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0478 Accredited to ISO/IEC 17025:2005	**National Physical Laboratory** **Issue No:** 054 **Issue date:** 02 April 2012
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Calibration performed by the Organisation at the locations specified below

Locations covered by the organisation and their relevant activities

Laboratory locations:

Location details		Activity	Location code
Address National Physical Laboratory Hampton Road Teddington Middlesex TW11 0LW	**Local contact** Mr Tahir MaqbaCustomer Services Manager Tel: +44 (0)20 8943 6796 Fax: +44 (0)20 8943 66184 Email: tahir.maqba@npl.co.uk	Calibration Acoustics Chemical Dimensional Electromagnetic Fibre optics Flow Force Humidity Mass Optical Pressure Radiological Temperature Time and Frequency Ultrasonics	Teddington
Address Wraysbury Reservoir Coppermill Road Wraysbury Middlesex TW19 5NW	**Local contact** Mr G Hayman Tel: +44 (0)20 8943 7172 Email: gary.hayman@npl.co.uk	Calibration Underwater Acoustics	Wraysbury

Site activities performed away from the locations listed above:

Location details	Activity	Location code
Customers' sites or premises The customers' site or premises must be suitable for the nature of the particular calibrations undertaken and will be the subject of contract review arrangements between the laboratory and the customer.	Calibration Time and Frequency Humidity Chemical *(Environmental air quality monitoring instruments)*	Customers' sites

DETAIL OF ACCREDITATION

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
DC VOLTAGE				Teddington
Standard cells, not thermostated	1.018 V nominal	0.09 ppm	Measured in a thermostated air enclosure at 20 °C	
Standard cells in a thermostated enclosure	1.018 V nominal	0.09 ppm		
Electronic reference standards	1.0 V 1.018 V 10 V	0.14 ppm 0.14 ppm 0.02 ppm	Supplementary data can be supplied showing detailed behaviour of standard cells or electronic devices	
DC RESISTANCE	0.1 mΩ 1 mΩ 10 mΩ 100 mΩ 1 Ω 10 Ω 25 Ω 100 Ω 1 kΩ 10 kΩ	2.4 ppm 0.85 ppm 0.80 ppm 0.18 ppm 0.06 ppm 0.05 ppm 0.05 ppm 0.05 ppm 0.05 ppm 0.06 ppm	4 terminal resistors at temperatures between 17 °C and 25 °C and at or less than 1 mW power dissipation	
	100 kΩ 1 MΩ 10 MΩ 100 MΩ	0.08 ppm 0.12 ppm 0.2 ppm 0.4 ppm	2-terminal resistors at temperatures between 17 °C and 25 °C and at or less than 1 mW power dissipation. Values >10 MΩ are not measured in oil.	
	1 GΩ	1.6 ppm	Measured in a 2-terminal configuration, in air, at 20 °C or 23 °C	
Temperature Coefficient	α β	α- 0.002 ppm K^{-1} β- 0.001 ppm K^{-2}	Resistance measurements at 4 temperatures in the range 15 °C to 30 °C. Uncertainty dependent on fit to curve and nominal value of resistor	
Current Carrying Resistors	100 μΩ to 10 Ω	0.5 ppm	For current levels up to 100 A. The uncertainty is dependent on measurement current, nominal value of resistor, elapsed time for which the current is applied and the specific calibration undertaken.	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)		Remarks	Location Code
AC RESISTANCE					Teddington
Specific values	1Ω				
	40 Hz to 1 kHz	5.0 ppm		The uncertainties quoted for AC resistance may depend on the type and construction of the resistor	
	1 kHz to 2 kHz	4.0 ppm			
	2 kHz to 3 kHz	5.0 ppm			
	3 kHz to 5 kHz	6.0 ppm			
	5 kHz to 10 kHz	15 ppm			
Other values	10 Ω to 10 k Ω			*Exceptions:*	
	40 Hz to 400 Hz	1.0 ppm		10 Ω/40 Hz: 1.5 ppm	
	400 Hz to 2 kHz	0.5 ppm		100 Ω/400 Hz to 1.59 kHz: 0.6 ppm	
	2 kHz to 3 kHz	1.2 ppm		100 Ω/1.59 kHz to 2 kHz: 0.8 ppm	
	3 kHz to 5 kHz	1.8 ppm		100 Ω/2 kHz to 3 kHz: 1.5 ppm	
	5 kHz to 10 kHz	6.0 ppm		10 kΩ/10 kHz: 8.0 ppm	
Time constant (τ)	Up to ± 200 ns	10 ns		All nominal values and frequencies	
AC CURRENT RATIO					
<u>Current Transformers</u>		*Ratio error*	*Phase error*		
Ratio and phase error (Primary to 1A or 5A secondary at unity power factor)	0.25 A to 0.5 A, 50 Hz	10 ppm	10 µrads	The uncertainties apply to compensated current transformers only.	
	0.5 A to 5 A, 50 Hz	2.5 ppm	2.5 µrads		
	5 A to 1000 A, 50 Hz to 400 Hz	2.5 ppm	2.5 µrads		
	1000 A to 5000 A, 50 Hz to 60 Hz	10 ppm	10 µrads	Above 10 kA, 5 A secondary only	
	5 kA to 10 kA, 50 Hz	20 ppm	20 µrads		
	10 kA to 20 kA, 50 Hz	20 ppm	20 µrads		
<u>Current Transformer Test Sets</u>	*At 50 Hz:*				
Ratio error	10 ppm to 20 %	3 ppm			
Phase angle error	10 µrads to 10 000 µrads	3 µrads			
<u>Current Transformers</u>		*Ratio error*	*Phase error*	The uncertainties apply to measurements carried out on uncompensated current transformers in accordance with BS EN 60044-1 at unity or 0.8 power factor as specified or required.	
Ratio and phase error	*50 Hz to 400 Hz*				
	Class 0.01, 0.02 and 0.03	10 ppm	10 µrads		
	Class 0.1 and higher	30 ppm	30 µrads		
<u>Current Transducers</u>					
with output voltage greater than 0.25 V	*50 Hz*	0.05 %			

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k=2)	Remarks	Location Code
AC/DC TRANSFER VOLTAGE				Teddington

AC/DC Transfer Voltage, at Specific Values, expressed as an Expanded Uncertainty (k=2) [± ppm]

For intermediate points the uncertainty will be determined using linear interpolation between the adjacent points.

Voltage	Frequency (Hz) 10	20 to 5k	10 k	20 k	50 k	100 k	200 k	300 k	500 k	700 k	1 M
1 mV	26	26	26	28	36	58	100	160	260	460	780
2 mV	26	26	26	26	30	47	80	120	190	310	490
5 mV	26	26	26	26	30	45	77	110	180	270	440
10 mV	26	26	26	26	30	42	72	100	170	240	370
20 mV	26	26	26	26	30	42	71	100	160	230	340
70 mV	26	26	26	26	30	41	70	100	160	230	330
100 mV	6	6	6	6	8	13	24	36	58	82	120
200 mV	6	6	6	6	8	13	24	36	58	82	120
300 mV	5	5	5	5	6	11	20	29	48	67	96
500 mV	5	5	5	5	6	9	16	23	38	54	76
1 V	5	5	5	5	6	7	12	16	25	37	51
2 V	5	5	5	5	5	6	9	12	17	26	38
3 V	5	5	5	5	5	6	9	12	17	26	38
4 V	5	5	5	5	5	6	7	9	13	20	31
5 V	5	5	5	5	5	6	7	9	13	20	31
10 V	6	6	6	6	6	7	9	10	15	23	33
20 V	7	7	7	7	7	7	10	13	16	27	35
30 V	7	7	7	7	7	8	12				
50 V	8	7	7	7	8	11	15				
70 V	8	7	7	7	8	12	15				
100 V	8	7	7	7	8	11	15				
200 V	9	8	8	10	13	22					
300 V	9	8	8	10	13	22					
500 V	14	10	11	14	23	42					
600 V	14	10	11	18	28	52					
700 V	14	10	11	18	28	52					
1 kV	14	10	12	23	32	62					

Measured Quantity Instrument or Gauge	Range	CMC	Remarks
AC/DC TRANSFER VOLTAGE (High Frequency)	1 V		
	3 MHz	51 ppm	
	10 MHz	64 ppm	
	20 MHz	140 ppm	
	30 MHz	300 ppm	
	50 MHz	600 ppm	
	70 MHz	0.11 %	
	100 MHz	0.21 %	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
AC VOLTAGE				Teddington

AC Voltage, at Specific Values, expressed as an Expanded Uncertainty (*k*=2) [± ppm]

For intermediate points the uncertainty will be determined using linear interpolation between the adjacent points.

Voltage	*Frequency (Hz)* 10	20 to 5k	10 k	20 k	50 k	100 k	200 k	300 k	500 k	700 k	1 M
500 mV	7	7	7	7	10	13	20	29	43	62	86
1 V	7	7	7	9	11	13	17	22	30	43	59
2 V	7	7	7	7	9	11	14	18	22	31	43
3 V	7	7	7	7	7	8	11	15	20	29	40
4 V	7	7	7	7	7	7	9	11	15	22	33
5 V	7	7	7	7	7	7	9	11	15	22	33
10 V	8	7	7	7	7	8	10	11	17	25	34
20 V	8	8	8	8	8	9	11	14	18	28	37
30 V	8	8	8	8	8	9	13				
50 V	9	9	9	9	9	12	16				
70 V	9	9	9	9	9	12	16				
100 V	9	9	9	9	9	12	16				
200 V	10	9	9	11	14	22					
300 V	10	9	9	11	14	22					
500 V	14	11	12	15	23	42					
600 V	14	11	12	19	28	52					
700 V	14	11	12	19	28	52					
1 kV	14	11	12	23	33	62					

AC/DC TRANSFER CURRENT

AC/DC Transfer Current, at Specific Values, expressed as an Expanded Uncertainty (*k*=2) [± ppm]

For intermediate points the uncertainty will be determined using linear interpolation between the adjacent points.

