Schedule of Accreditation

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Accredited to ISO/IEC 17025:2017

Millbrook Proving Ground Ltd

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Calibration performed at the above address only

DETAIL OF ACCREDITATION

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k = 2)	Remarks
ELECTRICAL			Electrical calibrations are performed as a comparison against a reference standard
DC RESISTANCE	0 Ω to 1 Ω 1 Ω to 20 Ω 20 Ω to 200 Ω 200 Ω to 2 kΩ 2 kΩ to 20 kΩ 20 kΩ to 200 kΩ 200 kΩ to 2 MΩ 2 MΩ to 20 MΩ 20 MΩ to 200 MΩ	190 μΩ 25 ppm + 180 μΩ 14 ppm + 770 μΩ 14 ppm + 5.7 mΩ 14 ppm + 57 mΩ 14 ppm + 1.1 Ω 19 ppm + 21 Ω 38 ppm + 340 Ω 490 ppm + 19 kΩ	These values can be both measured and generated, the uncertainties listed are appropriate for the calibration of suitably stable souces and measuring devices of sufficient resolution.
DC VOLTAGE	0 mV to 10 mV 10 mV to 200 mV 200 mV to 2 V 2 V to 20 V 20 V to 200 V 200 V to 1000 V	1.5 μV 13 ppm + 1.4 μV 10 ppm + 3.5 μV 8.8 ppm + 26 μV 11 ppm + 380 μV 13 ppm + 3.9 mV	
DC CURRENT	0 μA to 10 μA 10 μA to 200 μA 200 μA to 2 mA 2 mA to 20 mA 20 mA to 200 mA 200 mA to 2 A	4.1 nA 72 ppm + 4.0 nA 72 ppm + 21 nA 72 ppm + 270 nA 130 ppm + 2.8 μA 180 ppm + 48 μA	
AC VOLTAGE	2 mV to 100 mV *20 Hz to 40 Hz* *40 kHz to 2 kHz* *2 kHz to 20 kHz* *20 kHz to 100 kHz* 100 mV to 200 mV *20 Hz to 40 Hz* *40 kHz to 2 kHz* *2 kHz to 20 kHz* *20 kHz to 100 kHz*	 26 μV 23 μV 33 μV 67 μV 320 ppm + 26 μV 300 ppm + 23 μV 470 ppm + 33 μV 0.19 % + 67 μV	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k = 2)	Remarks
AC VOLTAGE continued	200 mV to 2 V		These values can be both measured and generated, the uncertainties listed are appropriate for the calibration of suitably stable souces and measuring devices of sufficient resolution.
	20 Hz to 40 Hz	260 ppm +140 μV	
	40 kHz to 20 kHz	250 ppm + 170 μV	
	20 kHz to 100 kHz	0.12 % + 670 μV	
	2 V to 20 V		
	20 Hz to 40 Hz	260 ppm +1.5 mV	
	40 kHz to 20 kHz	250 ppm + 2.3 mV	
	20 kHz to 100 kHz	0.12 % + 6.5 mV	
	20 V to 200 V		
	20 Hz to 40 Hz	260 ppm +15 mV	
	40 kHz to 20 kHz	250 ppm + 18 mV	
	20 kHz to 100 kHz	0.12 % + 62 mV	
	200 V to 1000 V		
	50 Hz to 2 kHz	300 ppm +140 mV	
	2 kHz to 20 kHz	470 ppm + 910 mV	
AC CURRENT			
	100 nA to 200 μA		
	10 Hz to 1 kHz	240 ppm + 28 nA	
	1 kHz to 5 kHz	240 ppm + 65 nA	
	200 μA to 2 mA		
	10 Hz to 1 kHz	240 ppm + 280 nA	
	1 kHz to 5 kHz	240 ppm + 650 nA	
	2 mA to 20 mA		
	10 Hz to 1 kHz	240 ppm + 2.6 μA	
	1 kHz to 5 kHz	240 ppm + 6.5 μA	
	20 mA to 200 mA		
	10 Hz to 1 kHz	240 ppm + 27 μA	
	1 kHz to 5 kHz	240 ppm + 65 μA	
	200 mA to 2 A		
	10 Hz to 1 kHz	580 ppm + 570 μA	
	1 kHz to 5 kHz	0.18 % ppm + 1.2 mA	
DC HIGH CURRENT			
	2 A to 3.2 A	700 ppm + 1.1 mA	These values can be or simulated using a multi turn coil generated, the uncertainties listed are appropriate for the calibration of suitably stable measuring devices of sufficient resolution.
	3.2 A to 10 .5 A	640 ppm + 2.5 mA	
	10.5 A to 20 A	640 ppm + 5.6 mA	
	20 A to 32 A	0.25 % + 6.3 mA	
	32 A to 105 A	0.24 % + 17 mA	
	105 A to 200 A	0.24 % + 54 mA	
	200 A to 525 A	0.24 % + 82 mA	
	525 A to 1000 A	0.24 % + 270 mA	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k = 2)	Remarks
AC HIGH CURRENT			
	2 A to 3.2 A *10 Hz to 3 kHz* 3.2 A to 10 .5 A *10 Hz to 3 kHz* 10.5 A to 20 A *10 Hz to 3 kHz* 20 A to 32 A *10 Hz to 100 Hz* *100 Hz to 440 Hz* 32 A to 200 A *10 Hz to 100 Hz* *100 Hz to 400 Hz* 200 A to 1000 A *10 Hz to 100 Hz*	 0.12 % + 860 µA 0.23 % + 4.3 mA 0.23 % + 8.4 mA 0.33 % + 13 mA 0.93 % + 33 mA 0.33 % + 110 mA 0.81 % + 290 mA 0.34 % + 540 mA	These values can be or simulated using a multi turn coil generated, the uncertainties listed are appropriate for the calibration of suitably stable measuring devices of sufficient resolution.
