 $\mu$ V/V + 400 $\mu$ V |
|                 | 40 Hz to 1 kHz    | 70 $\mu$ V/V + 400 $\mu$ V |
|                 | 1 kHz to 20 kHz   | 200 $\mu$ V                |
|                 | 20 kHz to 2 MHz   | 200 $\mu$ V*               |
| 6 V to 120 V    | 1 Hz to 40 Hz     | 0.02 % + 4 mV              |
|                 | 40 Hz to 1 kHz    | 4 mV                       |
|                 | 1 kHz to 20 kHz   | 2 mV                       |
|                 | 20 kHz to 1 MHz   | 2 mV*                      |
| 35 V to 700 V   | 1 Hz to 40 Hz     | 0.04 % + 28 mV             |
|                 | 40 Hz to 1 kHz    | 0.04 % + 28 mV             |
|                 | 1 kHz to 20 kHz   | 0.06 % + 14 mV             |
|                 | 20 kHz to 100 kHz | 14 mV*                     |

This is an abbreviated table.

\* best available over several discrete ranges combined (values given are typically from the lower end of the frequency range)

Fluke 8846A Multimeter Reference Instrument (RMS sinusoidal voltage given)

|                 |                 |                     |
|-----------------|-----------------|---------------------|
| >5 mV to 100 mV | 3 Hz to 5 Hz    | 1 % + 40 $\mu$ V    |
|                 | 5 Hz to 10 Hz   | 0.35 % + 40 $\mu$ V |
|                 | 10 Hz to 20 Hz  | 40 $\mu$ V          |
|                 | 20 Hz to 40 Hz  | 40 $\mu$ V          |
|                 | 40 Hz to 100 Hz | 40 $\mu$ V          |

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 23 of 53

## CERTIFICATE OF ACCREDITATION



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                 |                    |                      |
|-----------------|--------------------|----------------------|
|                 | 100 Hz to 200 Hz   | 40 $\mu$ V           |
|                 | 200 Hz to 1 kHz    | 40 $\mu$ V           |
|                 | 1 kHz to 20 kHz    | 40 $\mu$ V           |
|                 | 20 kHz to 50 kHz   | 0.1 % + 50 $\mu$ V   |
|                 | 50 kHz to 100 kHz  | 80 $\mu$ V           |
|                 | 100 kHz to 300 kHz | 2 % + 500 $\mu$ V    |
| >0.05 V to 1 V  | 3 Hz to 5 Hz       | 1 % + 300 $\mu$ V    |
|                 | 5 Hz to 10 Hz      | 0.35 % + 300 $\mu$ V |
|                 | 10 Hz to 20 Hz     | 0.04 % + 300 $\mu$ V |
|                 | 20 Hz to 40 Hz     | 0.02 % + 300 $\mu$ V |
|                 | 40 Hz to 100 Hz    | 0.01 % + 300 $\mu$ V |
|                 | 100 Hz to 200 Hz   | 0.01 % + 300 $\mu$ V |
|                 | 200 Hz to 1 kHz    | 0.01 % + 300 $\mu$ V |
|                 | 1 kHz to 20 kHz    | 300 $\mu$ V          |
|                 | 20 kHz to 50 kHz   | 500 $\mu$ V          |
|                 | 50 kHz to 100 kHz  | 800 $\mu$ V          |
|                 | 100 kHz to 300 kHz | 1 % + 5 mV           |
| >0.5 V to 10 V  | 3 Hz to 5 Hz       | 1 % + 3 mV           |
|                 | 5 Hz to 10 Hz      | 0.35 % + 3 mV        |
|                 | 10 Hz to 20 Hz     | 0.09 % + 3 mV        |
|                 | 20 Hz to 40 Hz     | 0.04 % + 3 mV        |
|                 | 40 Hz to 100 Hz    | 0.04 % + 3 mV        |
|                 | 100 Hz to 200 Hz   | 0.04 % + 3 mV        |
|                 | 200 Hz to 1 kHz    | 0.04 % + 3 mV        |
|                 | 1 kHz to 20 kHz    | 0.04 % + 3 mV        |
|                 | 20 kHz to 50 kHz   | 0.06 % + 5 mV        |
|                 | 50 kHz to 100 kHz  | 0.2 % + 8 mV         |
|                 | 100 kHz to 300 kHz | 1 % + 50 mV          |
| >5 V to 100 V   | 3 Hz to 5 Hz       | 1 % + 30 mV          |
|                 | 5 Hz to 10 Hz      | 0.35 % + 30 mV       |
|                 | 10 Hz to 20 Hz     | 0.31 % + 30 mV       |
|                 | 20 Hz to 40 Hz     | 0.08 % + 30 mV       |
|                 | 40 Hz to 100 Hz    | 0.06 % + 30 mV       |
|                 | 100 Hz to 200 Hz   | 0.06 % + 30 mV       |
|                 | 200 Hz to 1 kHz    | 0.05 % + 30 mV       |
|                 | 1 kHz to 20 kHz    | 0.03 % + 30 mV       |
|                 | 20 kHz to 50 kHz   | 0.05 % + 50 mV       |
|                 | 50 kHz to 100 kHz  | 0.1 % + 80 mV        |
|                 | 100 kHz to 300 kHz | 500 mV               |
| >50 V to 1000 V | 3 Hz to 5 Hz       | 1 % + 220 mV         |
|                 | 5 Hz to 10 Hz      | 0.35 % + 220 mV      |
|                 | 10 Hz to 20 Hz     | 0.31 % + 220 mV      |
|                 | 20 Hz to 40 Hz     | 0.08 % + 220 mV      |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 24 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                    |                 |
|--------------------|-----------------|
| 40 Hz to 100 Hz    | 0.07 % + 220 mV |
| 100 Hz to 200 Hz   | 0.06 % + 220 mV |
| 200 Hz to 1 kHz    | 0.06 % + 220 mV |
| 1 kHz to 20 kHz    | 0.06 % + 220 mV |
| 20 kHz to 50 kHz   | 370 mV          |
| 50 kHz to 100 kHz  | 600 mV          |
| 100 kHz to 300 kHz | 3.70 V          |

(c) DC current

330  $\mu$ A range  
0  $\mu$ A  
190  $\mu$ A  
329  $\mu$ A

0.15 nA  
11  $\mu$ A/A + 0.15 nA  
21  $\mu$ A/A

3.3 mA range  
1.9 mA  
3.29 mA

9.9  $\mu$ A/A  
22  $\mu$ A/A

33 mA range  
19 mA  
32.9 mA

23  $\mu$ A/A  
28  $\mu$ A/A

330 mA range  
190 mA  
329 mA

16  $\mu$ A/A  
50  $\mu$ A/A

3 A range  
1.09 A  
2.99 A

23  $\mu$ A/A  
170  $\mu$ A/A

20 A range  
10.9 A  
19.9 A

98  $\mu$ A/A  
78  $\mu$ A/A

Hewlett Packard 3458A Multimeter Reference Instrument

0 nA to 120 nA  
0  $\mu$ A to 1.2  $\mu$ A  
0  $\mu$ A to 12  $\mu$ A  
0  $\mu$ A to 120  $\mu$ A  
0 mA to 1.2 mA  
0 mA to 12 mA  
0 mA to 120 mA  
0 A to 1.05 A

50  $\mu$ A/A + 5.2 nA  
41  $\mu$ A/A + 5.2 nA  
41  $\mu$ A/A + 5.2 nA  
41  $\mu$ A/A + 5.4 nA  
37  $\mu$ A/A + 7 nA  
32  $\mu$ A/A + 50 nA  
62  $\mu$ A/A + 500 nA  
90  $\mu$ A/A + 10  $\mu$ A

Fluke 8846A Multimeter Reference Instrument

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page **25** of **53**



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                          |                        |
|--------------------------|------------------------|
| 0 $\mu$ A to 100 $\mu$ A | 0.02 % + 0.025 $\mu$ A |
| 0 mA to 1 mA             | 0.02 % + 0.05 $\mu$ A  |
| 0 mA to 10 mA            | 0.02 % + 2 $\mu$ A     |
| 0 mA to 100 mA           | 0.01 % + 5 $\mu$ A     |
| 0 mA to 400 mA           | 0.02 % + 20 $\mu$ A    |
| 0 A to 1 A               | 0.06 % + 200 $\mu$ A   |
| 0 A to 3 A               | 0.1 % + 600 $\mu$ A    |
| 0 A to 10 A              | 0.03 % + 800 $\mu$ A   |

(d) AC current

All values in  $\mu$ A/A

|      |    | 10 Hz | 20 Hz | 45 Hz | 65 Hz | 200 Hz | 500 Hz | 1 kHz | 5 kHz | 10 kHz | 30 kHz |
|------|----|-------|-------|-------|-------|--------|--------|-------|-------|--------|--------|
| 10   | μA |       |       |       |       | 3400   |        |       | 3100  |        |        |
| 33   | μA |       |       |       |       | 3400   |        | 310   | 1000  |        | 1300   |
| 100  | μA |       |       |       |       | 72     | 290    |       |       | 860    | 820    |
| 190  | μA |       |       | 110   |       |        | 100    | 860   |       |        |        |
| 199  | μA |       | 590   | 170   | 140   |        |        |       | 410   | 890    | 1200   |
| 330  | μA | 249   |       |       |       |        |        |       |       |        |        |
| 1.9  | mA | 320   |       | 300   |       |        |        | 82    | 440   |        | 800    |
| 3.3  | mA |       |       |       |       |        |        | 120   | 360   | 1000   | 1200   |
| 19   | mA | 370   |       |       |       |        |        | 45    | 380   |        | 800    |
| 33   | mA |       |       |       |       |        |        | 100   | 140   | 360    | 1200   |
| 190  | mA | 1200  |       | 160   |       |        |        | 57    | 77    |        | 710    |
| 330  | mA |       |       |       |       |        |        | 130   | 480   | 680    | 3500   |
| 1.09 | A  | 120   |       | 110   |       |        |        | 70    | 520   | 380    |        |
| 3    | A  | 1400  |       | 100   | 120   |        |        |       | 170   | 430    |        |
| 3.3  | A  |       |       | 120   | 120   | 140    | 480    | 120   | 170   |        |        |
| 10.9 | A  |       |       |       |       | 140    |        | 140   | 230   |        |        |
| 20   | A  |       |       | 110   | 90    | 100    |        | 120   | 500   |        |        |

Hewlett Packard 3458A Multimeter Reference Instrument (RMS sinusoidal current given)

|                            |                 |                 |
|----------------------------|-----------------|-----------------|
| 2.4 $\mu$ A to 120 $\mu$ A | 10 Hz to 20 Hz  | 0.4 % + 30 nA   |
|                            | 20 Hz to 45 Hz  | 0.10 % + 30 nA  |
|                            | 45 Hz to 100 Hz | 30 nA           |
|                            | 100 Hz to 1 kHz | 30 nA           |
| 0.06 mA to 1.2 mA          | 10 Hz to 20 Hz  | 0.4 % + 200 nA  |
|                            | 20 Hz to 45 Hz  | 0.10 % + 200 nA |
|                            | 45 Hz to 100 Hz | 200 nA          |
|                            | 100 Hz to 1 kHz | 200 nA          |