Current	*Frequency (Hz)* 10	20	40	100	400	1 k	2 k	5 k	10 k	20 k	50 k	70 k	100 k
1 mA	31	30	30	30	30	30	30	30	30	31	31	33	35
2 mA	17	17	16	16	16	16	16	16	17	18	19	22	25
3 mA	12	12	12	12	12	12	12	12	13	14	16	19	22
5 mA	11	10	10	10	10	10	10	10	12	13	15	19	22
10 mA	11	10	10	10	10	10	10	10	12	13	15	19	22
20 mA	11	10	10	10	10	10	10	10	12	13	15	19	22
30 mA	11	10	10	10	10	10	10	10	12	13	15	19	22
50 mA	11	10	10	10	10	10	10	10	12	13	15	19	22
0.1 A	14	13	12	12	12	12	12	12	12	13	20	23	42
0.2 A	23	20	16	16	16	16	16	16	16	17	28	33	61
0.25 A	23	20	16	16	16	16	16	16	16	17	28	33	61
0.3 A	30	26	16	17	16	18	16	17	15	24	43	52	81
0.5 A	30	26	16	17	16	18	16	17	15	24	43	52	81
1 A	38	31	19	19	19	20	17	18	17	33	53	62	100
2 A	47	37	22	20	21	22	20	21	20	43	63	83	120
2.5 A	47	37	22	20	21	22	20	21	20	43	63	83	120
3 A	55	43	25	23	24	24	23	21	22	53	83	100	160
5 A	55	43	25	23	24	24	23	21	22	53	83	100	160
10 A	63	49	27	25	26	26	25	26	23	62	100	120	200
20 A	72	56	31	28	30	29	28	29	28	73	120	140	240

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)		Remarks	Location Code
AC VOLTAGE RATIO					Teddington
<u>Selective error voltage transformers</u>					
Voltage ratio error and phase angle error	*At 50 Hz:* Up to 0.2 % Up to ± 8 minutes	 50 ppm 0.10 minute (30 μrads)		The uncertainties apply to selective error voltage transformers having a nominal ratio of 1:1 at nominal mains voltages of 110V, 230V, 240V and 250V	
<u>Inductive Voltage Dividers</u>		Voltage ratio uncertainty with respect to input voltage (x 10^{-8})			
Voltage ratio		*In-phase*	*Quadrature*		
	LF System			Normal operating range: Minimum voltage: 1 V Maximum voltage: 0.1 x f(Hz) from 40 Hz to 80 Hz; 0.15 x f(Hz) from 103 Hz to 203 Hz; 30 V otherwise.	
	40 Hz	16	17		
	60 Hz	16	17		
	80 Hz	12	14		
	103 Hz	9.1	11		
	120 Hz	7.0	8.3		
	203 Hz	6.1	7.6		
	303 Hz	6.1	6.8		
	400 Hz	6.1	6.8		
	600 Hz	6.1	6.8		
	800 Hz	6.1	6.8		
	1000 Hz	6.1	6.8		
	1300 Hz	6.1	6.8		
	1592 Hz	6.1	6.8		
	2000 Hz	6.8	7.9		
	3000 Hz	9.0	9.7		
	4000 Hz	14	14		
	5000 Hz	21	21		
	HF System			Normal operating range: Minimum voltage: 1 V Maximum voltage: 60 V	
	5 kHz	21	21		
	8 kHz	29	29		
	10 kHz	38	38		
	20 kHz	71	74		
	30 kHz	120	120		
	40 kHz	180	190		
	50 kHz	280	290		
	80 kHz	620	640		
	100 kHz	980	1020		
	120 kHz	1450	1540		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k=2)	Remarks	Location Code
AC POWER *Sinusoidal waveforms*	*40 Hz to 400 Hz:*			Teddington
	Current 2 mA to 130 A Voltage 1 V to 1000 V	40 ppm of full scale	20 °C and 23 °C at unity power factor	
		25 ppm of full scale	20 °C and 23 °C at zero power factor	
			Uncertainties increase at other power factors	
Current Response of Wattmeters	2 mA to 20 A	30 ppm of full scale	20 °C and 23 °C	
Voltage Response of Wattmeters	1 V to 1000 V	25 ppm of full scale	20 °C and 23 °C	
Auxiliary DC Voltage	DC, 1 V to 10 V	5.0 ppm of value	20 °C and 23 °C	
AC REACTIVE VOLT-AMPERES *Sinusoidal waveforms*	*50 Hz to 400 Hz:*			
	Current 2 mA to 130 A Voltage 1 V to 1000 V	40 ppm of full scale	20 °C and 23 °C at zero power factor	
		25 ppm of full scale	20 °C and 23 °C at unity power factor	
			Uncertainties increase at other power factors	
CALIBRATION OF EN 61000 HARMONIC AND FLICKER ANALYSERS *Sinusoidal waveforms*				
Current accuracy Current frequency response Voltage accuracy	100 mA to 20 A, *50 Hz* 100 mA to 20 A, *50 Hz to 2 kHz* 1 V to 1000 V, *50 Hz*	40 ppm 150 ppm 30 ppm		
Power measurements	Ranges as in *AC Power* above	45 ppm of full-scale	At unity power factor	
Non-sinusoidal waveforms				
Harmonic measurements for current waveforms	Peak values 1A to 10 A 50 Hz fundamental; harmonics up to 2 kHz	200 ppm	Steady-state, burst fluctuating or smoothly fluctuating harmonics	
Flicker (Pst)	Square or sine wave modulated, 230 V 50 Hz sine wave	0.30 % of Pst reading		
	Complex waveforms, 230 V 50 Hz sine wave	0.20 % of Pst reading	See the NPL web site for details about these complex waveforms.	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)		Remarks	Location Code
CAPACITANCE and DISSIPATION FACTOR				Capacitance and dissipation factor measurements are normally carried out between 20 °C and 23 °C but may exceptionally be carried out at any temperature between 18 °C and 25 °C. These measurements can be made at frequencies from 20 Hz to 100 kHz, depending on value, but with increased uncertainties.	**Teddington**
Fused-silica dielectric capacitors	*At 1 kHz and 1.592 kHz*	C	D		
	10 pF 100 pF	0.70 ppm 0.90 ppm	6.0×10^{-6} 7.0×10^{-6}		
Other types of capacitor	1 nF *1 kHz* *1.592 kHz* *10 kHz* *100 kHz*	 3.0 ppm 3.0 ppm 5.0 ppm 200 ppm	 20×10^{-6} 20×10^{-6} 20×10^{-6} 1.0×10^{-4}		
	At 1 kHz and 1.592 kHz				
	1 pF to 10 pF 10 pF to 1 nF 1 nF to 100 nF 100 nF to 1 µF	4.0 ppm 3.0 ppm 30 ppm 60 ppm	10×10^{-6} 7.0×10^{-6} 20×10^{-6} 20×10^{-6}		
General Radio Type 1417	1 µF to 10 mF *100 Hz, 120 Hz and 1 kHz*	0.1 % to 0.5 %	0.0010 to 0.0005		
	100 mF to 1 F *100 Hz and 120 Hz*	0.3 % to 1 %	0.0030 to 0.010		
Dissipation Factor Standard	0.0 to 0.001 *1 kHz*	20×10^{-5}			
	0.0 to 0.005 *50 Hz*	20×10^{-5}			

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
SELF-INDUCTANCE				Teddington

Expanded uncertainty at 95% confidence level (k=2) for the frequencies shown

Nominal value	20 Hz	50 Hz	100 Hz 400 Hz	1 kHz	1.592 kHz 2 kHz	5 kHz	10 kHz
1 µH			2.0 %	0.10 %	0.10 %	0.25 %	0.35 %
2 µH			1.0 %	0.10 %	0.10 %	0.22 %	0.30 %
3 µH			0.61 %	0.10 %	0.10 %	0.22 %	0.26 %
5 µH			0.35 %	600 ppm	600 ppm	0.11 %	0.15 %
10 µH	0.35 %	0.25 %	0.20 %	310 ppm	350 ppm	620 ppm	930 ppm
20 µH	0.18 %	0.13 %	0.10 %	150 ppm	160 ppm	320 ppm	460 ppm
30 µH	0.12 %	840 ppm	670 ppm	110 ppm	115 ppm	190 ppm	260 ppm
50 µH	700 ppm	500 ppm	400 ppm	100 ppm	100 ppm	160 ppm	200 ppm
100 µH	300 ppm	200 ppm	150 ppm	75 ppm	80 ppm	120 ppm	150 ppm
200 µH	250 ppm	180 ppm	100 ppm	75 ppm	85 ppm	110 ppm	150 ppm
300 µH	250 ppm	180 ppm	100 ppm	85 ppm	85 ppm	120 ppm	150 ppm
500 H	220 ppm	160 ppm	100 ppm	80 ppm	80 ppm	100 ppm	150 ppm
1 mH	180 ppm	150 ppm	95 ppm	70 ppm	75 ppm	100 ppm	150 ppm
2 mH	180 ppm	150 ppm	100 ppm	75 ppm	80 ppm	110 ppm	150 ppm
3 mH	180 ppm	150 ppm	100 ppm	85 ppm	85 ppm	120 ppm	150 ppm
5 mH	180 ppm	160 ppm	100 ppm	80 ppm	80 ppm	110 ppm	150 ppm
10 mH	180 ppm	150 ppm	100 ppm	70 ppm	70 ppm	100 ppm	130 ppm
20 mH	180 ppm	150 ppm	100 ppm	75 ppm	75 ppm	110 ppm	130 ppm
30 mH	180 ppm	150 ppm	100 ppm	85 ppm	85 ppm	110 ppm	150 ppm
50 mH	200 ppm	160 ppm	100 ppm	80 ppm	80 ppm	160 ppm	200 ppm
100 mH	185 ppm	150 ppm	85 ppm	70 ppm	70 ppm	140 ppm	200 ppm
200 mH	230 ppm	200 ppm	90 ppm	75 ppm	75 ppm	200 ppm	300 ppm
400 mH	240 ppm	200 ppm	90 ppm	75 ppm	75 ppm	200 ppm	380 ppm
500 mH	240 ppm	210 ppm	90 ppm	80 ppm	80 ppm	200 ppm	400 ppm
1 H	140 ppm	110 ppm	85 ppm	70 ppm	70 ppm	200 ppm	400 ppm
2 H	140 ppm	110 ppm	85 ppm	70 ppm	70 ppm	380 ppm	800 ppm
5 H	140 ppm	110 ppm	85 ppm	80 ppm	85 ppm		
10 H	140 ppm	110 ppm	85 ppm	80 ppm	85 ppm		

NOTE

Inductance measurements are normally carried out between 20 °C and 23 °C but may exceptionally be carried out at any temperature between 18 °C and 25 °C. The DC resistance of an inductor can also be reported as an indication of its temperature. Inductance measurements may be made at other frequencies between 20 Hz and 10 kHz but the uncertainties may be increased.