FREQUENCY			
	0.1 Hz to 10 MHz	4.0 in 10^7	Generation and Measurement
TIME INTERVAL	0 s to 1 hr	4 ms	Measurement of elapsed time
ACCELERATION TRANSDUCERS – Sinusoidal Reference (precision) grades <u>Piezoelectric Type</u>			
Transducer at 20^0C:	Nominal peak acceleration 10 ms^{-2} to 60 ms^{-2}		Calibration of charge sensitivity by comparison with a single ended (precision grade) transducer
High frequency test	Transducer mass 0 grams to 80 grams Charge sensitivity 0.08 pC/ms^{-2} to 0.30 pC/ms^{-2} *20 Hz to 10 000 Hz* Transducer mass 80 grams to 600 grams Charge sensitivity 0.30 pC/ms^{-2} to 2.0 pC/ms^{-2} *20 Hz to 10 000 Hz*	 0.60 % 1.0 %	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k = 2)	Remarks
ACCELERATION TRANSDUCERS – Sinusoidal continued			
Low frequency test	Charge sensitivity > 0.08 pC/ms^{-2}		
	2 Hz to 20 Hz	1.5 %	
Transducer and associated signal conditioner at 20 ^{0}C:			Calibration of transducer and signal conditioner systems can also be undertaken
High frequency test	Transducer mass 0 grams to 80 grams Voltage sensitivity 8 mV/ms^{-2} to 150 mV/ms^{-2}		
	20 Hz to 10 000 Hz	0.70 %	
	Transducer mass 80 grams to 600 grams Voltage sensitivity 8 mV/ms^{-2} to 150 mV/ms^{-2}		
	20 Hz to 10000 Hz	1.0 %	
Low frequency test	Sensitivity 3.0 mV/ms^{-2} to 150 mV/ms^{-2}		
	1 Hz to 20 Hz	2.0 %	
<u>Integral electronics type</u>			
Transducer at 20 ^{0}C:	Nominal peak acceleration 10 ms^{-2} to 60 ms^{-2}		
High frequency test	Transducer voltage sensitivity 0.12 mV/ms^{-2} to 150 mV/ms^{-2}		
	20 Hz to 5 kHz *6.3 kHz to 10 kHz*	0.70 % 2.0 %	
Low Frequency test	Transducer voltage sensitivity 0.25 mV/ms^{-2} to 1000 mV/ms^{-2}		
	2 Hz to 20 Hz	2.0 %	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k = 2)	Remarks
ACCELERATION TRANSDUCERS – Sinusoidal continued			
<u>Piezoelectric Type</u>			
Working (non-precision) grades			
Transducer at 20 ^{0}C	Nominal peak acceleration 1 ms^{-2} to 350 ms^{-2}		Calibration of charge sensitivity by comparison with a reference (precision grade) transducer. System calibrations comprising transducer (tx), signal conditioner and power supply can be undertaken within the quoted uncertainties.
High frequency test	Sensitivity (tx) or (system) 0.01 pC/ms^{-2} to 1000 pC/ms^{-2} (tx), 1.2 mV/ms^{-2} to 1000 mV/ms^{-2} (system)		
	20 Hz to 5000 Hz	1.5 %	
Low Frequency Test	Nominal peak acceleration 1 Hz: 1 ms^{-2} to 1.5 ms^{-2}		
	2 Hz to 4 Hz: 1 ms^{-2} to 5.0 ms^{-2}		
	5 Hz to 20 Hz: 1 ms^{-2} to 20 ms^{-2}		
	Sensitivity (tx)		
	0.300 pC/ms^{-2} to 1000 pC/ms^{-2} *1 Hz*	2.0 %	
	0.085 pC/ms^{-2} to 1000 pC/ms^{-2} *2 Hz to 4 Hz*	1.5 %	
	Sensitivity (system)		
	0.025 pC/ms^{-2} to 1000 pC/ms^{-2} *5 Hz to 20 Hz*	1.5 %	
	30 mV/ms^{-2} to 1000 mV/ms^{-2} *1 Hz*	2.0 %	
	8.5 mV/ms^{-2} to 1000 mV/ms^{-2} *2 Hz to 4 Hz*	1.5 %	
	2.5 mV/ms^{-2} to 1000 mV/ms^{-2} *5 Hz to 20 Hz*	1.5 %	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k = 2)	Remarks
ACCELERATION TRANSDUCERS – Sinusoidal continued			
Transducer at any temperature from - 50 ^{0}C to + 200 ^{0}C:	Nominal peak acceleration 1 ms^{-2} to 40 ms^{-2} Sensitivity (tx) or (system) 0.01 pC/ms^{-2} to 1000 pC/ms^{-2} (tx), 1.2 mV/ms^{-2} to 1000 mV/ms^{-2} (system)		
	20 Hz to 630 Hz	2.0 %	
<u>Piezoresistive or strain-gauge type</u>			
Working (non-precision) grades			
Transducer at 20 ^{0}C:			
High frequency test	Nominal peak acceleration 1 ms^{-2} to 350 ms^{-2} Sensitivity (tx) or (system) 0.02 mV/ms^{-2} to 1000 mV/ms^{-2} (tx), 1.2 mV/ms^{-2} to 1000 mV/ms^{-2} (system)		Calibration of voltage sensitivity by comparison with a reference (precision grade) transducer. System calibrations comprising transducer (tx), signal conditioner and power supply can be undertaken within the quoted uncertainties.