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 26 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                   |                   |                 |
|-------------------|-------------------|-----------------|
| 0.6 mA to 12 mA   | 1 kHz to 5 kHz    | 200 nA          |
|                   | 5 kHz to 20 kHz   | 200 nA          |
|                   | 20 kHz to 50 kHz  | 0.4 % + 400 nA  |
|                   | 50 kHz to 100 kHz | 0.55 % + 1.5 µA |
| 6 mA to 120 mA    | 10 Hz to 20 Hz    | 0.4 % + 2 µA    |
|                   | 20 Hz to 45 Hz    | 0.10 % + 2 µA   |
|                   | 45 Hz to 100 Hz   | 2 µA            |
|                   | 100 Hz to 1 kHz   | 2 µA            |
|                   | 1 kHz to 5 kHz    | 2 µA            |
|                   | 5 kHz to 20 kHz   | 2 µA            |
|                   | 20 kHz to 50 kHz  | 0.4 % + 4 µA    |
|                   | 50 kHz to 100 kHz | 0.55 % + 15 µA  |
| 52.5 mA to 1.05 A | 10 Hz to 20 Hz    | 0.4 % + 20 µA   |
|                   | 20 Hz to 45 Hz    | 0.10 % + 20 µA  |
|                   | 45 Hz to 100 Hz   | 20 µA           |
|                   | 100 Hz to 1 kHz   | 20 µA           |
|                   | 1 kHz to 5 kHz    | 20 µA           |
|                   | 5 kHz to 20 kHz   | 20 µA           |
|                   | 20 kHz to 50 kHz  | 0.4 % + 40 µA   |
|                   | 50 kHz to 100 kHz | 0.55 % + 150 µA |
|                   | 10 Hz to 20 Hz    | 0.4 % + 200 µA  |
|                   | 20 Hz to 45 Hz    | 0.16 % + 200 µA |
|                   | 45 Hz to 100 Hz   | 0.08 % + 200 µA |
|                   | 100 Hz to 1 kHz   | 0.1 % + 200 µA  |
|                   | 1 kHz to 5 kHz    | 0.1 % + 200 µA  |
|                   | 5 kHz to 20 kHz   | 0.1 % + 200 µA  |
|                   | 20 kHz to 50 kHz  | 1 % + 400 µA    |

Fluke 8846A Multimeter Reference Instrument (RMS sinusoidal current given)

|                  |                  |                  |
|------------------|------------------|------------------|
| >5 µA to 100 µA  | 3 Hz to 5 Hz     | 1.1 % + 0.06 µA  |
|                  | 5 Hz to 10 Hz    | 0.35 % + 0.06 µA |
|                  | 10 Hz to 20 Hz   | 0.32 % + 0.06 µA |
|                  | 20 Hz to 40 Hz   | 0.14 % + 0.06 µA |
|                  | 40 Hz to 100 Hz  | 0.13 % + 0.06 µA |
|                  | 100 Hz to 200 Hz | 0.12 % + 0.06 µA |
|                  | 200 Hz to 1 kHz  | 0.11 % + 0.06 µA |
|                  | 1 kHz to 5 kHz   | 0.06 % + 0.06 µA |
|                  | 5 kHz to 10 kHz  | 0.7 µA           |
| >0.05 mA to 1 mA | 3 Hz to 5 Hz     | 1 % + 0.4 µA     |
|                  | 5 Hz to 10 Hz    | 0.3 % + 0.4 µA   |
|                  | 10 Hz to 20 Hz   | 0.3 % + 0.4 µA   |
|                  | 20 Hz to 40 Hz   | 0.11 % + 0.4 µA  |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 27 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                  |                  |                      |
|------------------|------------------|----------------------|
|                  | 40 Hz to 100 Hz  | 0.1 % + 0.4 $\mu$ A  |
|                  | 100 Hz to 200 Hz | 0.09 % + 0.4 $\mu$ A |
|                  | 200 Hz to 1 kHz  | 0.09 % + 0.4 $\mu$ A |
|                  | 1 kHz to 5 kHz   | 0.1 % + 0.4 $\mu$ A  |
|                  | 5 kHz to 10 kHz  | 2.5 $\mu$ A          |
| >0.5 mA to 10 mA | 3 Hz to 5 Hz     | 1.1 % + 6 $\mu$ A    |
|                  | 5 Hz to 10 Hz    | 0.35 % + 6 $\mu$ A   |
|                  | 10 Hz to 20 Hz   | 0.15 % + 6 $\mu$ A   |
|                  | 20 Hz to 40 Hz   | 0.07 % + 6 $\mu$ A   |
|                  | 40 Hz to 100 Hz  | 0.06 % + 6 $\mu$ A   |
|                  | 100 Hz to 200 Hz | 0.06 % + 6 $\mu$ A   |
|                  | 200 Hz to 1 kHz  | 0.05 % + 6 $\mu$ A   |
|                  | 1 kHz to 5 kHz   | 6 $\mu$ A            |
|                  | 5 kHz to 10 kHz  | 70 $\mu$ A           |
| >5 mA to 100 mA  | 3 Hz to 5 Hz     | 1 % + 40 $\mu$ A     |
|                  | 5 Hz to 10 Hz    | 0.3 % + 40 $\mu$ A   |
|                  | 10 Hz to 20 Hz   | 0.2 % + 40 $\mu$ A   |
|                  | 20 Hz to 40 Hz   | 0.07 % + 40 $\mu$ A  |
|                  | 40 Hz to 100 Hz  | 0.07 % + 40 $\mu$ A  |
|                  | 100 Hz to 200 Hz | 0.07 % + 40 $\mu$ A  |
|                  | 200 Hz to 1 kHz  | 0.07 % + 40 $\mu$ A  |
|                  | 1 kHz to 5 kHz   | 0.1 % + 40 $\mu$ A   |
|                  | 5 kHz to 10 kHz  | 250 $\mu$ A          |
| >20 mA to 329 mA | 3 Hz to 5 Hz     | 1 % + 320 $\mu$ A    |
|                  | 5 Hz to 10 Hz    | 0.3 % + 320 $\mu$ A  |
|                  | 10 Hz to 20 Hz   | 0.2 % + 320 $\mu$ A  |
|                  | 20 Hz to 40 Hz   | 0.07 % + 320 $\mu$ A |
|                  | 40 Hz to 100 Hz  | 0.07 % + 320 $\mu$ A |
|                  | 100 Hz to 200 Hz | 0.06 % + 320 $\mu$ A |
|                  | 200 Hz to 1 kHz  | 0.05 % + 320 $\mu$ A |
|                  | 1 kHz to 5 kHz   | 320 $\mu$ A          |
|                  | 5 kHz to 10 kHz  | 2.30 mA              |
| >0.05 A to 1 A   | 3 Hz to 5 Hz     | 1 % + 400 $\mu$ A    |
|                  | 5 Hz to 10 Hz    | 0.3 % + 400 $\mu$ A  |
|                  | 10 Hz to 20 Hz   | 0.35 % + 400 $\mu$ A |
|                  | 20 Hz to 40 Hz   | 0.12 % + 400 $\mu$ A |
|                  | 40 Hz to 100 Hz  | 400 $\mu$ A          |
|                  | 100 Hz to 200 Hz | 400 $\mu$ A          |
|                  | 200 Hz to 1 kHz  | 400 $\mu$ A          |
|                  | 1 kHz to 5 kHz   | 400 $\mu$ A          |
|                  | 5 kHz to 10 kHz  | 7 mA                 |
| >0.15 A to 3 A   | 3 Hz to 5 Hz     | 1.1 % + 1.8 mA       |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 28 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                |                  |                 |
|----------------|------------------|-----------------|
|                | 5 Hz to 10 Hz    | 0.35 % + 1.8 mA |
|                | 10 Hz to 20 Hz   | 0.4 % + 1.8 mA  |
|                | 20 Hz to 40 Hz   | 0.17 % + 1.8 mA |
|                | 40 Hz to 100 Hz  | 1.8 mA          |
|                | 100 Hz to 200 Hz | 1.8 mA          |
|                | 200 Hz to 1 kHz  | 1.8 mA          |
|                | 1 kHz to 5 kHz   | 1.8 mA          |
|                | 5 kHz to 10 kHz  | 3.7 % + 21 mA   |
| >0.5 A to 10 A | 3 Hz to 5 Hz     | 1.1 % + 6 mA    |
|                | 5 Hz to 10 Hz    | 0.35 % + 6 mA   |
|                | 10 Hz to 20 Hz   | 0.4 % + 6 mA    |
|                | 20 Hz to 40 Hz   | 0.17 % + 6 mA   |
|                | 40 Hz to 100 Hz  | 6 mA            |
|                | 100 Hz to 200 Hz | 0.01 % + 6 mA   |
|                | 200 Hz to 1 kHz  | 0.02 % + 6 mA   |
|                | 1 kHz to 5 kHz   | 0.08 % + 6 mA   |
|                | 5 kHz to 10 kHz  | 0.35 % + 70 mA  |

(e) Resistance

Calibrator range

|                 |                                        |
|-----------------|----------------------------------------|
| 0 $\Omega$      | 18 $\mu\Omega$                         |
| 1.9 $\Omega$    | 21 $\mu\Omega/\Omega$ + 18 $\mu\Omega$ |
| 10.9 $\Omega$   | 15 $\mu\Omega/\Omega$                  |
| 11.9 $\Omega$   | 10 $\mu\Omega/\Omega$                  |
| 19 $\Omega$     | 10 $\mu\Omega/\Omega$                  |
| 30 $\Omega$     | 6.4 $\mu\Omega/\Omega$                 |
| 33 $\Omega$     | 6.2 $\mu\Omega/\Omega$                 |
| 109 $\Omega$    | 7.8 $\mu\Omega/\Omega$                 |
| 119 $\Omega$    | 8.6 $\mu\Omega/\Omega$                 |
| 190 $\Omega$    | 8.4 $\mu\Omega/\Omega$                 |
| 300 $\Omega$    | 6.1 $\mu\Omega/\Omega$                 |
| 330 $\Omega$    | 6.3 $\mu\Omega/\Omega$                 |
| 1.09 k $\Omega$ | 6.9 $\mu\Omega/\Omega$                 |
| 1.19 k $\Omega$ | 7.4 $\mu\Omega/\Omega$                 |
| 1.9 k $\Omega$  | 6.7 $\mu\Omega/\Omega$                 |
| 3 k $\Omega$    | 6.2 $\mu\Omega/\Omega$                 |
| 3.3 k $\Omega$  | 5.7 $\mu\Omega/\Omega$                 |
| 10.9 k $\Omega$ | 7.8 $\mu\Omega/\Omega$                 |
| 11.9 k $\Omega$ | 5.6 $\mu\Omega/\Omega$                 |
| 19 k $\Omega$   | 5.6 $\mu\Omega/\Omega$                 |
| 30 k $\Omega$   | 6.8 $\mu\Omega/\Omega$                 |
| 33 k $\Omega$   | 5.7 $\mu\Omega/\Omega$                 |
| 109 k $\Omega$  | 8.7 $\mu\Omega/\Omega$                 |
| 119 k $\Omega$  | 8.7 $\mu\Omega/\Omega$                 |
| 190 k $\Omega$  | 8.7 $\mu\Omega/\Omega$                 |