Measured Quantity Instrument or Gauge	Range	CMC	Remarks	Location Code
MUTUAL INDUCTANCE (single value only)	*At 1 kHz:*			Teddington
	1 mH	100 ppm		
	5 mH	80 ppm		
	10 mH	70 ppm		
	100 mH	70 ppm		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
DC MAGNETIC FIELD STRENGTH AND MAGNETIC FLUX DENSITY				Teddington
	0.8 mA/m (1 nT) to 16 A/m (20 µT)	0.15 % + 0.5 nT		
	16A/m (20 µT) to 72 A/m (90 µT)	0.0030 %		
	72 A/m (90 µT) to 40 kA/m (50 mT)	0.20 %		
	40 kA/m (50 mT) to 10.5 MA/m (13T)	0.0015 %		
AC MAGNETIC FIELD STRENGTH AND MAGNETIC FLUX DENSITY				
	8 mA/m (10 nT) to 17.5 kA/m (22 mT) *10 Hz to 60 Hz*	0.25 %		
	8 mA/m (10 nT) to 80 A/m (100 µT) *60 Hz to 20 kHz*	0.25 %		
	8 mA/m (10 nT) to 40 A/m (50 µT) *20 kHz to 50 kHz*	0.40 %		
	8 mA/m (10 nT) to 15.9 A/m (20 µT) *50 kHz to 120 kHz*	0.70 %		
Standard solenoids and Helmholtz coils	*DC* *12 Hz to 60 Hz* *60 Hz to 20 kHz*	0.015 % 0.050 % 0.25 %		
Search coils	*12 Hz to 60 Hz* *60 Hz to 20 kHz* *20 kHz to 50 kHz* *50 kHz to 120 kHz*	0.090 % 0.25 % 0.40 % 0.70 %		
NORMAL MAGNETIZATION CURVES AND HYSTERESIS LOOPS				
Ring specimens	H = 0.1 kA/m to 10 kA/m (DC) B = 0 T to 2.5 T (DC)	0.40 % 0.40 %	In accordance with EN 60404 Part 4: 1997 and IEC 60404 Part 4:1995	
Bar or rod specimens	H = 0.1 kA/m to 200 kA/m (DC) B = 0 T to 2.5 T (DC)	0.40 % 0.40 %	In accordance with EN 60404 Part 4: 1997 and IEC 60404 Part 4:1995	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
COERCIVITY				Teddington
Soft magnetic materials (Relay steel)	H_{c1} up to 500 A/m (DC)	0.30 %	In accordance with BS 6404 Part 7: 1986 and IEC 60404 Part 7:1982	
DEMAGNETIZATION CURVE FOR HARD MAGNETIC MATERIALS				
Remanence	Up to 2 T (DC)	0.30 %	In accordance with BS 6404 Part 5: 1995 and IEC 60404 Part 5: 1993	
Coercivity	H_{CB} up to 1.2 MA/m (DC) H_{CJ} up to 1.6 MA/m (DC)	0.40 % 0.40 %		
Maximum energy product	Up to 400 kJ/m^3 (DC)	0.50 %		
RELATIVE MAGNETIC PERMEABILITY, μ_r				
For low magnetic permeability materials	(μ_r - 1) from 0.001 to 1.5 (DC) (μ_r - 1) from 0.0002 to 0.001 (DC)	0.20 % 2.2 %	In accordance with BS 5884:1987	
Permeability measuring instruments and indicators	(μ_r - 1) from 0.001 to 1.5 (DC)	0.20 %	The uncertainty may be increased depending on the characteristics of the device being calibrated	
MAGNETIC DIPOLE MOMENT	0.06 Am^2 to 1 kAm^2	0.11 %		
POWER LOSS				
Specific total power loss of Epstein strips and of sheets 500 mm square	At *50 Hz and 60 Hz*		Method of measurement: For strips: IEC 60404 Part 2:1996 BS 6404 Part 2:1996 For sheets: IEC 60404 Part 3:1992 BS 6404 Part 3:1992	
Non-oriented material Oriented material	Up to J = 1.3 T Up to J = 1.7 T	0.65 % 0.65 %		
Non-oriented material Oriented material	J = 1.3 T to 1.7 T J = 1.7 T to 1.8 T	0.75 % 0.75 %		
For Epstein strips only	*At 400 Hz*			
Non-oriented material Oriented material	Up to J = 1.3 T Up to J = 1.7 T	0.70 % 0.70 %	Measurements can be made at frequencies up to 16 kHz but with an increase in uncertainty using IEC 60404 Part 10:1988 BS EN 10252:1997	
Non-oriented material Oriented material	J = 1.3 T to 1.7 T J = 1.7 T to 1.8 T	1.8 % 1.8 %		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
POWER LOSS (continued)				Teddington
Soft magnetic materials in ring form only	J = 100 mT *50 Hz to 100 kHz*	0.65 %		
APPARENT POWER				
Non-oriented (isotropic) material	At *50 Hz and 60 Hz* Up to J = 1.3 T J = 1.3 T to 1.5 T J = 1.5 T to 1.7 T	 1.1 % 1.5 % 2.6 %	Method of measurement: For strips: IEC 60404 Part 2: 1996 For sheets: IEC 60404 Part 3: 1992 BS 6404 Part 3:1992	
Oriented (isotropic) material	At *50 Hz and 60 Hz* Up to J = 1.5 T J = 1.5 T to 1.8 T	 1.1 % 2.6 %		
Soft magnetic materials in ring form only	J = 100 mT *50 Hz to 100 kHz*	1.1 %		
AC PERMEABILITY	*50 Hz and 60 Hz, rms or peak values*			
Oriented (non-isotropic) and non-oriented (isotropic) materials	B = 0.5 T to 2.2 T H = 0.5 kA/m to 10 kA/m	0.45 %		
AC MAGNETIC FIELD STRENGTH	*50 Hz and 60 Hz, rms or peak values*			
Oriented (non-isotropic) and non-oriented (isotropic) materials	H = 0.5 kA/m to 10 kA/m	0.45 %	Method of measurement (for strips) in accordance with IEC 60404 Part 2: 1996, BS 6404 Part 2:1996 and (for sheets), IEC 60404 Part 3:1992 BS 6404 Part 3:1992.	
AC CONDUCTIVITY				
AC conductivity reference materials	2 MS/m to 60 MS/m *10 kHz to 100 kHz, 20°C*	0.70 %	Calibration of sets of reference materials produced by NPL.	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k=2)	Remarks	Location Code
POWER FLUX DENSITY				Teddington
	0.01 to 3000 W/m^2 *10 Hz to 300 MHz*	0.68 dB	Electrically small probes	
	0.01 to 650 W/m^2 *180 MHz to 2.5 GHz*	0.80 dB	Electrically small probes	
	0.01 to 660 W/m^2 *10 Hz to 180 MHz*	0.68 dB	All probes and small active dipoles	
	0.01 to 660 W/m^2 *250 MHz to 500 MHz* *500 MHz to 1.1 GHz* *1.1 GHz to 2.4 GHz*	 0.65 dB 0.62 dB 0.47 dB	 All probes and small active dipoles All probes and small active dipoles All probes and small active dipoles	
	0.01 to 950 W/m^2 *2.4 GHz to 18 GHz*	0.40 dB	All probes and small active dipoles	
	0.01 to 663 W/m^2 *18 GHz to 40 GHz*	0.35 dB	All probes and small active dipoles	
	0.5 to 50 W/m^2 *43.5 GHz to 45.5 GHz*	0.35 dB	All probes and small active dipoles	
FIELD STRENGTH				
Electric Field	0.05 V/m to 1000 V/m *10 Hz to 300 MHz*	0.68 dB	Electrically small probes	
	0.05 V/m to 600 V/m *180 MHz to 2.5 GHz*	0.80 dB	Electrically small probes	
	0.05 V/m to 600 V/m *10 Hz to 180 MHz*	0.68 dB	All probes and small active dipoles	
	0.05 V/m to 200 V/m *250 MHz to 500 MHz* *500 MHz to 1.1 GHz* *1.1 GHz to 2.4 GHz*	 0.65 dB 0.62 dB 0.47 dB	 All probes and small active dipoles All probes and small active dipoles All probes and small active dipoles	
	0.05 V/m to 600 V/m *2.4 GHz to 18 GHz*	0.40 dB	All probes and small active dipoles	
	0.2 V/m to 500 V/m *18 GHz to 40 GHz*	0.35 dB	All probes and small active dipoles	
	15 V/m to 140 V/m *43.5 GHz to 45.5 GHz*	0.35 dB	All probes and small active dipoles	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
FIELD STRENGTH (cont'd)				Teddington
Magnetic Field	0.1 mA/m to 2.7 A/m *10 Hz to 300 MHz*	0.68 dB	Electrically small probes	
	0.1 mA/m to 1.6 A/m *180 MHz to 2.5 GHz*	0.80 dB	Electrically small probes	
	0.1 mA/m to 1.3 A/m *10 Hz to 180 MHz*	0.68 dB	All probes and small active dipoles	
	0.1 mA/m to 0.5 A/m *250 MHz to 500 MHz*	0.65 dB	All probes and small active dipoles	
	500 MHz to 1.1 GHz	0.62 dB	All probes and small active dipoles	
	1.1 GHz to 2.4 GHz	0.47 dB	All probes and small active dipoles	
<u>PFD and Field Strength Indicating Meters</u>				
Injected DC Voltage	0.15 mV to 1 V	0.47 %	Meter Sensitivity	
Measured DC Voltage	0.09 V to 3.5 V	0.44 %	Analogue output voltage for FSD	
DC Current	5 mA to 100 mA	0.10 %	Battery Charge	
AC Voltage	1 V to 5 V, *8 kHz to 12 kHz*	0.60 %	Low frequency source check	
Frequency	8 kHz to 12 kHz	0.012 %	Low frequency source check	
Time Interval	2 s to 660 s	0.10 s	Response time and maximum hold	
ANTENNA GAIN			All measurements are performed at 23 °C	
Waveguide Feed	0 to 21 dB *2.6 GHz to 3.95 GHz*	0.08 dB	Waveguide No 10	
	0 to 22 dB *3.3 GHz to 4.9 GHz*	0.07 dB	Waveguide No 11A	
	0 to 23 dB *3.95 GHz to 5.85 GHz*	0.07 dB	Waveguide No 12	
	0 to 24 dB *5.85 GHz to 8.2 GHz*	0.05 dB	Waveguide No 14	
	0 to 25 dB *7.05 GHz to 10.0 GHz*	0.05 dB	Waveguide No 15	