	20 Hz to 5000 Hz	2.0 %	
Low frequency test	Nominal peak acceleration 1 Hz: 1 ms^{-2} to 1.5 ms^{-2}		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k = 2)	Remarks
ACCELERATION TRANSDUCERS – Sinusoidal continued			
Piezoresistive or strain-gauge type (cont'd)			
Working (non-precision) grades (cont'd)			
Low frequency test (cont'd)	Sensitivity (tx)		
	0.60 mV/ms^{-2} to 1000 mV/ms^{-2} *1 Hz*	2.0 %	
	0.17 mV/ms^{-2} to 1000 mV/ms^{-2} *2 Hz to 4 Hz*	2.0 %	
	0.05 mV/ms^{-2} to 1000 mV/ms^{-2} *5 Hz to 20 Hz*	2.0 %	
	Sensitivity (system)		
	30 mV/ms^{-2} to 1000 mV/ms^{-2} *1 Hz*	2.0 %	
	8.5 mV/ms^{-2} to 1000 mV/ms^{-2} *2 Hz to 4 Hz*	2.0 %	
	2.5 mV/ms^{-2} to 1000 mV/ms^{-2} *5 Hz to 20 Hz*	2.0 %	
Transducer at any temperature from - 50 ^{0}C to + 200 ^{0}C:	Nominal peak acceleration 1 ms^{-2} to 40 ms^{-2}		
	Sensitivity (tx) or (system) 0.02 mV/ms^{-2} to 1000 mV/ms^{-2} (tx) 1.2 mV/ms^{-2} to 1000 mV/ms^{-2} (system)		
	20 Hz to 630 Hz	2.5 %	
Integral electronics type Transducer at 20 ^{0}C:	Nominal peak acceleration 1 ms^{-2} to 350 ms^{-2}		
High frequency test	Sensitivity (tx) or (system) 0.12 mV/ms^{-2} to 1000 mV/ms^{-2} (tx), 1.2 mV/ms^{-2} to 1000 mV/ms^{-2} (system)		Calibration of voltage sensitivity by comparison with a reference (precision grade) transducer. System calibrations comprising transducer (tx), signal conditioner and power supply can be undertaken within the stated CMCs.
	20 Hz to 5000 Hz	2.0 %	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k = 2)	Remarks
ACCELERATION TRANSDUCERS - Sinusoidal (cont'd)			
Integral electronics type (cont'd)			
Working (non-precision) grades (cont'd)			
Low frequency test	Nominal peak acceleration 1 Hz: 1 ms^{-2} to 1.5 ms^{-2}		
	2 Hz to 4 Hz: 1 ms^{-2} to 5.0 ms^{-2}		
	5 Hz to 20 Hz: 1 ms^{-2} to 20 ms^{-2}		
	Sensitivity (tx)		
	3.0 mV/ms^{-2} to 1000 mV/ms^{-2} *1 Hz*	2.0 %	
	0.85 mV/ms^{-2} to 1000 mV/ms^{-2} *2 Hz to 4 Hz*	2.0 %	
	0.25 mV/ms^{-2} to 1000 mV/ms^{-2} *5 Hz to 20 Hz*	2.0 %	
	Sensitivity (system)		
	30 mV/ms-2 to 1000 mV/ms-2 *1 Hz*	2.0 %	
	8.5 mV/ms^{-2} to 1000 mV/ms^{-2} *2 Hz to 4 Hz*	2.0 %	
	2.5 mV/ms^{-2} to 1000 mV/ms^{-2} *5 Hz to 20 Hz*	2.0 %	
Transducer at any temperature from - 50 ^{0}C to + 200 ^{0}C:	Nominal peak acceleration 1 ms^{-2} to 40 ms^{-2}		
	Sensitivity 0.12 mV/ms^{-2} to 1000 mV/ms^{-2} (tx), 1.2 mV/ms^{-2} to 1000 mV/ms^{-2} (system)		
	20 Hz to 630 Hz	2.5 %	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k = 2)	Remarks
ACCELERATION TRANSDUCERS - SHOCK CALIBRATION			
Working (non-precision) grades			
<u>Piezoelectric type</u>			
Transducer at 20 ^{0}C:	Sensitivity 0.0001 pC/ms^{-2} to 100 pC/ms^{-2}		The transducer to be calibrated must have a mass of no more than 40 grams
	200 ms^{-2} to 5000 ms^{-2} 5000 ms^{-2} to 50000 ms^{-2}	2.0 % 2.8 %	Calibration of charge sensitivity by comparison with a reference (precision grade) transducer
<u>Piezoresistive type</u>			The upper limit for the calibrated acceleration level is subject to a maximum charge output of 10 nC, e.g. for a device sensitivity of 1 pC/ms^{-2} the maximum acceleration level for calibration would be: 10 nC / 1 pC/ms^{-2} = 10000 ms^{-2}
Transducer at 20 ^{0}C:	Sensitivity 0.0001 mV/ms^{-2} to 100 mV/ms^{-2}		
	200 ms^{-2} to 5000 ms^{-2} 5000 ms^{-2} to 50000 ms^{-2}	2.0 % 2.8 %	Calibration of voltage sensitivity by comparison with a reference (precision grade) transducer The upper limit for the calibrated acceleration level is subject to a maximum voltage output of 10 V, e.g. for a device sensitivity of 1 mV/ms^{-2} the maximum acceleration level for calibration would be: 10 V / 1 mV/ms^{-2} = 10000 ms