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 29 of 53

## CERTIFICATE OF ACCREDITATION



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Metrology & Calibration Laboratory

Accreditation Number 271

## SCOPE OF ACCREDITATION

|         |          |
|---------|----------|
| 300 kΩ  | 14 μΩ/Ω  |
| 330 kΩ  | 14 μΩ/Ω  |
| 1.09 MΩ | 16 μΩ/Ω  |
| 1.19 mΩ | 17 μΩ/Ω  |
| 1.9 MΩ  | 16 μΩ/Ω  |
| 3 MΩ    | 14 μΩ/Ω  |
| 3.3 MΩ  | 14 μΩ/Ω  |
| 10.9 MΩ | 24 μΩ/Ω  |
| 11.9 MΩ | 84 μΩ/Ω  |
| 19 MΩ   | 24 μΩ/Ω  |
| 30 MΩ   | 150 μΩ/Ω |
| 33 MΩ   | 160 μΩ/Ω |
| 109 MΩ  | 140 μΩ/Ω |
| 119 MΩ  | 260 μΩ/Ω |
| 400 MΩ  | 840 μΩ/Ω |
| 640 MΩ  | 930 μΩ/Ω |
| 1090 MΩ | 940 μΩ/Ω |

## Hewlett Packard 3458A Multimeter Reference Instrument

|               |                   |
|---------------|-------------------|
| 0 Ω to 12 Ω   | 24 μΩ/Ω + 50 μΩ   |
| 0 Ω to 120 Ω  | 12 μΩ/Ω + 500 μΩ  |
| 0 Ω to 1.2 kΩ | 10 μΩ/Ω + 500 μΩ  |
| 0 Ω to 12 kΩ  | 10 μΩ/Ω + 5 mΩ    |
| 0 Ω to 120 kΩ | 11 μΩ/Ω + 50 mΩ   |
| 0 Ω to 1.2 MΩ | 15 μΩ/Ω + 2 Ω     |
| 0 Ω to 12 MΩ  | 50 μΩ/Ω + 100 Ω   |
| 0 Ω to 120 MΩ | 500 μΩ/Ω + 1 kΩ   |
| 0 Ω to 1.2 GΩ | 5000 μΩ/Ω + 10 kΩ |

## Fluke 8846A Multimeter Reference Instrument

|               |                 |
|---------------|-----------------|
| 0 Ω to 10 Ω   | 0.05 % + 3 mΩ   |
| 0 Ω to 100 Ω  | 0.02 % + 4 mΩ   |
| 0 Ω to 1 kΩ   | 0.02 % + 10 mΩ  |
| 0 Ω to 10 kΩ  | 0.02 % + 100 mΩ |
| 0 Ω to 100 kΩ | 0.01 % + 1 Ω    |
| 0 Ω to 1 MΩ   | 0.01 % + 10 Ω   |
| 0 Ω to 10 MΩ  | 0.04 % + 100 Ω  |
| 0 Ω to 100 MΩ | 0.4 % + 10 kΩ   |
| 0 Ω to 1 GΩ   | 2 % + 100 kΩ    |

(i) Other

Phase angle

0° to 360°

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 30 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

V & V

Amplitude

35 mV to 50 V

Frequency

60 Hz to 10 kHz

0.075°

V & I

Amplitude (V)

35 mV to 33 V

Amplitude (I)

300 mA to 20 A

Frequency

10 Hz to 1 kHz

0.075°

Electrical simulation of temperature signal for calibration of resistance temperature device calibrators

-200 °C to 0 °C

0.0041 °C

0 °C to 100 °C

0.0048 °C

100 °C to 300 °C

0.0054 °C

300 °C to 600 °C

0.0082 °C

600 °C to 850 °C

0.012 °C

Electrical simulation of temperature signal for calibration of thermocouple calibrators

-200 °C to 0 °C

0.021 °C

0 °C to 100 °C

0.012 °C

100 °C to 300 °C

0.020 °C

300 °C to 600 °C

0.021 °C

600 °C to 1200 °C

0.022 °C

## 5.89 Indicating Instruments and Recording Instruments

By comparison with reference calibrator to an in-house method based on manufacturer recommendations and/or customer requirements

(a) DC voltmeters

220 mV range

0 mV

0.39 µV

219\* mV

6.3 µV/V + 0.39 µV

2.2 V range

0.22 V

4.6 µV/V

2.19\* V

5.0 µV/V

11 V range

2.2 V

4.2 µV/V

10.9\* V

3.3 µV/V

22 V range

11 V

3.4 µV/V

21.9\* V

3.3 µV/V

Operations Manager  
Authorisation:

*[Signature]*

Issue 73

Date:04/09/26

Page **31** of **53**



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

220 V range

22 V

219.9 V

6.3  $\mu\text{V/V}$

4.8  $\mu\text{V/V}$

1000 V range

220 V

1000 V

7.9  $\mu\text{V/V}$

6.5  $\mu\text{V/V}$

(b) AC voltmeters

Using a calibrator reference source – all values in  $\mu\text{V/V}$

|      |    | 10<br>Hz | 20<br>Hz | 40<br>Hz | 50<br>Hz | 1<br>kHz | 20<br>kHz | 30<br>kHz | 50<br>kHz | 100<br>kHz | 300<br>kHz | 500<br>kHz | 1<br>MHz |
|------|----|----------|----------|----------|----------|----------|-----------|-----------|-----------|------------|------------|------------|----------|
| 2    | mV | 2100     | 2100     | 1900     |          |          |           | 2000      |           | 2700       | 5500       | 10000      | 12000    |
| 2.2  | mV | 1900     | 1900     | 1800     |          |          |           | 1900      |           | 2500       | 2500       | 9900       | 11000    |
| 22   | mV | 400      |          | 260      | 240      |          |           |           | 360       | 660        | 1400       | 2200       | 4200     |
| 220  | mV | 290      | 280      | 110      | 81       |          |           |           | 140       | 380        | 920        | 2100       | 7500     |
| 2.2  | V  | 260      | 240      | 91       | 58       |          |           |           | 87        | 130        | 920        | 2400       | 8800     |
| 22   | V  | 250      | 240      | 91       | 66       |          |           |           | 190       | 320        | 800        | 1800       | 1500     |
| 220  | V  | 240      | 240      | 91       | 52       |          |           |           | 83        | 150        |            |            |          |
| 250  | V  |          | 330      |          |          | 460      |           |           |           | 470        | 1800       |            |          |
| 750  | V  |          |          | 467      |          |          |           |           |           |            |            |            |          |
| 1050 | V  |          |          | 68       |          |          | 130       | 460       |           |            |            |            |          |

By comparison to a reference device - all values in  $\mu\text{V/V}$

|      |    | 0.01<br>Hz | 10<br>Hz | 20<br>Hz | 45<br>Hz | 1<br>kHz | 5<br>kHz | 10<br>kHz | 20<br>kHz | 30 kHz | 50<br>kHz | 100<br>kHz | 500<br>kHz |
|------|----|------------|----------|----------|----------|----------|----------|-----------|-----------|--------|-----------|------------|------------|
| 1    | mV | 45000      | 380      | 380      | 180      | 180      | 180      | 180       | 280       | 330    | 960       | 1900       | 1900       |
| 33   | mV | 5000       | 320      | 320      | 71       | 120      | 51       | 64        | 120       | 120    | 300       | 580        | 580        |
| 330  | mV | 5000       | 320      | 320      | 33       | 120      | 42       | 48        | 120       | 150    | 440       | 780        | 780        |
| 3.3  | V  | 5000       | 320      | 320      | 30       | 120      | 100      | 98        | 120       | 98     | 150       |            |            |
| 33   | V  |            |          |          | 320      | 120      | 64       | 120       | 220       | 110    | 550       |            |            |
| 330  | V  |            |          |          | 320      | 120      | 64       | 180       |           |        |           |            |            |
| 1020 | V  |            |          |          | 320      | 120      | 64       | 180       |           |        |           |            |            |

(c) DC ammeters

220  $\mu\text{A}$  range

0  $\mu\text{A}$

220  $\mu\text{A}$

5.3 nA

38  $\mu\text{A/A} + 5.3 \text{ nA}$

2.2 mA range

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 32 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory

Accreditation Number 271

**SCOPE OF ACCREDITATION**

|              |               |
|--------------|---------------|
| 0.22 mA      | 59 $\mu$ A/A  |
| 2.19 mA      | 34 $\mu$ A/A  |
| 22 mA range  |               |
| 2.2 mA       | 48 $\mu$ A/A  |
| 21.9 mA      | 32 $\mu$ A/A  |
| 220 mA range |               |
| 22 mA        | 66 $\mu$ A/A  |
| 219.9 mA     | 48 $\mu$ A/A  |
| 2.2 A range  |               |
| 0.22 A       | 120 $\mu$ A/A |
| 2.2 A        | 110 $\mu$ A/A |
| 11 A range   |               |
| 2.2 A        | 440 $\mu$ A/A |
| 11 A         | 300 $\mu$ A/A |
| 20 A range   |               |
| 11 A         | 810 $\mu$ A/A |
| 19.9 A       | 790 $\mu$ A/A |

Clamp meters using current coil (nominal ranges)

|        |        |
|--------|--------|
| 4 mA   | 0.47 % |
| 12 mA  | 0.31 % |
| 20 mA  | 0.21 % |
| 100 mA | 0.19 % |
| 3 A    | 2.20 % |
| 10 A   | 0.69 % |
| 20 A   | 0.68 % |
| 100 A  | 0.67 % |
| 150 A  | 0.63 % |
| 550 A  | 0.58 % |
| 600 A  | 0.58 % |
| 900 A  | 0.55 % |

Fluke 5522A Calibrator Reference Instrument

|                          |               |
|--------------------------|---------------|
| 0 $\mu$ A to 330 $\mu$ A | 81 $\mu$ A/A  |
| 0 mA to 3.3 mA           | 26 $\mu$ A/A  |
| 0 mA to 33 mA            | 36 $\mu$ A/A  |
| 0 mA to 330 mA           | 41 $\mu$ A/A  |
| 0 mA to 1.1 A            | 98 $\mu$ A/A  |
| 1.1 A to 3 A             | 110 $\mu$ A/A |
| 0 A to 11 A              | 120 $\mu$ A/A |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 33 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

11 A to 20.5 A

1000  $\mu$ A/A

Fluke 52120A Transconductance Amplifier Reference Instrument (using Fluke 5522A Calibrator)

CMC uncertainty for DC Current is calculated as the root sum of squares of the uncertainties for the appropriate Fluke 5522A voltage or current output values and the Fluke 52120A Range. Example uncertainties are given below (truncated to two significant figures). Output values are at 10 % and 100 % of each range.