The uncertainties apply to calibrations covering a waveguide bandwidth.

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
ANTENNA GAIN (cont'd)				
Waveguide Feed	0 to 26 dB *8.2 GHz to 12.4 GHz*	0.05 dB	Waveguide No 16	Teddington
	0 to 27 dB *10.0 GHz to 15.0 GHz*	0.05 dB	Waveguide No 17	
	0 to 28 dB *12.4 GHz to 18.0 GHz*	0.04 dB	Waveguide No 18	
	0 to 30 dB *18.0 GHz to 26.5 GHz*	0.04 dB	Waveguide No 20	
	0 to 31 dB *26.5 GHz to 40.0 GHz*	0.04 dB	Waveguide No 22	
	0 to 31 dB *43.5 GHz to 45.5 GHz*	0.05 dB	Waveguide No 23 The uncertainties apply to calibrations covering a waveguide bandwidth.	
Coaxial Feed	0 to 28 dB *1 GHz to 18 GHz*	0.05 dB	50 Ω APC-7 or Type N connectors	
	0 to 28 dB *1 GHz to 26.5 GHz*	0.05 dB	50 Ω 3.5 mm connector	
<u>EMC Antennas</u>				
Waveguide Feed	0 to 21 dB *2.6 GHz to 3.95 GHz*	0.7 dB	Waveguide No 10	
	0 to 22 dB *3.3 GHz to 4.9 GHz*	0.7 dB	Waveguide No 11A	
	0 to 23 dB *3.95 GHz to 5.85 GHz*	0.7 dB	Waveguide No 12	
	0 to 24 dB *5.85 GHz to 8.2 GHz*	0.7 dB	Waveguide No 14	
	0 to 25 dB *7.05 GHz to 10.0 GHz*	0.7 dB	Waveguide No 15	
	0 to 26 dB *8.2 GHz to 12.4 GHz*	0.7 dB	Waveguide No 16	
	0 to 27 dB *10.0 GHz to 15.0 GHz*	0.7 dB	Waveguide No 17	
	0 to 28 dB *12.4 GHz to 18.0 GHz*	0.7 dB	Waveguide No 18	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
ANTENNA GAIN (cont'd)				Teddington
<u>EMC Antennas</u>				
Waveguide Feed	0 to 30 dB *18.0 GHz to 26.5 GHz*	0.7 dB	Waveguide No 20	
	0 to 31 dB *26.5 GHz to 40.0 GHz*	0.7 dB	Waveguide No 22	
	0 to 31 dB *43.5 GHz to 45.5 GHz*	0.7 dB	Waveguide No 23	
Coaxial Feed	0 to 28 dB *1 GHz to 18 GHz*	0.8 dB (0.6 dB for conical log spiral antennas)	50 Ω APC-7 or Type N connectors	
	0 to 30 dB *1 GHz to 26.5 GHz*	0.8 dB (0.6 dB for conical log spiral antennas)	50 Ω 3.5 mm connectors	
	0 to 30 dB *18 GHz to 40 GHz*	0.8 dB	50 Ω 2.92 mm connectors For coaxially fed antennas the antenna factor is calculated from the antenna gain.	
ANTENNA COMPLEX REFLECTION COEFFICIENT			The uncertainties for complex reflection coefficient apply to both real and imaginary parts. All measurements are performed at 23 °C	
Waveguide feed	0 to 0.5, real and imaginary parts			
	2.6 GHz to 3.95 GHz	0.008	Waveguide No 10	
	3.3 GHz to 4.9 GHz	0.008	Waveguide No 11A	
	3.95 GHz to 5.85 GHz	0.008	Waveguide No 12	
	5.85 GHz to 8.2 GHz	0.008	Waveguide No 14	
	7.05 GHz to 10.0 GHz	0.008	Waveguide No 15	
	8.2 GHz to 12.4 GHz	0.008	Waveguide No 16	
	10.0 GHz to 15.0 GHz	0.008	Waveguide No 17	
	12.4 GHz to 18.0 GHz	0.008	Waveguide No 18	
	18.0 GHz to 26.5 GHz	0.008	Waveguide No 20	
	26.5 GHz to 40.0 GHz	0.008	Waveguide No 22	
	33.0 GHz to 50.0 GHz	0.013	Waveguide No 23	
7 mm coaxial feed	0 to 0.5, real and imaginary parts			
	1.0 GHz to 1.5 GHz	0.015	50 Ω Type N connectors	
	1.5 GHz to 18.0 GHz	0.011	50 Ω Type N connectors	
	1.0 GHz to 8.2 GHz	0.013	50 Ω GPC-7 connectors	
	8.2 GHz to 18.0 GHz	0.018	50 Ω GPC-7 connectors	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k=2)	Remarks	Location Code
ANTENNA COMPLEX REFLECTION COEFFICIENT (cont'd)				Teddington
3.5 mm coaxial feed	0 to 0.5, real and imaginary parts			
	1.0 GHz to 8.2 GHz	0.010	50 Ω GPC-3.5 connectors	
	8.2 GHz to 18 GHz	0.020	50 Ω GPC-3.5 connectors	
	18.0 GHz to 26.5 GHz	0.026	50 Ω GPC-3.5 connectors	
2.92 mm coaxial feed	0 to 0.5, real and imaginary parts			
	1 GHz to 18 GHz	0.041	50 Ω 2.92 mm connectors	
	18 to 40 GHz	0.078	50 Ω 2.92 mm connectors	
ANTENNA FACTOR	- 10 dB/m to - 50 dB/m			
Linear dipole	*20 MHz to 500 MHz*	0.35 dB	Defined height*	
Linear dipole	*20 MHz to 100 MHz*	0.7 dB	Free-space	
Linear dipole	*100 MHz to 500 MHz*	0.5 dB	Free-space	
Linear dipole	*500 MHz to 700 MHz*	0.5 dB	2 m height or free-space	
Linear dipole	*700 MHz to 1700 MHz*	0.7 dB	2 m height or free-space	
Linear dipole	*700 MHz to 1000 MHz*	0.5 dB	Using resonant elements	
Biconical antenna	*20 MHz to 300 MHz*	0.5 dB	Free-space or defined height*	
Log antenna	*80 MHz to 200 MHz*	1.0 dB	Defined height* or 2.5 m	
Log antenna	*80 MHz to 5 GHz*	0.5 dB	Free-space	
Bilog antenna	*20 MHz to 2 GHz*	0.7 dB	Free-space	
Spiral antenna	*100 MHz to 1 GHz*	1.0 dB	Free-space	
Horn antenna	*200 MHz to 2 GHz*	1.0 dB	Free-space	
Rod antenna	*100 Hz to 100 MHz*	1.0 dB	Free-field	
			* The antenna is horizontally polarised at a defined height above a metal ground plane.	
REFLECTION COEFFICIENT	0 to 1.0			
	0.3 MHz to 6 GHz	0.05	For measurements on antennas fitted with 50 Ω Type N connectors	
E-field emitters	*30 MHz to 7 GHz*	1.1 dB		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
NOISE				Teddington
Available Noise Temperature	77 K to 10^5 K (ENR up to 25 dB)			
	10 MHz to 18 GHz	1.0 % to 4.0 % (0.05 dB to 0.2 dB)	50 Ω 7 mm coaxial line, APC-7 connectors. 50 Ω devices with other connector types can be measured but with larger uncertainties.	
	18 GHz to 26.5 GHz	2.0 % to 5.0 % (0.09 dB to 0.23 dB)	50 Ω 2.4 mm coaxial line, GPC 2.4 connectors. 50 Ω devices with other connector types can be measured but with larger uncertainties.	
Available Noise Temperature	77 K to 10^5 K (ENR up to 25 dB)		Higher excess noise ratio devices can be measured with increased uncertainties. The uncertainties apply to noise sources with Voltage Reflection Coefficient not greater than 0.5. For higher values of VRC the uncertainties will be increased.	
	26.5 GHz to 40.0 GHz	2.3 % to 3.7 % (0.11 dB to 0.17 dB)	50 Ω 2.4 mm coaxial line, GPC 2.4 connectors. 50 Ω devices with other connector types can be measured but with larger uncertainties.	
	600 K to 10^5 K (ENR up to 35 dB)			
	2.6 GHz to 4.0 GHz	0.35 % to 0.66 % (0.016 dB to 0.030 dB)	Waveguide No 10	
	5.4 GHz to 8.2 GHz	0.8 % to 0.94 % (0.035 dB to 0.04 dB)	Waveguide No 14	
	8.2 GHz to 12.4 GHz	0.6 % (0.025 dB)	Waveguide No 16	
	12.4 GHz to 18.0 GHz	0.7 % to 0.8 % (0.03 dB to 0.035 dB)	Waveguide No 18	
	77 K to 10^5 K (ENR up to 25 dB)			
	18 GHz to 26.5 GHz	1.1 % to 2.0 % (0.05 dB to 0.09 dB)	Waveguide No 20	
	26.5 GHz to 40.0 GHz	1.0 % to 1.5 % (0.046 dB to 0.07 dB)	Waveguide No 22	
	33 GHz to 50 GHz	1.1 % to 1.5 % (0.05 dB to 0.07 dB)	Waveguide No 23	
	50 GHz to 75 GHz	1.4 % to 2.7 % (0.06 dB to 0.12 dB)	Waveguide No 25	
	75 GHz to 110 GHz	2.3 % to 2.7 % (0.10 dB to 0.12 dB)	Waveguide No 27	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
ATTENUATION				Teddington
Coaxial Line	0 dB to 100 dB *0.5 MHz to 18 GHz*	(0.0006 dB per 10 dB) + 0.0006 dB	14 mm Coaxial Line (GR-900 connector) up to 8.0 GHz. 7 mm Coaxial Line:	
	100 dB to 120 dB *0.5 MHz to 100 MHz*	0.0008 dB per 10 dB	*Standard N-Type connector up to 12.4 GHz.*	
	120 dB to 130 dB *0.5 MHz to 100 MHz*	(0.001 dB per 10 dB) + 0.01 dB	*Precision N-type and GPC-7 connectors to 18 GHz.*	
	0 dB to 80 dB *18 GHz to 40 GHz*	(0.0006 dB per 10 dB) + 0.0006 dB	3.5 mm Coaxial Line up to 26.5 GHz (GPC-3.5 connectors) 2.92 mm Coaxial Line up to 40 GHz (K connector). 2.4 mm Coaxial Line up to 40 GHz (2.4 mm connector).	
Waveguide	0 dB to 90 dB *2.6 GHz to 3.95 GHz* *3.3 GHz to 4.9 GHz* *3.95 GHz to 5.85 GHz* *5.85 GHz to 8.2 GHz* *7.05 GHz to 10.0 GHz* *8.2 GHz to 12.4 GHz* *10.0 GHz to 15.0 GHz* *12.4 GHz to 18.0 GHz*	(0.0006 dB per 10 dB) + 0.0006 dB	Waveguide No 10 Waveguide No 11A Waveguide No 12 Waveguide No 14 Waveguide No 15 Waveguide No 16 Waveguide No 17 Waveguide No 18	
	0 dB to 80 dB *18 GHz to 26.5 GHz* *26.5 GHz to 40 GHz*	(0.0006 dB per 10 dB) + 0.0006 dB	Waveguide No 20 Waveguide No 22 NOTE The uncertainties for attenuation apply to the measurement of a device that is well matched to the ideal characteristic impedance of the transmission line system. The quoted uncertainty will be increased for other devices to account for mismatch and repeatability, when these contributions exceed that which has been allowed for in this schedule.	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
RF POWER Calibration factor and effective efficiency - guided wave systems	0.1 mW to 10 mW			Teddington
	8.2 GHz to 12.4 GHz	0.4 %	Waveguide No 16	
	12.4 GHz to 18.0 GHz	0.4 %	Waveguide No 18	
	18.0 GHz to 26.5 GHz	0.5 %	Waveguide No 20	
	26.5 GHz to 40.0 GHz	0.5 %	Waveguide No 22	
	40 GHz to 50 GHz	0.9 %	Waveguide No 23	
	50.0 GHz to 75 GHz	1.2 %	Waveguide No 25	
	75 GHz to 110.0 GHz	1.6 %	Waveguide No 27	
RF POWER Calibration factor and effective efficiency – coaxial line systems	Nominal power range 0.01 mW to 10 mW			
	10 MHz to 100 MHz	0.25 %	Calibration of 7mm power sensors and thermistor mounts against the NPL 7 mm colorimeter. The uncertainties apply to devices with type N connectors with VRC less than 0.01 in a 50 Ω coaxial system. The uncertainties may be increased for devices with a higher VRC or fitted with other connector types.	
	100 MHz to 4 GHz	0.40 %		
	4 GHz to 8 GHz	0.45 %		
	8 GHz to 12 GHz	0.55 %		
	12 GHz to 15 GHz	0.60 %		
	15 GHz to 18 GHz	0.70 %		
COMPLEX REFLECTION COEFFICIENT (in support of Noise and Power calibrations)				
Magnitude	0 to 1.0			
	2.6 GHz to 3.95 GHz	0.004	Waveguide No 10	
	3.3 GHz to 4.9 GHz	0.004	Waveguide No 11A	
	3.95 GHz to 5.85 GHz	0.004	Waveguide No 12	
	5.85 GHz to 8.2 GHz	0.004	Waveguide No 14	
	7.05 GHz to 10.0 GHz	0.004	Waveguide No 15	
	8.2 GHz to 12.4 GHz	0.004	Waveguide No 16	
	10.0 GHz to 15.0 GHz	0.004	Waveguide No 17	
	12.4 GHz to 18.0 GHz	0.004	Waveguide No 18	
	18.0 GHz to 26.5 GHz	0.004	Waveguide No 20	
	26.5 GHz to 40.0 GHz	0.004	Waveguide No 22	
	40.0 GHz to 50 GHz	0.004	Waveguide No 23	
	60.0 GHz to 62 GHz	0.004	Waveguide No 25	
	75 GHz to 110 GHz	0.004	Waveguide No27	
	10 MHz to 18 GHz	0.004	50 Ω APC-7 or Type N Connectors	
	10 MHz to 26.5 GHz	0.005	50 Ω 3.5 mm connectors	
Phase	-180° to 180° *Frequency range as for magnitude*	$\sin^{-1}\frac{(\text{magnitude uncertainty})^{\circ}}{\text{magnitude}}$	If the magnitude is less than its uncertainty then the phase uncertainty is 180°	