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k = 2)	Remarks
<u>Integral electronics type</u>			
Transducer at 20 ^{0}C:	Sensitivity 0.0001 mV/ms^{-2} to 100 mV/ms^{-2}		Calibration of voltage sensitivity by comparison with a reference (precision grade) transducer.
	200 ms^{-2} to 5000 ms^{-2} 5000 ms^{-2} to 50000 ms^{-2}	2.0 % 2.8 %	The upper limit for the calibrated acceleration level is subject to a maximum voltage output of 10 V, e.g. for a device sensitivity of 1 mV/ms^{-2} the maximum acceleration level for calibration would be: 10 V / 1 mV/ms^{-2} = 10000 ms^{-2}
<u>System</u>			
System components at 20 ^{0}C:	Sensitivity 0.0001 mV/ms^{-2} to 100 mV/ms^{-2}		Calibration of system voltage sensitivity by comparison with a reference (precision grade) transducer.
	200 ms^{-2} to 5000 ms^{-2} 5000 ms^{-2} to 50000 ms^{-2}	2.0 % 2.8 %	System calibrations comprising transducer, signal conditioner and power supply can be undertaken. The upper limit for the calibrated acceleration level is dependent on the system conditioner configuration and output
CHARGE AMPLIFIERS			
Precision and working grade types for use with transducers	Calibration of voltage output per picocoulomb or millivolt input *1 Hz to 100 kHz*	0.40 %	Minimum input 1 pC or 10 mV
With respect to a set point of 160 Hz with reference at voltages between 10 mV and 1 V			
PORTABLE CALIBRATORS	*20 Hz to 2 kHz*	2.0 %	Calibration of portable calibrators by comparison methods