Fluke 52120A, Fluke 5522A Reference Instruments current

| Range         | Output |            |
|---------------|--------|------------|
| 0.2 A to 2 A  | 0.2 A  | 0.49 mA/A  |
|               | 2 A    | 0.13 mA/A  |
|               | 2 A    | 0.45 mA/A  |
| 2 A to 20 A   | 20 A   | 0.091 mA/A |
|               | 10 A   | 0.44 mA/A  |
| 10 A to 100 A | 100 A  | 0.082 mA/A |

Fluke 52120A Transconductance Amplifier and Fluke 52120A/COIL 3KA (using Fluke 5522A Calibrator) Reference Instruments

CMC uncertainty for equivalent DC Current using the Fluke 52120A and 52120A/COIL 3KA is calculated as the root sum of squares of the uncertainties for the appropriate Fluke 5522A voltage or current output values, the Fluke 52120A Range and the Fluke 52120A/COIL 3KA Range. Example uncertainties are given below (rounded to two significant figures).

Fluke 52120A, Fluke 5522A Reference Instruments current

|                 |        |           |
|-----------------|--------|-----------|
| 5 A to 50 A     | 5 A    | 9.8 mA/A  |
|                 | 50 A   | 7.3 mA/A  |
| 50 A to 500 A   | 50 A   | 9.8 mA/A  |
|                 | 500 A  | 7.3 mA/A  |
| 250 A to 2500 A | 250 A  | 3.2 mA/A  |
|                 | 2500 A | 0.65 mA/A |

Fluke 52120A Transconductance Amplifier and Fluke 52120A/COIL 6KA (using Fluke 5522A Calibrator) Reference Instruments

CMC uncertainty for equivalent DC Current using the Fluke 52120A and 52120A/COIL 6KA is calculated as the root sum of squares of the uncertainties for the appropriate Fluke 5522A voltage or current output values, the Fluke 52120A Range and the Fluke 52120A/COIL 6KA Range. Example uncertainties are given below (rounded to two significant figures).

Fluke 52120A, Fluke 5522A Reference Instruments current

|               |      |          |
|---------------|------|----------|
| 10 A to 100 A | 10 A | 8.4 mA/A |
|---------------|------|----------|

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 34 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                 |        |          |
|-----------------|--------|----------|
| 100 A to 1000 A | 100 A  | 7.1 mA/A |
|                 | 100 A  | 8.4 mA/A |
|                 | 1000 A | 7.1 mA/A |
| 500 A to 5000 A | 500 A  | 5.5 mA/A |
|                 | 5000 A | 4.3 mA/A |

(d) AC ammeters

All values in  $\mu\text{A/A}$

|     |    | 10 Hz | 20 Hz | 40 Hz | 45 Hz | 100 Hz | 1 kHz | 5 kHz | 10 kHz | 30 kHz |
|-----|----|-------|-------|-------|-------|--------|-------|-------|--------|--------|
| 9   | μA | 1900  | 1900  | 1100  |       |        | 930   | 1500  | 7700   |        |
| 220 | μA | 570   | 580   | 540   |       |        | 130   | 320   | 1200   | 13000  |
| 330 | μA |       |       |       |       |        |       |       |        |        |
| 2.2 | mA | 280   | 240   | 160   |       |        | 100   | 220   | 1200   |        |
| 3.3 | mA | 430   | 240   |       |       |        | 100   | 200   | 1100   |        |
| 22  | mA |       |       | 160   |       |        |       |       |        | 3100   |
| 33  | mA | 280   | 240   | 360   |       |        | 100   | 190   | 1000   | 3500   |
| 220 | mA |       | 380   |       |       |        | 460   | 1000  | 8100   |        |
| 330 | mA |       |       |       |       |        |       |       |        |        |
| 2.2 | A  |       |       | 360   | 360   |        | 360   | 820   | 3200   |        |
| 11  | A  |       |       |       |       |        | 1300  | 23000 |        |        |
| 20  | A  |       |       |       | 1100  | 1100   | 1300  | 23000 |        |        |

Clamp meters using current coil (nominal ranges)

|        |        |        |
|--------|--------|--------|
| 3 mA   | 50 Hz  | 0.22 % |
| 30 mA  | 50 Hz  | 0.63 % |
| 300 mA | 50 Hz  | 0.36 % |
| 3 A    | 50 Hz  | 0.28 % |
| 10 A   | 50 Hz  | 0.61 % |
| 100 A  | 50 Hz  | 0.80 % |
| 550 A  | 50 Hz  | 0.20 % |
| 600 A  | 50 Hz  | 0.71 % |
| 900 A  | 50 Hz  | 0.66 % |
| 20 A   | 400 Hz | 1.8 %  |
| 50 A   | 400 Hz | 1.3 %  |
| 100 A  | 400 Hz | 1.2 %  |
| 120 A  | 400 Hz | 1.1 %  |
| 250 A  | 400 Hz | 1.2 %  |
| 400 A  | 400 Hz | 1.1 %  |

Toroidal-Type Clamps

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 35 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

20 A to 150 A      40 to 60 Hz      0.44 %  
150 A to 1000 A      40 to 60 Hz      0.38 %

Fluke 5522A Calibrator Reference Instrument

All values in  $\mu\text{A/A}$

|      |               | 10 Hz | 20 Hz | 40 Hz | 45 Hz | 100 Hz | 1 kHz | 5 kHz | 10 kHz | 30 kHz |
|------|---------------|-------|-------|-------|-------|--------|-------|-------|--------|--------|
| 29   | $\mu\text{A}$ | 600   | 470   | 300   | 440   | 1300   | 1200  | 1600  | 3200   | 3200   |
| 330  | $\mu\text{A}$ | 550   | 350   | 250   | 240   | 150    | 260   | 1100  | 2200   | 2200   |
| 3.3  | $\text{mA}$   | 460   | 260   | 160   | 160   | 160    | 260   | 1100  | 2100   | 2100   |
| 33   | $\text{mA}$   | 560   | 290   | 160   | 160   | 160    | 250   | 300   | 1600   | 1600   |
| 330  | $\text{mA}$   | 690   | 620   | 190   | 190   | 190    | 910   | 4500  |        |        |
| 1.1  | A             | 630   | 700   | 330   | 330   | 330    | 730   | 12000 |        |        |
| 3    | A             |       |       | 280   | 350   | 380    | 13000 |       |        |        |
| 11   | A             |       |       | 1200  | 1300  | 540    | 8800  |       |        |        |
| 20.5 | A             |       |       | 1200  | 1300  | 540    | 8800  |       |        |        |

Fluke 52120A Transconductance Amplifier (using Fluke 5500A Calibrator) Reference Instruments

CMC uncertainty for AC Current is calculated as the root sum of squares of the uncertainties for the appropriate Fluke 5500A voltage or current output values and the Fluke 52120A range.

Example uncertainties are given below (rounded to two significant figures).

Available frequency range 10 Hz to 10 kHz. Output values are at 10 % and 100 % of each range

Uncertainty values in  $\text{mA/A}$

| Range         | Output | 50 Hz | 400 Hz | 10 kHz |
|---------------|--------|-------|--------|--------|
| 0.2 A to 2 A  | 0.2 A  | 5.4   | 5.4    | 310    |
|               | 2 A    | 0.56  | 0.56   | 31     |
| 2 A to 20 A   | 2 A    | 4.7   | 4.7    | 47     |
|               | 20 A   | 0.49  | 0.49   | 4.7    |
| 12 A to 120 A | 12 A   | 1.6   | 7.8    | 88     |
|               | 120 A  | 0.23  | 0.80   | 35     |

Fluke 52120A Transconductance Amplifier and Fluke 52120A/COIL 3KA (using 5522A Calibrator) Reference Instruments

CMC uncertainty for equivalent AC Current using the Fluke 52120A and 52120A/COIL 3KA is calculated as the root sum of squares of the uncertainties for the appropriate Fluke 5522A voltage or current output values, the Fluke 52120A Range and the Fluke 52120A/COIL 3KA Range.

Example uncertainties are given below (rounded to two significant figures).

Available frequency range is 50 Hz to 400 Hz.

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 36 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

Uncertainty values in mA/A

| Range           | Output | 50 Hz | 400 Hz |
|-----------------|--------|-------|--------|
| 5 A to 50 A     | 5A     | 11    | 11     |
|                 | 50 A   | 7.3   | 7.3    |
| 50 A to 500 A   | 50 A   | 11    | 11     |
|                 | 500 A  | 7.3   | 7.3    |
| 300 A to 3000 A | 300 A  | 3.4   | 8.4    |
|                 | 3000 A | 0.56  | 1.0    |

Fluke 52120A Transconductance Amplifier and Fluke 52120A/COIL 6KA (using 5522A Calibrator) Reference Instruments

CMC uncertainty for equivalent AC Current using the Fluke 52120A and 52120A/COIL 6KA is calculated as the root sum of squares of the uncertainties for the appropriate Fluke 5500A voltage or current output values, the Fluke 52120A Range and the Fluke 52120A/COIL 6KA Range.

Example uncertainties are given below (rounded to two significant figures).

Available frequency range is 50 Hz to 400 Hz.

Uncertainty values in mA/A

| Range           | Output | 50 Hz | 400 Hz |
|-----------------|--------|-------|--------|
| 10 A to 100 A   | 10 A   | 10    | 10     |
|                 | 100 A  | 7.2   | 7.2    |
| 100 A to 1000 A | 100 A  | 9.6   | 9.6    |
|                 | 1000 A | 7.2   | 7.2    |
| 600 A to 6000 A | 600 A  | 5.8   | 9.3    |
|                 | 6000 A | 4.3   | 3.9    |

(e) Wattmeters

CMC uncertainty for power (W and VA) is calculated as the root sum of squares of the uncertainties for the appropriate voltage and current values (and power factor, if applicable).

Voltage limitations: 1 mVac to 1020 Vac, or 0 V to 1020 Vdc. Current limitations: 29  $\mu$ Aac to 20.5 Aac, or 0 A to 20.5 Adc. Auxiliary voltage limitations: 10 mVac to 5 Vac, or 0 V to 7 Vdc.

The range of direct output is from 29 nWac through to 20.91 kWac (at unity power factor), or 0 Wdc through to 20.91 kWdc (or equivalent in VA).

Power can be simulated over greater ranges for equipment incorporating current clamps or current transformers. (Maximum output available for the voltage input is 1020 V, and maximum output available for the "current" input is 20.5 A or 5 V).

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 37 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

(f) Varmeters

CMC uncertainty for reactive power (VAR) is calculated as the root sum of squares of the uncertainties for the appropriate voltage, current, and power factor values.

Voltage and current limitations apply as for 5.89 (e)

(g) Phase angle indicators

Refer to 5.88 (i)

|               |                  |       |
|---------------|------------------|-------|
| 0° to 179.98° | 10 Hz to 65 Hz   | 0.10° |
|               | 65 Hz to 500 Hz  | 0.25° |
|               | 500 Hz to 1 kHz  | 0.50° |
|               | 1 kHz to 5 kHz   | 2.5°  |
|               | 5 kHz to 10 kHz  | 5.0°  |
|               | 10 kHz to 30 kHz | 10°   |

(h) Power factor meters

CMC uncertainty for power factor may be calculated from the least uncertainty given above for Phase angle indicators. (For example: Least uncertainty for power factor of 0.500 at 50 Hz is  $\text{ACos}(0.500) \pm 0.10^\circ$ , which is 0.500 (+ 0.001511, -0.001512) or  $0.500 \pm 0.002$ ).