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Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
RISETIME	5 ps to 50 ps 50 ps to 1 ns	1.3 ps 0.5 % + 3 ps	Calibration of oscilloscope sampling heads	Teddington
	300 ps to 10 ns	0.2 % + 20 ps	Calibration of real-time digital oscilloscopes	Teddington
	11 ps to 60 ps 60 ps to 10 ns	0.9 ps 0.5 % + 1.4 ps	Calibration of pulse generators	Teddington
Pulse Amplitude	50 mV to 800 mV 800 mV to 1 V	0.3 % 0.5 %		Teddington
Pulse Aberrations (e.g. pre-shoot, overshoot, pulse settling error)	Pulse settling error Others	0.05 % of amplitude 0.1 % of amplitude	The quoted uncertainty will depend on the measurement bandwidth and the type and position of the aberration. Generally the assigned uncertainty will not be larger than 1 %.	Teddington
TIME AND FREQUENCY				Teddington
Characterisation of GPS disciplined oscillators and frequency standards				Teddington
Time offset Time offset	From UTC (NPL) From UTC	2 ns 10 ns		Teddington
Frequency	5 MHz and 10 MHz	5×10^{-14}	The stated uncertainty can only be attained over a minimum period of 24 hours. Calibration of frequency standards with a 1 pps output can also be undertaken.	Teddington
Time delay (coaxial cables)	Up to 300 ns	1 ns	For cable characterisation in support of GPSDO calibration.	Teddington
Remote characterisation of GPS disciplined oscillators and frequency standards			The capability relates to a remote common-view service where NPL-supplied software gathers data and returns it to NPL for processing. The user is supplied with instructions for the setting up of the equipment and the antenna.	Customers' sites
Time offset	Weekly values relative to UTC (NPL)	20 ns		Customers' sites
Time offset	Weekly values relative to estimated UTC	40 ns		Customers' sites
Time offset	Post-processed values relative to corrected UTC data	28 ns	The stated uncertainty for frequency can only be attained over a minimum period of 24 hours. Calibration of frequency standards with a 1 pps output can also be undertaken.	Customers' sites
Frequency	5 MHz and 10 MHz	1×10^{-13}		Customers' sites