END

Appendix - Calibration and Measurement Capabilities

Introduction

The definitive statement of the accreditation status of a calibration laboratory is the Accreditation Certificate and the associated Schedule of Accreditation. This Schedule of Accreditation is a critical document, as it defines the measurement capabilities, ranges and boundaries of the calibration activities for which the organisation holds accreditation.

Calibration and Measurement Capabilities (CMCs)

The capabilities provided by accredited calibration laboratories are described by the Calibration and Measurement Capability (CMC), which expresses the lowest uncertainty of measurement that can be achieved during a calibration. If a particular device under calibration itself contributes significantly to the uncertainty (for example, if it has limited resolution or exhibits significant non-repeatability) then the uncertainty quoted on a calibration certificate will be increased to account for such factors. The CIPM-ILAC definition of the CMC is as follows:

A CMC is a calibration and measurement capability available to customers under normal conditions:
(a) as published in the BIPM key comparison database (KCDB) of the CIPM MRA; or
(b) as described in the laboratory's scope of accreditation granted by a signatory to the ILAC Arrangement.

The CMC is normally used to describe the uncertainty that appears in an accredited calibration laboratory's schedule of accreditation and is the uncertainty for which the laboratory has been accredited using the procedure that was the subject of assessment. The CMC is calculated according to the procedures given in M3003 and is normally stated as an expanded uncertainty at a coverage probability of 95 %, which usually requires the use of a coverage factor of $k = 2$. An accredited laboratory is not permitted to quote an uncertainty that is smaller than the published CMC in certificates issued under its accreditation.

The CMC may be described using various methods in the Schedule of Accreditation:

As a single value that is valid throughout the range.
As an explicit function of the measurand or of a parameter (see below).
As a range of values. The range is stated such that the customer can make a reasonable estimate of the likely uncertainty at any point within the range.
As a matrix or table where the CMCs depend on the values of the measurand and a further quantity.
In graphical form, providing there is sufficient resolution on each axis to obtain at least two significant figures for the CMC.

Expression of CMCs - symbols and units

In general, only units of the SI and those units recognised for use with the SI are used to express the values of quantities and of the associated CMCs. Nevertheless, other commonly used units may be used where considered appropriate for the intended audience. For example, the term "ppm" (part per million) is frequently used by manufacturers of test and measurement equipment to specify the performance of their products. Terms like this may be used in Schedules of Accreditation where they are in common use and understood by the users of such equipment, providing their use does not introduce any ambiguity in the capability that is being described.

When the CMC is expressed as an explicit function of the measurand or of a parameter, this often comprises a relative term (e.g., percentage) and an absolute term, i.e. one expressed in the same units as those of the measurand. This form of expression is used to describe the capability that can be achieved over a range of values. Some examples are shown below. It should be noted that these expressions are *not* mathematical formulae but are instead written in a commonly used shorthand for expressing uncertainties - therefore, for purposes of clarity, an indication of how they are to be interpreted is also provided below.

DC voltage, 100 mV to 1 V: 0.0025 % + 5.0 µV

Over the range 100 mV to 1 V, the CMC is 0.0025 %·V + 5.0 µV, where V is the measured voltage.

Hydraulic pressure, 0.5 MPa to 140 MPa: 0.0036 % + 0.12 ppm/MPa + 4.0 Pa

Over the range 0.5 MPa to 140 MPa, the CMC is $0.0036\ \%\cdot p + (0.12\cdot 10^{-6}\cdot p\cdot 10^{-6}) + 4.0$ Pa, where p is the measured pressure in Pa.

It should be noted that the percentage symbol (%) simply represents the number 0.01. In cases where the CMC is stated only as a percentage, this is to be interpreted as meaning percentage of the measured value or indication.

Thus, for example, a CMC of 1.5 % means $1.5 \cdot 0.01 \cdot i$, where i is the instrument indication.