Voltage and current limitations apply as for 5.89 (e)

(i) Ohmmeters

|                |                                        |
|----------------|----------------------------------------|
| 0 $\Omega$     | 38 $\mu\Omega$                         |
| 1 $\Omega$     | 46 $\mu\Omega/\Omega$ + 38 $\mu\Omega$ |
| 1.9 $\Omega$   | 84 $\mu\Omega/\Omega$                  |
| 10 $\Omega$    | 21 $\mu\Omega/\Omega$                  |
| 19 $\Omega$    | 21 $\mu\Omega/\Omega$                  |
| 100 $\Omega$   | 9.2 $\mu\Omega/\Omega$                 |
| 190 $\Omega$   | 9.5 $\mu\Omega/\Omega$                 |
| 1 k $\Omega$   | 6.2 $\mu\Omega/\Omega$                 |
| 1.9 k $\Omega$ | 6.5 $\mu\Omega/\Omega$                 |
| 10 k $\Omega$  | 6.2 $\mu\Omega/\Omega$                 |
| 19 k $\Omega$  | 6.1 $\mu\Omega/\Omega$                 |
| 100 k $\Omega$ | 7.7 $\mu\Omega/\Omega$                 |
| 190 k $\Omega$ | 9.2 $\mu\Omega/\Omega$                 |
| 1 M $\Omega$   | 12 $\mu\Omega/\Omega$                  |
| 1.9 M $\Omega$ | 16 $\mu\Omega/\Omega$                  |
| 10 M $\Omega$  | 36 $\mu\Omega/\Omega$                  |
| 19 M $\Omega$  | 42 $\mu\Omega/\Omega$                  |
| 100 M $\Omega$ | 93 $\mu\Omega/\Omega$                  |
| 1 G $\Omega$   | 220 $\mu\Omega/\Omega$                 |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 38 of 53

## CERTIFICATE OF ACCREDITATION



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Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

Using a Fluke 5522A Calibrator Reference Instrument

|                                   |                         |
|-----------------------------------|-------------------------|
| 0 $\Omega$ to 11 $\Omega$         | 91 $\mu\Omega/\Omega$   |
| 11 $\Omega$ to 33 $\Omega$        | 45 $\mu\Omega/\Omega$   |
| 33 $\Omega$ to 110 $\Omega$       | 20 $\mu\Omega/\Omega$   |
| 110 $\Omega$ to 330 $\Omega$      | 12 $\mu\Omega/\Omega$   |
| 330 $\Omega$ to 1.1 k $\Omega$    | 16 $\mu\Omega/\Omega$   |
| 1.1 k $\Omega$ to 3.3 k $\Omega$  | 11 $\mu\Omega/\Omega$   |
| 3.3 k $\Omega$ to 11 k $\Omega$   | 9.2 $\mu\Omega/\Omega$  |
| 11 k $\Omega$ to 33 k $\Omega$    | 22 $\mu\Omega/\Omega$   |
| 33 k $\Omega$ to 110 k $\Omega$   | 19 $\mu\Omega/\Omega$   |
| 110 k $\Omega$ to 330 k $\Omega$  | 26 $\mu\Omega/\Omega$   |
| 330 k $\Omega$ to 1.1 M $\Omega$  | 22 $\mu\Omega/\Omega$   |
| 1.1 M $\Omega$ to 3.3 M $\Omega$  | 49 $\mu\Omega/\Omega$   |
| 3.3 M $\Omega$ to 11 M $\Omega$   | 85 $\mu\Omega/\Omega$   |
| 11 M $\Omega$ to 33 M $\Omega$    | 76 $\mu\Omega/\Omega$   |
| 33 M $\Omega$ to 110 M $\Omega$   | 130 $\mu\Omega/\Omega$  |
| 110 M $\Omega$ to 330 M $\Omega$  | 300 $\mu\Omega/\Omega$  |
| 330 M $\Omega$ to 1100 M $\Omega$ | 1500 $\mu\Omega/\Omega$ |

(j) LCR meters

| Capacitance        | Frequency |                             |
|--------------------|-----------|-----------------------------|
| 0.22 nF            | 5 kHz     | 1800 $\mu\text{F}/\text{F}$ |
| 0.39 nF            | 1 kHz     | 2900 $\mu\text{F}/\text{F}$ |
| 0.48 nF            | 1 kHz     | 1300 $\mu\text{F}/\text{F}$ |
| 0.6 nF             | 1 kHz     | 830 $\mu\text{F}/\text{F}$  |
| 1 nF               | 1 kHz     | 540 $\mu\text{F}/\text{F}$  |
| 2 nF               | 1 kHz     | 460 $\mu\text{F}/\text{F}$  |
| 7 nF               | 1 kHz     | 390 $\mu\text{F}/\text{F}$  |
| 10.9 nF            | 1 kHz     | 190 $\mu\text{F}/\text{F}$  |
| 20 nF              | 1 kHz     | 190 $\mu\text{F}/\text{F}$  |
| 70 nF              | 1 kHz     | 240 $\mu\text{F}/\text{F}$  |
| 109 nF             | 1 kHz     | 270 $\mu\text{F}/\text{F}$  |
| 200 nF             | 1 kHz     | 480 $\mu\text{F}/\text{F}$  |
| 300 nF             | 1 kHz     | 690 $\mu\text{F}/\text{F}$  |
| 0.7 $\mu\text{F}$  | 100 Hz    | 780 $\mu\text{F}/\text{F}$  |
| 1.09 $\mu\text{F}$ | 100 Hz    | 780 $\mu\text{F}/\text{F}$  |
| 2 $\mu\text{F}$    | 100 Hz    | 790 $\mu\text{F}/\text{F}$  |
| 3 $\mu\text{F}$    | 100 Hz    | 780 $\mu\text{F}/\text{F}$  |
| 7 $\mu\text{F}$    | 100 Hz    | 790 $\mu\text{F}/\text{F}$  |
| 10 $\mu\text{F}$   | 100 Hz    | 830 $\mu\text{F}/\text{F}$  |
| 20 $\mu\text{F}$   | 100 Hz    | 910 $\mu\text{F}/\text{F}$  |
| 30 $\mu\text{F}$   | 100 Hz    | 1000 $\mu\text{F}/\text{F}$ |
| 70 $\mu\text{F}$   | 50 Hz     | 630 $\mu\text{F}/\text{F}$  |

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 39 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory

Accreditation Number 271

**SCOPE OF ACCREDITATION**

|             |       |               |
|-------------|-------|---------------|
| 109 $\mu$ F | 50 Hz | 780 $\mu$ F/F |
| 200 $\mu$ F | dc    | 290 $\mu$ F/F |
| 300 $\mu$ F | dc    | 250 $\mu$ F/F |
| 0.33 mF     | dc    | 240 $\mu$ F/F |
| 0.7 mF      | dc    | 280 $\mu$ F/F |
| 1.09 mF     | dc    | 240 $\mu$ F/F |
| 1.1 mF      | dc    | 230 $\mu$ F/F |
| 2 mF        | dc    | 250 $\mu$ F/F |
| 3 mF        | dc    | 230 $\mu$ F/F |
| 3.3 mF      | dc    | 250 $\mu$ F/F |
| 10.9 mF     | dc    | 240 $\mu$ F/F |
| 20 mF       | dc    | 230 $\mu$ F/F |
| 30 mF       | dc    | 230 $\mu$ F/F |
| 33 mF       | dc    | 230 $\mu$ F/F |
| 110 mF      | dc    | 240 $\mu$ F/F |

Using a Fluke 5522A Calibrator Reference Instrument

|                             |                 |
|-----------------------------|-----------------|
| 0.22 nF to 0.4 nF           | 25000 $\mu$ F/F |
| 0.4 nF to 1.1 nF            | 9100 $\mu$ F/F  |
| 1.1 nF to 3.3 nF            | 3000 $\mu$ F/F  |
| 3.3 nF to 11 nF             | 1900 $\mu$ F/F  |
| 11 nF to 33 nF              | 3000 $\mu$ F/F  |
| 33 nF to 110 nF             | 910 $\mu$ F/F   |
| 110 nF to 330 nF            | 910 $\mu$ F/F   |
| 0.33 $\mu$ F to 1.1 $\mu$ F | 1900 $\mu$ F/F  |
| 1.1 $\mu$ F to 3.3 $\mu$ F  | 1900 $\mu$ F/F  |
| 3.3 $\mu$ F to 11 $\mu$ F   | 1300 $\mu$ F/F  |
| 11 $\mu$ F to 33 $\mu$ F    | 1600 $\mu$ F/F  |
| 33 $\mu$ F to 110 $\mu$ F   | 970 $\mu$ F/F   |
| 110 $\mu$ F to 330 $\mu$ F  | 1700 $\mu$ F/F  |
| 0.33 mF to 1.1 mF           | 2100 $\mu$ F/F  |
| 1.1 mF to 3.3 mF            | 1500 $\mu$ F/F  |
| 3.3 mF to 11 mF             | 1500 $\mu$ F/F  |
| 11 mF to 33 mF              | 1500 $\mu$ F/F  |
| 33 mF to 110 mF             | 1300 $\mu$ F/F  |

(n) Digital storage recorders

CMC uncertainties for oscilloscope calibrations using the Wavetek 9500 Calibrator Reference Instrument