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k=2)	Remarks	Location Code
Primary Impedance Measurement System *(PIMMS)*				Teddington
NOTE For the linear voltage reflection and transmission coefficient measurands (i.e. complex-valued *S*-parameters) described in this section of the Schedule, the Best Measurement Capability is shown as an interval of values, where a selected value within the interval represents an expanded uncertainty at a level of confidence of approximately 95%. Furthermore, a selected value within the interval will represent the uncertainty applied equally and simultaneously to *both* the Real and Imaginary parts of the *S*-parameter. The uncertainty value therefore defines a circular *region* of uncertainty, in the appropriate complex *S*-parameter plane, centred on the measured, quoted, mean value with radius equal to the stated expanded uncertainty. For Voltage Reflection Coefficients (VRCs), the stated uncertainty is assumed here to be independent of the nominal |VRC|, so a single interval is presented applicable for all |VRC| in the range 0 ≤ |VRC| ≤ 1. For Voltage Transmission Coefficients (VTCs), the stated uncertainty is dependent on the nominal |VTC|, so uncertainty intervals are presented for selected, representative, values of |VTC| in the range, 0 ≤ |VTC| ≤ 1.				
Linear complex voltage reflection coefficient (VRC) in 50 Ω coaxial line	7 mm connector, from 45 MHz to 18 GHz: -1 ≤ Re(VRC) ≤ +1 -1 ≤ Im(VRC) ≤ +1 constrained by: 0 ≤ |VRC| ≤ 1	0.002 to 0.007		
	Type-N connector, from 45 MHz to 18 GHz: -1 ≤ Re(VRC) ≤ +1 -1 ≤ Im(VRC) ≤ +1 constrained by: 0 ≤ |VRC| ≤ 1	0.002 to 0.007		
	3.5 mm connector, from 45 MHz to 33 GHz: -1 ≤ Re(VRC) ≤ +1 -1 ≤ Im(VRC) ≤ +1 constrained by: 0 ≤ |VRC| ≤ 1	0.006 to 0.012		
Linear complex VRC in rectangular waveguide	WG16/WR90/R100 flange, from 8.2 GHz to 12.4 GHz: -1 ≤ Re(VRC) ≤ +1 -1 ≤ Im(VRC) ≤ +1 constrained by: 0 ≤ |VRC| ≤ 1	0.0015 to 0.0020		
	WG18/WR62/R140 flange, from 12.4 GHz to 18 GHz: -1 ≤ Re(VRC) ≤ +1 -1 ≤ Im(VRC) ≤ +1 constrained by: 0 ≤ |VRC| ≤ 1	0.0015 to 0.0030		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
	Primary Impedance Measurement System *(PIMMS)* (continued)			
Linear complex VRC in rectangular waveguide	WG20/WR42/R220 flange, from 18 GHz to 26.5 GHz: -1 ≤ Re(VRC) ≤ +1 -1 ≤ Im(VRC) ≤ +1 constrained by: 0 ≤ |VRC| ≤ 1	0.0015 to 0.0030		Teddington
	WG22/WR28/R320 flange, from 26.5 GHz to 40 GHz: -1 ≤ Re(VRC) ≤ +1 -1 ≤ Im(VRC) ≤ +1 constrained by: 0 ≤ |VRC| ≤ 1	0.004 to 0.006		
Linear complex voltage transmission coefficient (VTC) in 50 Ω coaxial line	7 mm connector, from 45 MHz to 18 GHz: -1 ≤ Re(VTC) ≤ +1 -1 ≤ Im(VTC) ≤ +1 constrained by: 0 ≤ |VTC| ≤ 1			
	|VTC| = 0 |VTC| = 0.1 |VTC| = 1	0.000005 to 0.00005 0.00015 to 0.0005 0.0015 to 0.005		
	Type-N connector, from 45 MHz to 18 GHz: -1 ≤ Re(VTC) ≤ +1 -1 ≤ Im(VTC) ≤ +1 constrained by: 0 ≤ |VTC| ≤ 1			
	|VTC| = 0 |VTC| = 0.1 |VTC| = 1	0.000005 to 0.00005 0.00015 to 0.0005 0.0005 to 0.005		
	3.5 mm connector, from 45 MHz to 33 GHz: -1 ≤ Re(VTC) ≤ +1 -1 ≤ Im(VTC) ≤ +1 constrained by: 0 ≤ |VTC| ≤ 1			
	|VTC| = 0 |VTC| = 0.1 |VTC| = 1	0.000005 to 0.00010 0.00015 to 0.0005 0.0015 to 0.005		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
	Primary Impedance Measurement System *(PIMMS)* (continued)			
Linear complex VTC in rectangular waveguide	WG16/WR90/R100 flange, from 8.2 GHz to 12.4 GHz: -1 ≤ Re(VTC) ≤ +1 -1 ≤ Im(VTC) ≤ +1 constrained by: 0 ≤ |VTC| ≤ 1			Teddington
	|VTC| = 0.1 |VTC| = 1	0.00015 to 0.00030 0.0025 to 0.0045		
	WG18/WR62/R140 flange, from 12.4 GHz to 18 GHz: -1 ≤ Re(VTC) ≤ +1 -1 ≤ Im(VTC) ≤ +1 constrained by: 0 ≤ |VTC| ≤ 1			
	|VTC| = 0.1 |VTC| = 1	0.00060 to 0.0010 0.0065 to 0.0095		
	WG20/WR42/R220 flange, from 18 GHz to 26.5 GHz: -1 ≤ Re(VTC) ≤ +1 -1 ≤ Im(VTC) ≤ +1 constrained by: 0 ≤ |VTC| ≤ 1			
	|VTC| = 0.1 |VTC| = 1	0.0007 to 0.0010 0.005 to 0.0085		
	WG22/WR28/R320 flange, from 26.5 GHz to 40 GHz: -1 ≤ Re(VTC) ≤ +1 -1 ≤ Im(VTC) ≤ +1 constrained by: 0 ≤ |VTC| ≤ 1			
	|VTC| = 0.1 |VTC| = 1	0.0010 to 0.0055 0.007 to 0.010		
Mechanically-derived characteristic impedance of nominal 50 Ω coaxial line	7 mm line size, including Type-N 3.5 mm line size	0.03 Ω 0.06 Ω	Based on measurements of the diameters of air line conductors. These measurements are made using air gauging techniques	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k=2)	Remarks	Location Code
LENGTH				Teddington
Gauge blocks: millimetre	As BS EN ISO 3650:1999 0.5 mm to 25 mm 25 mm to 50 mm 50 mm to 75 mm 75 mm to 100 mm	 0.020 µm 0.020 µm to 0.022 µm 0.022 µm to 0.025 µm 0.025 µm to 0.029 µm	Measurement of central length by interferometry. Measured twice, wrung to a platen by each of the two measuring faces in turn, and the mean of these two measurements stated on the certificate.	
Gauge blocks: inch	As BS 4311:2007 0.01 in to 0.4 in 0.4 in to 1 in 2 in 3 in 4 in	 0.76 µ inch 0.76 to µ inch 0.78 µ inch 0.86 µ inch 0.98 µ inch 1.14 µ inch		
Gauge blocks: millimetre	As BS EN ISO 3650:1999 0.5 mm to 10 mm 10 mm to 25 mm 25 mm to 50 mm 50 mm to 75 mm 75 mm to 100 mm	 0.032 µm to 0.033 µm 0.033 µm to 0.037 µm 0.037 µm to 0.050 µm 0.050 µm to 0.065 µm 0.065 µm to 0.082 µm	Measurement of central length by mechanical comparison.	
Gauge blocks: inch	As BS 4311:2007 0.01 to 0.4 in 0.4 in to 1 in 2 in 3 in 4 in	 1.26 to 1.30 µ inch 1.30 to 1.47 µ inch 1.97 µ inch 2.60 µ inch 3.29 µ inch		
Long gauge blocks: millimetre	As BS EN ISO 3650:1999 Grades K and O 100 mm to 1000 mm	$\sqrt{0.049^2 + (0.083 \times L)^2}$ µm i.e., 0.050 µm to 0.100 µm	Measurement of length by absolute interferometry of long gauge blocks of length L (in metres) to the stated standards.	
	As BS EN ISO 3650:1999 Grades K and O 100 mm to 1000 mm	0.116 + (0.263 x L) µm i.e., 0.143 to 0.379 µm	Measurement of length by interferometric comparison of long gauge blocks of length L (in metres) to the stated standards.	
Length bars: millimetre	As BS 5317:1976 Reference and calibration grades			
	0 mm to 100 mm	$\sqrt{0.065^2 + (0.42 \times L)^2}$ µm i.e. 0.065 µm to 0.078 µm	Measurement of length by absolute interferometry of length bars of length L (in metres) to the stated standards.	
	100 mm to 1200 mm	$\sqrt{0.049^2 + (0.083 \times L)^2}$ µm i.e. 0.050 µm to 0.111 µm		
	Above 100 mm up to 1200 mm	0.116 + (0.263 x L) µm i.e. 0.143 to 0.432 µm	Measurement of length by interferometric comparison of length bars of length L (in metres) to the stated standards.	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
LENGTH (cont'd)				Teddington
Length bars: Inch	As BS 1790:1961 Reference and calibration grades			
	0.5 in to 4 in	$\sqrt{2.56^2 + (0.42 \times L)^2}$ μ inch i.e. 2.57 μ inch to 3.07 μ inch	Measurement of length by absolute interferometry of length bars of length *L* (in inches) to the stated standards.	
	4 in to 48 in	$\sqrt{1.9^2 + (0.083 \times L)^2}$ μ inch i.e. 1.93 μ inch to 4.42 μ inch		
	4 in to 48 in	4.57 + (0.263 x L) μ inch i.e. 5.62 μ inch to 17.2 μ inch	Measurement of length by interferometric comparison of long gauge blocks of length *L* (in inches) to the stated standards.	
Thermal expansion coefficient at 20 °C	Expansion coefficient 9×10^{-6} K^{-1} to 13×10^{-6} K^{-1}	(0.004 + 11/*L* + 0.000 007*L*) $\times 10^{-6}$ K^{-1}, where *L* is length of gauge block or length bar in millimetres.	The uncertainty applies to the measurement of the linear coefficient of thermal expansion, at 20 °C, of long series gauge blocks and length bars above 100 mm, up to 1200 mm (4 inch to 48 inch) which comply with the following standards: Reference and calibration grades of BS 1790:1961 (inch). Reference and calibration grades of BS 5317:1976 (millimetre). Grades K, 0 of ISO 3650:1998.	
Step gauges	210 mm to 1020 mm	(128 + 236 L) nm		
Thread measuring cylinders	0.1 mm to 5 mm diameter	0.080 + (0.0010 x diameter in mm) μm	As BS 3777:1964 BS 5590:1978 and specials	
Plain plug gauges (parallel) reference cylinders and rollers	0.1 mm to 100 mm diameter	0.070 + (0.0011 x diameter in mm) μm		
	100 mm to 150 mm diameter	0.050 + (0.0014 x diameter in mm) μm		
Plain setting rings (parallel)	3 mm to 250 mm diameter	0.070 + (0.0005 x diameter in mm) μm	As BS 4064:1966 and BS 4065:1966 Grade AA, and equivalent quality setting rings	
Stage micrometers and graticules	0 mm to 150 mm	0.50 μm		
Linewidth standards	0.5 μm to 10 μm 10 μm to 50 μm	0.050 μm 0.10 μm		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
LENGTH (cont'd)				Teddington
Reference stage graticules for image analysers	Grid sizes 0 to 400 µm x 400 µm Spot sizes 3 µm to 48 µm	 0.10 µm 0.10 µm		
Reference master screw plug and ring gauges (taper) to API specifications 5B and 7	0 in to 20 in diameter	Pitch diameters 0.00037 in Major diameter 0.0002 in Minor diameter 0.0006 in Pitch 0.00012 in Taper 0.00011 in Flank angle 3.0 minutes of arc Stand off 0.00034 in		
ANGLE				
Indexing tables	From 0° to 360°	0.040 seconds of arc		
Precision polygons	4 sides to 12 sides, excluding 7 and 11 sides	0.11 seconds of arc		
Combination angle gauges	0° to 45°	0.30 seconds of arc	As MOY/SCMI/18 and MOY/SCMI/45	
Autocollimators *Visual and photoelectric*	0 minutes of arc to 10 minutes of arc	0.060 seconds of arc		
FORM				
Roundness reference standards	0 mm to 100 mm diameter	0.0050 µm		
OTHER MEASURING INSTRUMENTS, EQUIPMENT AND MACHINES				
Laser frequency (Vacuum wavelength)	Nominal wavelengths 500 nm to 2.0 µm	1 part in 10^{13}		
Laser interferometer systems	0 to 45 m			
	Compensated	$\sqrt{0.08^2+(0.2\times L)^2}$ µm	*L* = length (m)	
	Uncompensated	$\sqrt{0.08^2+(012\times L)^2}$ µm	*L* = length (m)	
Extensometer calibration rigs	Displacements 0 mm to 1000 mm	32 + (3.5 x *R*) nm where *R* is the extension in mm		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k=2)	Remarks	Location Code
INFRA-RED				Teddington
	Thermal Radiation	0.0020 (, <0.1) 0.0010 (, >0.9)		