|                              |                               |                           |
|------------------------------|-------------------------------|---------------------------|
| DC Voltage into 1 M $\Omega$ | -222.4 V to -99.999 V         | 0.014 % + 25 $\mu$ V      |
|                              | -99.999 V to -9.9999V         | 0.012 % + 25 $\mu$ V      |
|                              | -9.9999 V to -999.99 mV       | 0.019 % + 25 $\mu$ V      |
|                              | -999.99 mV to -99.999 mV      | 50 $\mu$ V/V + 25 $\mu$ V |
|                              | -99.999 mV to -9.9999 mV      | 25 $\mu$ V                |
|                              | -9.9999 mV to -999.99 $\mu$ V | 25 $\mu$ V                |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 40 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                                                                     |                                     |                           |
|---------------------------------------------------------------------|-------------------------------------|---------------------------|
|                                                                     | -999.99 $\mu$ V to -888 $\mu$ V     | 0.025 % + 25 $\mu$ V      |
|                                                                     | 0 V                                 | 15 $\mu$ V                |
|                                                                     | 888 $\mu$ V to 1 mV                 | 0.025 % + 25 $\mu$ V      |
|                                                                     | 1 mV to 10 mV                       | 25 $\mu$ V                |
|                                                                     | 10 mV to 100 mV                     | 25 $\mu$ V                |
|                                                                     | 100 mV to 1V                        | 30 $\mu$ V/V + 25 $\mu$ V |
|                                                                     | 1 V to 10 V                         | 0.016 % + 25 $\mu$ V      |
|                                                                     | 10 V to 100 V                       | 0.015 % + 25 $\mu$ V      |
|                                                                     | 100 V to 222.4 V                    | 0.012 % + 25 $\mu$ V      |
| DC Voltage into 50 $\Omega$                                         | -5.56 V to -888 $\mu$ V             | 0.025 % + 25 $\mu$ V      |
|                                                                     | 0 V                                 | 15 $\mu$ V                |
|                                                                     | 888 $\mu$ V to 5.56 V               | 0.025 % + 25 $\mu$ V      |
| Square Voltage into 1 M $\Omega$ (negative, positive, or symmetric) | 35.52 $\mu$ Vpp to 999.99 $\mu$ Vpp | 1 % + 10 $\mu$ V          |
|                                                                     | 1 mVpp to 21 mVpp                   | 0.1 % + 15 $\mu$ V        |
|                                                                     | 21.001 mVpp to 556 mVpp             | 0.1 % + 1 $\mu$ V         |
|                                                                     | 556.01 mVpp to 210 Vpp              | 0.05 % + 1 $\mu$ V        |
|                                                                     | 0 V                                 | 15 $\mu$ V                |
| Output Frequency                                                    | 10 Hz to 100 kHz                    | 0.25 $\mu$ Hz/Hz          |
| Square Voltage into 50 $\Omega$ (negative, positive or symmetric)   | 35.52 $\mu$ Vpp to 999.99 $\mu$ Vpp | 1.0 % + 10 $\mu$ V        |
|                                                                     | 1 mVpp to 21 mVpp                   | 0.1 % + 15 $\mu$ V        |
|                                                                     | 21.001 mVpp to 556 mVpp             | 0.1 % + 1 $\mu$ V         |
|                                                                     | 556.01 mVpp to 5.56 Vpp             | 0.05 % + 1 $\mu$ V        |
|                                                                     | 0 V                                 | 15 $\mu$ V                |
| Output Frequency                                                    | 10 Hz to 100 kHz                    | 0.25 $\mu$ Hz/Hz          |
| Levelled Sine                                                       |                                     |                           |
| Reference level                                                     |                                     |                           |
| 50 kHz to 10 MHz                                                    | 4.4 mVpp to 5.56 Vpp                | 1.5 %                     |
| Flatness relative to reference level                                |                                     |                           |
| 100 mHz to 100 MHz                                                  | 4.44 mVpp to 1 Vpp                  | 0.7 %                     |
|                                                                     | 1 Vpp to 3.337 Vpp                  | 0.7 %                     |
|                                                                     | 3.337 Vpp to 5.56 Vpp               | 1.5 %                     |
| 100 MHz to 550 MHz                                                  | 4.44 mVpp to 1 Vpp                  | 2 %                       |
|                                                                     | 1 Vpp to 3.337 Vpp                  | 2 %                       |
|                                                                     | 3.337 Vpp to 5.56 Vpp               | 3 %                       |
| 550 MHz to 1.1 GHz                                                  | 4.44 mVpp to 1 Vpp                  | 2 %                       |
|                                                                     | 1 Vpp to 3.3369 Vpp                 | 2 %                       |
| Low Edge into 50 $\Omega$ and 1 M $\Omega$                          |                                     |                           |

|                                   |  |          |               |               |
|-----------------------------------|--|----------|---------------|---------------|
| Operations Manager Authorisation: |  | Issue 73 | Date:04/09/26 | Page 41 of 53 |
|-----------------------------------|--|----------|---------------|---------------|

## CERTIFICATE OF ACCREDITATION



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                                                   |                               |                |
|---------------------------------------------------|-------------------------------|----------------|
| Output Voltage                                    | 4.4 mVpp to 3.1 Vpp           | 3 %            |
| Rise/Fall Time<br>(10 % to 90 %)                  | 4.44 mVpp to 3.1 Vpp          | 500 ps nominal |
| Output Period                                     | 500 ns to 100 ms              | 0.25 $\mu$ s/s |
| High Edge into 50 $\Omega$                        |                               |                |
| Output Voltage                                    | 888 mVpp to 5.56 Vpp          | 3 %            |
| Rise/Fall Time<br>(10 % to 90 %)                  | 888 mVpp to 5.56 Vpp          | 100 ns nominal |
| Output Period                                     | 10 $\mu$ s to 100 ms          | 0.25 $\mu$ s/s |
| High Edge into 1 M $\Omega$                       |                               |                |
| Output Voltage                                    | 888 mVpp to 100 Vpp           | 3 %            |
|                                                   | 100.01 Vpp to 210 Vpp         | 3 %            |
| Rise/Fall Time<br>(10 % to 90 %)                  | 888 mVpp to 100 Vpp           | 150 ns nominal |
|                                                   | 100.01 Vpp to 210 Vpp         | 200 ns nominal |
| Output Period                                     | 10 $\mu$ s to 100 ms          | 0.25 $\mu$ s/s |
| Fast Edge into 50 $\Omega$                        |                               |                |
| Output Voltage                                    | 4.44 Vpp to 3.1 Vpp           | 3 %            |
| Rise/Fall Time<br>(10 % to 90 %)                  | 4.44 Vpp to 3.1 Vpp           | 150 ps nominal |
| Output Period                                     | 500 ns to 100 ms              | 0.25 $\mu$ s/s |
| Time Markers<br>into 50 $\Omega$ and 1 M $\Omega$ |                               |                |
| Square (nom. peak<br>to peak)                     | 9.0091 ns to 55 s             |                |
|                                                   | 100 mV, 250 mV, 500 mV        | 0.25 $\mu$ s/s |
|                                                   | 1 V                           | 0.05 $\mu$ s/s |
|                                                   | (Rise/Fall Time 1 ns typical) |                |
| Sine (nom. peak<br>to peak)                       | 450.5 ps to 909.1 ps          |                |
|                                                   | 100 mV, 250 mV, 500 mV        | 0.25 $\mu$ s/s |
|                                                   | 909.1 ps to 9.0091 $\mu$ s    |                |
|                                                   | 100 mV, 250 mV, 500 mV, 1 V   | 0.25 $\mu$ s/s |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 42 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                              |                                                                                                         |                                                    |
|------------------------------|---------------------------------------------------------------------------------------------------------|----------------------------------------------------|
|                              | (Rise/Fall Time 1 ns typical)                                                                           |                                                    |
| Pulse (nom. peak to peak)    | 900.91 ns to 55 s<br>100 mV, 250 mV, 500 mV, 1 V<br>(Rise/Fall Time 1 ns typical)                       | 0.25 µs/s                                          |
| Triangle (nom. peak to peak) | 900.91 ns to 55 s<br>100 mV, 250 mV, 500 mV, 1 V<br>(Rise/Fall Time 2.5 % period)                       | 0.25 µs/s                                          |
| DC Current                   | 88.8 µA to 111.2 mA<br>-111.2 mA to -88.8 µA                                                            | 0.25 % + 0.5 µA<br>0.25 % + 0.5 µA                 |
| Square Current               | 88.8 µApp to 111.2 mApp                                                                                 | 0.25 % + 0.5 µA                                    |
| Resistance                   | 10 Ω to 40 Ω<br>40 Ω to 90 Ω<br>90 Ω to 150 Ω<br>50 kΩ to 800 kΩ<br>800 kΩ to 1.2 MΩ<br>1.2 MΩ to 12 MΩ | 0.5 %<br>0.1 %<br>0.5 %<br>0.5 %<br>0.1 %<br>0.5 % |
| Capacitance                  | 1 pF to 35 pF<br>35 pF to 95 pF                                                                         | 2 % + 0.25 pF<br>2 % + 0.25 pF                     |

### Composite Video Output

Amplitude 1.0 V peak to peak  
Pattern: (Full Raster) White, Grey or Black  
Sync Polarity: Positive or Negative  
Standards: 625-line 50 Hz, 525-line 60 Hz  
Trigger Output: Composite Sync or Odd Field start

### LF Linear Ramp

Waveforms: 1 V peak to peak triangle, symmetrical about ground  
Ramp Time: 1 ms, 10 ms, 100 ms or 1 s  
(Ramp Time wave form is rising/falling/flat over period 3 x s  
For example: 1 ms rising, 1 ms falling, 1 ms flat, over 3 ms period)

### Overload Pulse

Amplitude: 5 V to 20 V into 50 Ω  
Polarity: Positive or Negative from ground  
Duration: 0.2 s to 100 s (subject to pulse energy limits)  
Energy: 1.6 J to 50 J  
Power into 50 Ω: 0.5 W to 8 W

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 43 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

Trigger: Manual triggering only, maximum repetition rate 0.3 Hz

Zero Skew

Unadjusted Skew < 50 ps ch to ch  
Skew Temp Coefficient: <0.2 ps/°C  
Output Amplitude: 1 Vpp  
Frequency Range: 10 Hz to 100 MHz

Input Leakage Function

Open Circuit Output Leakage < 50 pA  
Short Circuit Output Offset < 15 µV

(q) Other specified devices

Voltage simulation of temperature (Fluke 5522A Calibrator Reference Instrument)

Simulated thermocouple output and thermocouple measurement

Thermocouple Type

|   |                    |          |
|---|--------------------|----------|
| B | 600 °C to 800 °C   | 0.44 °C  |
|   | 800 °C to 1000 °C  | 0.34 °C  |
|   | 1000 °C to 1550 °C | 0.30 °C  |
|   | 1550 °C to 1820 °C | 0.33 °C  |
| C | 0 °C to 150 °C     | 0.30 °C  |
|   | 150 °C to 650 °C   | 0.26 °C  |
|   | 650 °C to 1000 °C  | 0.31 °C  |
|   | 1000 °C to 1800 °C | 0.50 °C  |
|   | 1800 °C to 2316 °C | 0.74 °C  |
| E | -250 °C to -100 °C | 0.33 °C  |
|   | -100 °C to -25 °C  | 0.16 °C  |
|   | -25 °C to -350 °C  | 0.12 °C  |
|   | 350 °C to 650 °C   | 0.11 °C  |
|   | 650 °C to 1000 °C  | 0.12 °C  |
| J | -210 °C to -100 °C | 0.22 °C  |
|   | -100 °C to -30 °C  | 0.16 °C  |
|   | -30 °C to 150 °C   | 0.070 °C |
|   | 150 °C to 760 °C   | 0.15 °C  |
|   | 760 °C to 1200 °C  | 0.15 °C  |
| K | -200 °C to -100 °C | 0.33 °C  |
|   | -100 °C to -25 °C  | 0.18 °C  |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 44 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|   |                    |         |
|---|--------------------|---------|
|   | -25 °C to 120 °C   | 0.16 °C |
|   | 120 °C to 1000 °C  | 0.21 °C |
|   | 1000 °C to 1372 °C | 0.24 °C |
| L | -200 °C to -100 °C | 0.16 °C |
|   | -100 °C to 800 °C  | 0.17 °C |
|   | 800 °C to 900 °C   | 0.15 °C |
| N | -200 °C to -100 °C | 0.40 °C |
|   | -100 °C to -25 °C  | 0.22 °C |
|   | -25 °C to 120 °C   | 0.19 °C |
|   | 120 °C to 410 °C   | 0.18 °C |
|   | 410 °C to 1300 °C  | 0.23 °C |
| R | 0 °C to 250 °C     | 0.57 °C |
|   | 250 °C to 400 °C   | 0.35 °C |
|   | 400 °C to 1000 °C  | 0.33 °C |
|   | 1000 °C to 1767 °C | 0.40 °C |
| S | 0 °C to 250 °C     | 0.47 °C |
|   | 250 °C to 1000 °C  | 0.36 °C |
|   | 1000 °C to 1400 °C | 0.37 °C |
|   | 1400 °C to 1767 °C | 0.46 °C |
| T | -250 °C to -150 °C | 0.56 °C |
|   | -150 °C to 0 °C    | 0.24 °C |
|   | 0 °C to 120 °C     | 0.16 °C |
|   | 120 °C to 400 °C   | 0.14 °C |
| U | -200 °C to 0 °C    | 0.30 °C |
|   | 0 °C to 600 °C     | 0.15 °C |

Temperature standard is selectable between ITS-90 or IPTS-68.

Simulated RTD output

RTD Type

|               |                   |                      |
|---------------|-------------------|----------------------|
| Pt 385, 100 Ω | -200 °C to -80 °C | 0.007 °C to 0.015 °C |
|               | -80 °C to 0 °C    | 0.015 °C to 0.02 °C  |
|               | 0 °C to 100 °C    | 0.02 °C to 0.03 °C   |
|               | 100 °C to 300 °C  | 0.03 °C to 0.05 °C   |
|               | 300 °C to 400 °C  | 0.05 °C to 0.06 °C   |
|               | 400 °C to 630 °C  | 0.06 °C to 0.08 °C   |
|               | 630 °C to 800 °C  | 0.08 °C to 0.09 °C   |
| Pt 385 1000 Ω | -200 °C to -80 °C | 0.007 °C to 0.015 °C |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 45 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

|                        |                    |                      |
|------------------------|--------------------|----------------------|
|                        | -80 °C to 0 °C     | 0.015 °C to 0.018 °C |
|                        | 0 °C to 100 °C     | 0.018 °C to 0.03 °C  |
|                        | 100 °C to 260 °C   | 0.03 °C to 0.04 °C   |
|                        | 260 °C to 300 °C   | 0.04 °C to 0.05 °C   |
|                        | 300 °C to 400 °C   | 0.04 °C to 0.05 °C   |
|                        | 400 °C to 600 °C   | 0.05 °C to 0.07 °C   |
|                        | 600 °C to 630 °C   | 0.07 °C to 0.08 °C   |
| Pt 3916 Ω              | -200 °C to -190 °C | 0.007 °C             |
|                        | -190 °C to -80 °C  | 0.007 °C to 0.015 °C |
|                        | -80 °C to 0 °C     | 0.015 °C to 0.02 °C  |
|                        | 0 °C to 100 °C     | 0.02 °C to 0.03 °C   |
|                        | 100 °C to 260 °C   | 0.03 °C to 0.04 °C   |
|                        | 260 °C to 300 °C   | 0.04 °C to 0.05 °C   |
|                        | 300 °C to 400 °C   | 0.05 °C              |
|                        | 400 °C to 600 °C   | 0.05 °C to 0.07 °C   |
|                        | 600 °C to 630 °C   | 0.07 °C              |
| Pt 3926 Ω              | -200 °C to -80 °C  | 0.007 °C to 0.015 °C |
|                        | -80 °C to 0 °C     | 0.015 °C to 0.02 °C  |
|                        | 0 °C to 100 °C     | 0.02 °C to 0.03 °C   |
|                        | 100 °C to 300 °C   | 0.03 °C to 0.05 °C   |
|                        | 300 °C to 400 °C   | 0.05 °C              |
|                        | 400 °C to 630 °C   | 0.05 °C to 0.07 °C   |
| PtNi 385 120 Ω (Ni120) | -80 °C to 0 °C     | 0.008 °C to 0.012 °C |
|                        | 0 °C to 100 °C     | 0.008 °C to 0.017 °C |
|                        | 100 °C to 260 °C   | 0.017 °C to 0.012 °C |

Temperature standard is selectable between ITS-90 or IPTS-68

Thermocouple simulation by special method, reference junction at 0 °C, converting resistance measurements to temperature units using the tables outlined in appendix D of "Traceable Temperatures" second edition.

Source

|            |         |
|------------|---------|
| -200.00 °C | 0.07 °C |
| 0 °C       | 0.03 °C |
| 500 °C     | 0.03 °C |
| 1000 °C    | 0.03 °C |
| 1370 °C    | 0.04 °C |

Measure

|            |         |
|------------|---------|
| -199.00 °C | 0.07 °C |
| 0 °C       | 0.03 °C |
| 500 °C     | 0.03 °C |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 46 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory

Accreditation Number 271

**SCOPE OF ACCREDITATION**

|         |         |
|---------|---------|
| 1000 °C | 0.05 °C |
| 1370 °C | 0.06 °C |

Internal reference cold junction check

|         |         |
|---------|---------|
| 0.00 °C | 0.02 °C |
|---------|---------|

RTD simulation by special method, converting resistance measurements to temperature units using the tables outlined in appendix C of "Traceable Temperatures" second edition.

Source/Measure

|            |          |
|------------|----------|
| -199.00 °C | 0.002 °C |
| 0 °C       | 0.004 °C |
| 100 °C     | 0.005 °C |
| 500 °C     | 0.010 °C |
| 800 °C     | 0.014 °C |

AC Harmonics (Fluke 5522A Calibrator Reference Instrument)

| Fundamental frequency | Voltage          | Current          | Auxiliary Voltage |
|-----------------------|------------------|------------------|-------------------|
| 10 Hz to 45 Hz        | 33 mV to 33 V    | 3.3 mA to 3 A    | 0 mV to 5 V       |
| 45 Hz to 65 Hz        | 33 mV to 1020 V  | 3.3 mA to 20.5 A | 10 mV to 5 V      |
| 65 Hz to 500 Hz       | 33 mV to 1020 V  | 33 mA to 20.5 A  | 100 mV to 5 V     |
| 500 Hz to 5 kHz       | 330 mV to 1020 V | 33 mA to 20.5 A  | 100 mV to 5 V     |
| 5 kHz to 10 kHz       | 3.3 V to 1020 V  | 33 mA to 330 mA  | 100 mV to 5 V     |
| 10 kHz to 30 kHz      | 3.3 V to 1020 V  | 33 mA to 330 mA  | 100 mV to 3.3 V   |

Maximum frequency of harmonic output: 30 kHz (10 kHz for 3.3 V to 5 V Auxiliary Voltage).

Harmonics available: 2 through 50, limited by maximum frequency of harmonic output.

(For example: a fundamental frequency of 5 kHz limits the maximum harmonic to 6, i.e. 30 kHz. Harmonics through to 50 are available for a fundamental frequency from 10 to 600 Hz {200 Hz for 3.3 to 5 V Auxiliary Voltage}).

CMC uncertainty for amplitude (voltage or current) is as per the uncertainties given in sections (a) DC voltmeters, (b) AC Voltmeters, (c) DC ammeters, and (d) AC ammeters, except that the floor component is doubled. (Note that uncertainties for Auxiliary Voltage are not given).

CMC uncertainty for phase is the greater of that given in (g) Phase angle indicators or 1°.

For example: the CMC uncertainty for phase for a 400 Hz fundamental frequency and 10 kHz harmonic frequency is 10° (from Phase angle least uncertainty for 10 kHz). Another example: the CMC uncertainty for phase for a 50 Hz fundamental frequency and 400 Hz harmonic frequency is 1° (Phase angle CMC uncertainty for 400 Hz is 0.25°, therefore 1° is used).

Electrical test equipment

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 47 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

The CMC uncertainties in this section are applicable to the use of the Fluke 5322A/5/VLC Multifunction Electrical Tester Calibrator and 5322A Resistance Multiplier for the calibration of the following equipment: Insulation testers, PAT testers, RCD testers, Line/Loop testers, Earth testers and equipment employing one or more such functions.

Where the 'Range' specified is not a single point, the lowest CMC uncertainty is given for the range.

### Low Resistance (Continuity) – 4-Wire

|                   |         |
|-------------------|---------|
| 9.62 mΩ           | 0.6 %   |
| 0.1 Ω to 0.199 Ω  | 1 %     |
| 0.2 Ω to 0.499 Ω  | 0.8 %   |
| 0.5 Ω to 1.999 Ω  | 0.4 %   |
| 2 Ω to 4.999 Ω    | 0.2 %   |
| 5 Ω to 29.99 Ω    | 0.05 %  |
| 30 Ω to 199.9 Ω   | 0.043 % |
| 0.2 kΩ to 4.99 kΩ | 0.05 %  |
| 5 kΩ to 10 kΩ     | 0.05 %  |

### Low Resistance (Continuity) – 2-Wire

|                   |         |
|-------------------|---------|
| 0.1 Ω to 0.199 Ω  | 5 %     |
| 0.2 Ω to 0.499 Ω  | 2 %     |
| 0.5 Ω to 1.999 Ω  | 0.5 %   |
| 2 Ω to 4.999 Ω    | 0.4 %   |
| 5 Ω to 29.99 Ω    | 0.1 %   |
| 30 Ω to 199.9 Ω   | 0.035 % |
| 0.2 kΩ to 4.99 kΩ | 0.05 %  |
| 5 kΩ to 10 kΩ     | 0.05 %  |

### Low Resistance (Continuity) – Current

For CMCs using multimeters – refer to 5.88 (c) and (d)

### High Resistance (Insulation) – Resistance

|                    |        |
|--------------------|--------|
| 10 kΩ to 99.99 kΩ  | 0.03 % |
| 100 kΩ to 999 kΩ   | 0.03 % |
| 1 MΩ to 9.999 MΩ   | 0.06 % |
| 10 MΩ to 999.9 MΩ  | 0.14 % |
| 1 GΩ to 9.999 GΩ   | 0.5 %  |
| 10 GΩ to 100 GΩ    | 0.6 %  |
| 100 GΩ to 199.9 GΩ | 0.69 % |
| 200 GΩ to 999.9 GΩ | 1.6 %  |
| 1000 GΩ to 1999 GΩ | 0.79 % |
| 2 TΩ to 10 TΩ      | 1.7 %  |

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 48 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

Uncertainty is valid to 3000 V. For test voltages above 3000 V, add 0.1 % for each 1000 V above 3000 V in range 10.00 MΩ to 999 MΩ and 0.3 % in range 1.000 GΩ to 100.0 GΩ

**High Resistance (Insulation) – Voltage**

For CMCs using multimeters for voltages 0 to 1000 V– refer to 5.88 (a)

Voltages greater than 1000 V

|                  |        |
|------------------|--------|
| 1000 V to 1100 V | 0.91 % |
| 1100 V to 1575 V | 1.2 %  |
| 1575 V to 2500 V | 0.79 % |
| 2500 V to 5500 V | 0.57 % |

**High Resistance (Insulation) – Current**

For CMCs using multimeters – refer to 5.88 (c)