Wavenumber, v for QA checks on mid-IR spectrophotometers	*Nominal Values:* 3060.0 cm^{-1} 2849.5 cm^{-1} 1942.9 cm^{-1} 1601.2 cm^{-1} 1583.0 cm^{-1} 1154.5 cm^{-1} 1028.3 cm^{-1}	 0.30 cm^{-1} 0.40 cm^{-1} 0.40 cm^{-1} 0.30 cm^{-1} 0.30 cm^{-1} 0.30 cm^{-1} 0.30 cm^{-1}	Calibrated Artefact: Matt polystyrene film nominally 0.04 mm thick Each film is individually calibrated at all seven selected transmittance minima Films are measured in a spectrophotometer with a nominal sample compartment temperature of 30 °C ± 5 °C	
PHOTOMETRY				
Luminous intensity (tungsten lamps)	1 to 100 cd 100 to 1000 cd 1000 to 10000 cd	0.70 % 0.60 % 0.70 %	The actual measurement uncertainty quoted on certificates depends critically on the lamp repeatability or the meter performance. The best measurement capability relates to that which can be achieved using specially designed transfer standards and, in the case of sources, assumes that the correlated colour temperature or spectral power distribution is known. For illuminance/luminance meters, the calibration only applies for a tungsten source at a correlated colour temperature of 2856 K.	
Illuminance (tungsten lamps and illuminance meters)	0.1 to 500 lux 500 to 5000 lux 5000 to 20000 lux 20000 to 50000 lux	0.90 % 0.80 % 0.90 % 1.0 %		
Luminance (tungsten sources and luminance meters)	1 to 100 cd m^{-2} 100 to 1000 cd m^{-2} 1000 to 10000 cd m^{-2}	1.3 % 1.2 % 1.3 %		
Correlated colour temperature (tungsten lamps and colour temperature meters)	2000 to 3200 K	10 K		
Luminous flux (tungsten lamps)	1 to 100 lumen 100 to 20000 lumen	0.90 % 0.70 %		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
SPECTRORADIOMETRY OF SOURCES				Teddington
Relative and absolute spectral irradiance of tungsten and tungsten halogen sources	250 nm to 400 nm 300 nm to 400 nm 400 nm to 800 nm 800 nm to 1600 nm 1600 nm to 2500 nm	5.5 % to 3.5 % 3.5 % to 2.6 % 2.6 % to 1.7 % 1.7 % to 2.0 % 2.0 % to 2.8 %	For lamps rated 50 W to 5000 W (nominal), correlated colour temperature in the range 2600 K to 3250 K.	
Relative and absolute spectral radiance of tungsten and tungsten halogen based sources	300 nm to 400 nm 400 nm to 800 nm 800 nm to 1600 nm 1600 nm to 2500 nm	3.5 % to 2.7 % 2.7 % to 1.8 % 1.8 % to 2.1 % 2.1 % to 3.0 %	For lamps rated 50 W to 5000 W (nominal), correlated colour temperature in the range 2600 K to 3250 K.	
RADIOMETRY				
Spectral responsivity of laser power meters	100 pW to 1 mW *350 nm to 1600 nm*	0.040 %	At laser wavelength or peak wavelength of bandpass filter.	
Spectral responsivity	200 nm to 240 nm 240 nm to 380 nm 380 nm to 405 nm 405 nm to 920 nm 920 nm to 1800 nm	1.0 % 0.80 % 0.30 % 0.10 % 0.30 %		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
COLORIMETRY AND SPECTROPHOTOMETRY - REGULAR TRANSMITTANCE				Teddington
Regular transmittance	0.001 %T to 100 %T *Wavelength range (nm):* $200 \leq \lambda \leq 210$ $210 < \lambda \leq 310$ $310 < \lambda \leq 800$ $800 < \lambda \leq 3000$	Absolute uncertainty for 90 %T, 60 %T and 0.001 %T: 0.50 %, 0.30 % and 0.000027 % 0.30 %, 0.15 % and 0.000018 % 0.30 %, 0.15 % and 0.000011 % 0.30 %, 0.30 % and 0.000022 %		
Optical density	0 D to 5.0 D *Wavelength range (nm):* $200 \leq \lambda \leq 210$ $210 < \lambda \leq 310$ $310 < \lambda \leq 800$ $800 < \lambda \leq 3000$	Absolute uncertainty for 0.05 D, 0.22 D and 5.0 D: 0.0024 D, 0.0022 D and 0.012 D 0.0014 D, 0.0011 D and 0.0077 D 0.0014 D, 0.0011 D and 0.0048 D 0.0014 D, 0.0022 D and 0.0097 D	Optical density is equivalent to absorbance (A) and is calculated from regular transmittance using the formula $D = \log_{10}(100/\%T)$.	
Wavelength of absorption peaks	200 to 3000 nm	0.10 nm		
Colour data: CIELAB L* a* b*	 0 to 100 - 200 to + 200 - 200 to + 200	 0.050 0.050 0.050	Colour data is normally given for the CIE 2° and 10° observers and CIE Standard Illuminants A, C and D65. Other Standard Illuminants on request.	
Colour data: CIE				
x, y, u', v'	0 to 1	0.00020		
Luminous transmittance Y	0 %Y to 100 %Y	0.15 % for 60 %Y		
COLORIMETRY AND SPECTROPHOTOMETRY - DIFFUSE REFLECTANCE				
Spectral diffuse reflectance; specular included and specular excluded geometries	0 %R to 100 %R *Wavelength range (nm):* $200 \leq \lambda \leq 315$ $315 < \lambda \leq 460$ $460 < \lambda \leq 800$ $800 < \lambda \leq 2000$ $2000 < \lambda \leq 2500$	Absolute uncertainty: 1.6 % for white, 0.60 % for black (0.050 + 0.0055R) % (0.050 + 0.0035R) % 1.6 % for white, 0.35 % for black 2.1 % for white, 0.65 % for black	Best measurement capability is for measurement against similar NPL masters, and examples are given covering the range from 'white' samples to 'black' samples. Higher uncertainties may apply where no similar master exists.	
Spectral radiance factor (see Notes 1 and 2)	0% to 102%R *Wavelength range (nm):* $200 \leq \lambda \leq 315$ $315 < \lambda \leq 800$ $800 < \lambda \leq 2000$ $2000 < \lambda \leq 2500$	Absolute uncertainty: 1.6 % for white, 0.60 % for black (0.050 + 0.0070R) % 2.3 % for white, 0.30 % for black 2.8 % for white, 0.70 % for black	Radiance factor results are expressed relative to the perfect reflecting (lambertian) diffuser. A result >100 % implies that the sample reflects more radiation at 45° than a lambertian diffuser. See also the remark above.	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
COLORIMETRY AND SPECTROPHOTOMETRY - DIFFUSE REFLECTANCE (cont'd)				Teddington
Colour data: CIELAB L* a* b*	 0 to 100 - 200 to + 200 - 200 to + 200	 0.15 0.10 0.10	Colour data is normally given for the CIE 2° and 10° observers and CIE Standard Illuminants A, C and D65. Other Standard Illuminants on request.	
Colour data: CIE x, y, u', v' Luminous transmittance Y	 0 to 1 0 %Y to 100 %Y	 0.00020 0.55 % for white, 0.10 % for black	Colour data is normally given for the CIE 2° and 10° observers and CIE Standard Illuminants A, C and D65. Other Standard Illuminants on request.	
TEMPERATURE				
Resistance thermometers, fixed point calibrations	- 196 °C to - 38.8344 °C - 189.3442 °C - 38.8344 °C to + 0.01 °C 0 °C to 29.7646 °C 0 °C to 156.5985 °C 231.928 °C 419.527 °C 0 °C to 419.527 °C 419.527 °C to 660.323 °C 660.323 °C to 961.78 °C	0.0017 °C to 0.00035 °C 0.00050 °C 0.00035 °C to 0.00016 °C 0.00016 °C to 0.00030 °C 0.00030 °C to 0.00070 °C 0.00070 °C 0.00090 °C 0.0010 °C 0.0010 °C to 0.0025 °C 0.0025 °C to 0.0040 °C		
Resistance thermometers, calibration by comparison	- 196 °C - 100 °C to - 80 °C - 80 °C to 0 °C 0 °C to 50 °C 50 °C to 100 °C	0.0017 °C 0.010 °C 0.0040 °C 0.0030 °C 0.0050 °C	Comparison at LN_2 and in acetone and water baths	
Temperature indicators with resistance sensor	- 196 °C to + 100 °C	As for sensor		
Water triple point cells	0.01 °C	0.000084 °C	Comparison with NPL reference cells	
Diphenyl ether triple point cells	26.862 °C	0.0020 °C		
Ethylene carbonate triple point cells	36.315 °C	0.0020 °C		
Benzoic acid triple point cells	122.33 °C	0.0050 °C		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
TEMPERATURE (cont'd)				Teddington
Thermocouples noble metal type Pt-Rh	420 °C 962 °C, 1064 °C, 1085 C 1324 °C 1492 °C	0.13 °C 0.21 °C 0.53 °C 0.72 °C	ITS-90 fixed points Secondary fixed point Co-C Secondary fixed point Pd-C derived from ITS-90	
	0 °C to 960 °C 960 °C to 1330 °C 1330 °C to 1500 °C	0.30 °C 0.22 °C to 0.55 °C 0.55 °C to 0.72 °C	Polynomial interpolation with improved homogeneity	
	1100 °C to 1600 °C	1.0 °C to 1.5 °C	Wire bridge method	
Thermocouples noble metal type Pt-Pd	420 °C 962 °C, 1085 °C 1324 °C 1492°C	0.10 °C 0.070 °C 0.53 °C 0.72 °C	ITS-90 fixed points Secondary fixed point Co-C Secondary fixed point Pd-C derived from ITS-90	
Thermocouples, noble metal type Au-Pt	420 °C, 660°C, 962 °C	0.05 °C		
	0 °C to 1000 °C	0.05 °C	if Zn and Ag fixed points	
	0 °C to 400 °C 400 °C - 1000 °C	0.07 °C 0.05 °C	if Zn, Al, Ag fixed points are used	
Thermocouples, base-metal types	- 196 °C - 80 °C to 0 °C 0 °C to 50 °C 50 °C to 100 °C	0.50 °C 0.10 °C 0.050 °C 0.10 °C	Comparison at LN_2 and in acetone and water baths	
Temperature indicators with thermocouple sensors	- 196 °C to + 100 °C	As for sensor		
Compensating and extension cables	- 25 °C to + 100 °C	As for base-metal thermocouples		
Standard lamps, evacuated	700 °C to 1000 °C 1000 °C to 1700 °C	1.0 °C to 0.40 °C 0.40 °C to 1.0 °C		
Standard lamps, gas filled	1300 °C to 1600 °C 1600 °C to 2200 °C 2200 °C to 2600 °C	3.5 °C to 1.5 °C 1.5 °C to 2.0 °C 2.0 °C to 5.5 °C	Calibration current limited to 70 A	
Disappearing filament pyrometers	800 °C to 1100 °C 1100 °C to 1700 °C 1700 °C to 2800 °C	10 °C to 3.0 °C 3.0 °C to 5.0 °C 5.0 °C to 8.0 °C		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
TEMPERATURE (cont'd)				
Infrared Thermometers	- 40 °C to + 50 °C 15 °C to 45 °C 50 °C to 260 °C 260 °C to 600 °C 600 °C to 1000 °C 1000 °C to 3000 °C	0.10 °C 0.050 °C 0.10 °C 0.20 °C 0.30 °C 0.050 % of Celsius temperature	Including tympanic thermometers	Teddington
Blackbody Sources	- 40 °C to + 260 °C 260 °C to 600 °C 600 °C to 1000 °C 962 °C, 1064 °C, 1085 °C 1000 °C to 3000 °C	0.20 °C 0.24 °C 0.30 °C 0.060 °C 0.050 % of Celsius temperature		Teddington
HUMIDITY			The accreditation covers other humidity units directly related to dew-point, e.g. vapour pressure, PPM weight, PPM volume, g/kg etc.	Teddington
Dew-point	+ 90 °C to + 80 °C + 80 °C to + 60 °C + 60 °C to - 60 °C - 60 °C to - 75 °C - 75 °C to - 90 °C	0.10 °C to 0.040 °C 0.040 °C to 0.030 °C 0.030 °C 0.030 °C to 0.10 °C 0.10 °C to 0.50 °C		Teddington
Dew point under pressures	- 60 °C to + 10 °C	0.07 °C	At pressures up to 1000 kPa	Teddington
Relative Humidity	1 %rh to 98 %rh at temperatures - 40 °C to + 100 °C	0.60 % of reading + 0.10 %rh		Teddington
Temperature Sensors incorporated in humidity instruments	- 40 °C to + 100 °C	0.080 °C		Teddington
Calibration of dew point hygrometers	- 90 °C to + 90 °C	0.80 °C to 0.10 °C	The calibration/evaluation of climatic chambers can be undertaken	Customers' sites
Calibration of relative humidity hygrometers	1 %rh to 98 %rh at temperatures with the range - 40 °C to + 100 °C	1.0 % of reading		Customers' sites
Temperature Sensors incorporated in humidity instruments	- 40 °C to + 100 °C	0.20 °C		Customers' sites