**Ground Bond (Earth Bond) Resistance – DC – 4-Wire**

|          |        |
|----------|--------|
| 1.023 mΩ | 4.3 %  |
| 16.4 mΩ  | 3.6 %  |
| 42.56 mΩ | 3.7 %  |
| 87.1 mΩ  | 1.9 %  |
| 326.6 mΩ | 0.98 % |
| 464 mΩ   | 0.63 % |
| 862.5 mΩ | 0.81 % |
| 1.6887 Ω | 1 %    |
| 4.637 Ω  | 0.22 % |
| 8.64 Ω   | 0.13 % |
| 17.001 Ω | 0.29 % |
| 47.12 Ω  | 0.15 % |
| 91.47 Ω  | 0.13 % |
| 174.51 Ω | 0.11 % |
| 467.9 Ω  | 0.21 % |
| 875.8 Ω  | 0.1 %  |
| 1689.2 Ω | 0.11 % |

**Ground Bond (Earth Bond) Resistance – DC – 2-Wire**

|          |        |
|----------|--------|
| 28.14 mΩ | 4 %    |
| 53.82 mΩ | 4 %    |
| 98.2 mΩ  | 2.2 %  |
| 338.5 mΩ | 1.1 %  |
| 476.9 mΩ | 0.61 % |
| 875.3 mΩ | 0.83 % |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 49 of 53

## CERTIFICATE OF ACCREDITATION



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory

Accreditation Number 271

## SCOPE OF ACCREDITATION

|                 |        |
|-----------------|--------|
| 1.7055 $\Omega$ | 1 %    |
| 4.654 $\Omega$  | 0.24 % |
| 8.657 $\Omega$  | 0.16 % |
| 17.019 $\Omega$ | 0.35 % |
| 47.14 $\Omega$  | 0.21 % |
| 91.48 $\Omega$  | 0.12 % |
| 174.54 $\Omega$ | 0.12 % |
| 468 $\Omega$    | 0.21 % |
| 875.8 $\Omega$  | 0.1 %  |
| 1689.4 $\Omega$ | 0.11 % |

## Ground Bond (Earth Bond) Resistance – AC – 4-Wire

|                  |        |
|------------------|--------|
| 1.01 m $\Omega$  | 6.2 %  |
| 16.4 m $\Omega$  | 6.2 %  |
| 42.6 m $\Omega$  | 6.5 %  |
| 87.1 m $\Omega$  | 3.1 %  |
| 326.6 m $\Omega$ | 1.6 %  |
| 464.4 m $\Omega$ | 1.1 %  |
| 862.7 m $\Omega$ | 0.53 % |
| 1.6887 $\Omega$  | 1.7 %  |
| 4.638 $\Omega$   | 0.88 % |
| 8.642 $\Omega$   | 0.87 % |
| 17 $\Omega$      | 0.85 % |
| 47.13 $\Omega$   | 0.85 % |
| 91.47 $\Omega$   | 0.86 % |
| 174.51 $\Omega$  | 0.87 % |
| 467.9 $\Omega$   | 1.1 %  |
| 876 $\Omega$     | 0.86 % |
| 1690 $\Omega$    | 0.95 % |

## Ground Bond (Earth Bond) Resistance – AC – 2-Wire

|                  |        |
|------------------|--------|
| 32.37 m $\Omega$ | 12 %   |
| 57.74 m $\Omega$ | 9.1 %  |
| 101.8 m $\Omega$ | 4.5 %  |
| 342.3 m $\Omega$ | 2 %    |
| 481 m $\Omega$   | 1.3 %  |
| 879 m $\Omega$   | 1.1 %  |
| 1.7059 $\Omega$  | 1.8 %  |
| 4.655 $\Omega$   | 0.9 %  |
| 8.658 $\Omega$   | 0.87 % |
| 17.022 $\Omega$  | 0.88 % |
| 47.15 $\Omega$   | 1.1 %  |
| 91.49 $\Omega$   | 0.87 % |
| 174.53 $\Omega$  | 0.86 % |
| 468 $\Omega$     | 1.1 %  |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 50 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory

Accreditation Number 271

**SCOPE OF ACCREDITATION**

|                 |        |
|-----------------|--------|
| 876.2 $\Omega$  | 0.87 % |
| 1690.2 $\Omega$ | 0.95 % |

Ground Bond Resistance – AC & DC – 4-Wire – Low Test Current Measurement

|                    |       |
|--------------------|-------|
| 0 A to 0.09 A      | 10 mA |
| 0.091 A to 0.218 A | 5 %   |
| 0.219 A to 0.98 A  | 1.7 % |
| 0.981 A to 3.299 A | 1.1 % |

Ground Bond Resistance – AC & DC – 4-Wire – High Test Current Measurement

|                   |        |
|-------------------|--------|
| 0 A to 0.29 A     | 100 mA |
| 0.3 A to 1.09 A   | 10 %   |
| 1.1 A to 2.09 A   | 5.2 %  |
| 2.1 A to 3.99 A   | 3.1 %  |
| 4 A to 9.8 A      | 1.7 %  |
| 9.81 A to 15.39 A | 1.4 %  |
| 15.4 A to 32.99 A | 1.1 %  |

Ground Bond Resistance – AC & DC – 2-Wire – Low Test Current Measurement

|                   |       |
|-------------------|-------|
| 0 A to 0.029 A    | 10 mA |
| 0.03 A to 0.099 A | 10 %  |
| 0.1 A to 0.189 A  | 5.8 % |
| 0.19 A to 0.469 A | 2.8 % |
| 0.47 A to 0.989 A | 1.7 % |
| 0.99 A to 3.299 A | 1.1 % |

Ground Bond Resistance – AC & DC – 2-Wire – High Test Current Measurement

|                   |        |
|-------------------|--------|
| 0 A to 0.29 A     | 100 mA |
| 0.3 A to 1.09 A   | 5 %    |
| 1.1 A to 2.09 A   | 3.2 %  |
| 2.1 A to 3.99 A   | 2.1 %  |
| 4 A to 9.8 A      | 1.5 %  |
| 9.81 A to 15.39 A | 1.1 %  |
| 15.4 A to 32.99 A | 1.1 %  |

Line/Loop Impedance

|                  |       |
|------------------|-------|
| 32.37 m $\Omega$ | 12 %  |
| 57.74 m $\Omega$ | 9.1 % |
| 101.8 m $\Omega$ | 4.5 % |
| 342.3 m $\Omega$ | 2 %   |
| 481 m $\Omega$   | 1.3 % |
| 0.879 $\Omega$   | 1.1 % |

Operations Manager  
Authorisation:

Issue 73

Date:04/09/26

Page 51 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory

Accreditation Number 271

### SCOPE OF ACCREDITATION

|                   |        |
|-------------------|--------|
| 1.7059 $\Omega$   | 1.8 %  |
| 4.655 $\Omega$    | 0.9 %  |
| 8.658 $\Omega$    | 0.87 % |
| 17.022 $\Omega$   | 0.88 % |
| 47.15 $\Omega$    | 1.1 %  |
| 91.49 $\Omega$    | 0.87 % |
| 174.53 $\Omega$   | 0.86 % |
| 468 $\Omega$      | 1.1 %  |
| 876.2 $\Omega$    | 0.87 % |
| 1.6902 k $\Omega$ | 0.95 % |

#### Leakage Current – Passive, Differential, Substitute (AC)

|                              |        |
|------------------------------|--------|
| 100 $\mu$ A to 300.9 $\mu$ A | 0.6 %  |
| 0.301 mA to 3 mA             | 0.18 % |
| 3.001 mA to 30.009 mA        | 0.31 % |

#### RCD Trip Current

|                   |       |
|-------------------|-------|
| 3 mA to 30 mA     | 0.4 % |
| 30 mA to 300 mA   | 0.4 % |
| 300 mA to 3000 mA | 0.3 % |

#### RCD Trip Time

|                     |              |
|---------------------|--------------|
| 10 ms to 99.99 ms   | 0.36 %       |
| 100 ms to 999.99 ms | 0.044 %      |
| 1000 ms to 5000 ms  | 80 $\mu$ s/s |

#### AC Voltage Output

For CMCs using calibrators – refer to 5.89 (b)

#### AC Voltage Output – Frequency

For CMCs using meters or counters – refer to 5.91 (a) and (c)

#### DC Voltage Output

For CMCs using calibrators – refer to 5.89 (a)

#### AC Voltage Multimeter

For CMCs using multimeters for voltages 0 to 1000 V – refer to 5.88 (b)

|                  |                |        |
|------------------|----------------|--------|
| 1000 V to 2996 V | 50 Hz to 60 Hz | 0.21 % |
| 2996 V to 5500 V | 50 Hz to 60 Hz | 0.3 %  |

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 52 of 53



Trescal Holding New Zealand Ltd  
Metrology & Calibration Laboratory  
**SCOPE OF ACCREDITATION**

Accreditation Number 271

#### DC Voltage Multimeter

For CMCs using multimeters for voltages 0 to 1000 V – refer to 5.88 (a)

|                  |        |
|------------------|--------|
| 1000 V to 2998 V | 0.18 % |
| 2998 V to 5500 V | 0.1 %  |

#### 5.91 Time and Frequency

In accordance with in-house methods based on manufacturer's recommendations

##### (a) Frequency meters

###### Nominal range

|           |                       |
|-----------|-----------------------|
| 10 Hz     | 1.3 $\mu\text{Hz/Hz}$ |
| 100 Hz    | 1.3 $\mu\text{Hz/Hz}$ |
| 120 Hz    | 1.3 $\mu\text{Hz/Hz}$ |
| 1000 Hz   | 1.3 $\mu\text{Hz/Hz}$ |
| 10 kHz    | 1.3 $\mu\text{Hz/Hz}$ |
| 50 kHz    | 1.3 $\mu\text{Hz/Hz}$ |
| 100 kHz   | 1.3 $\mu\text{Hz/Hz}$ |
| 1000 kHz  | 1.3 $\mu\text{Hz/Hz}$ |
| 2000 kHz  | 1.4 $\mu\text{Hz/Hz}$ |
| 10000 kHz | 1.3 $\mu\text{Hz/Hz}$ |

###### Frequency Range

|                       |                    |                        |
|-----------------------|--------------------|------------------------|
| Levelled sine voltage | 0.1 Hz to 12 kHz   | 3 $\mu\text{Hz/Hz}$    |
|                       | 12 kHz to 1100 MHz | 0.25 $\mu\text{Hz/Hz}$ |
| Square voltage        | 10 Hz to 100 kHz   | 0.25 $\mu\text{Hz/Hz}$ |

###### Period Range

|              |                  |                      |
|--------------|------------------|----------------------|
| Time markers | 450.5 ps to 55 s | 0.25 $\mu\text{s/s}$ |
|--------------|------------------|----------------------|

##### (c) Counters

###### Frequency Range

|              |                     |                        |
|--------------|---------------------|------------------------|
| Time markers | 0.02 Hz to 2200 MHz | 0.25 $\mu\text{Hz/Hz}$ |
|--------------|---------------------|------------------------|

###### Note 1:

Unless stated otherwise the CMC is based on the performance of the best available device and measurement uncertainties achieved for specific calibrations may be greater than the CMC Uncertainty. A laboratory may not report measurement uncertainties lower than its CMC. However, if the device under calibration has a greater accuracy than the device used to calculate the CMC the laboratory may be able to use the calibration data to lower its CMC Uncertainty. Please contact the laboratory to discuss your specific requirements.

Operations Manager  
Authorisation:

Issue 73

Date: 04/09/26

Page 53 of 53