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k=2)	Remarks	Location Code
NEUTRON DOSIMETRY				Teddington
NEUTRON SOURCE EMISSION RATE				
Emission rate from radionuclide neutron sources	Source emission rate $10^5 s^{-1}$ to $2 \times 10^9 s^{-1}$	1.0 % to 1.2 % depending on source	Service reference number: RN05 Induced ^{56}Mn activity measured using sodium iodide detectors	
	Source emission rate $10^2 s^{-1}$ to $2 \times 10^6 s^{-1}$	1.2 % to 1.5 % depending on source	Service reference number: RN05 Relative measurement performed using a moderating detector assembly	
Anisotropy of emission from radionuclide neutron sources	Source emission rate $10^5 s^{-1}$ to $10^8 s^{-1}$ Anisotropy factor 0.5 to 1.2	1.0 % to 0.7 % depending on source	Service reference number: RN05. Measurements performed using a precision long counter in a low-scatter environment	
NEUTRON FLUENCE				
Thermal neutron fluence	Energy: thermal Thermal neutron beam Fluence rates: $10^3 cm^{-2} s^{-1}$ to $4 \times 10^4 cm^{-2} s^{-1}$	1.2 % for Wescott fluence 4.0 % for 'true' fluence	Service reference number: RN01 Fast neutrons moderated in a graphite pile. Beam of thermal neutrons extracted. Fluence standard - gold foil activation Service conforms to ISO Standard 8529 Parts 1 to 3.	
Thermal neutron fluence	Energy: thermal Thermal neutrons in cavity -Fluence rates; $10^4 cm^{-2} s^{-1}$ to $3 \times 10^7 cm^{-2} s^{-1}$	1.0 % for Westcott fluence	Service reference number: RN01. Fast neutrons moderated in graphite pile. Thermal neutrons in a small 150 cm^3 cavity. Fluence standard - gold foil activation.	
Fast neutron fluence	Energy: 70 keV to 17 MeV Monoenergetic fields Fluence rates: 1 $cm^{-2} s^{-1}$ to 1500 $cm^{-2} s^{-1}$	4.0 %	Service reference number: RN02. Neutrons are produced using beams of protons or deuterons from a 3.5 MV Van de Graaff accelerator. Fluences measured using precision long counter. Service conforms to ISO Standard 8529 Parts 1 to 3.	
Fast neutron fluence	Energy: 13.5 MeV to 19 MeV Monoenergetic fields Fluence: $5 \times 10^8 cm^{-2}$ to $10^{14} cm^{-2}$	1.3 %	Service reference number: RN03 Iron and aluminium foil activation for measurement of customer's field.	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
NEUTRON FLUENCE (cont'd)				Teddington
Fast neutron fluence	Energy: broad energy range from sources: ^{241}Am-Be, ^{252}Cf, ^{241}Am-B, ^{241}Am-Li, ^{241}Am-F Fluence rates: 1 cm^{-2} s^{-1} to 400 cm^{-2} s^{-1} at 1 m from source	1.3 %	Service reference number: RN04. Fields are produced using radionuclide neutron sources of known emission rate. Actual fluence rate depends on particular source Service conforms to ISO Standard 8529 Parts 1 to 3.	
NEUTRON DOSE EQUIVALENT				
Thermal and fast neutron dose equivalents	Energy: thermal Thermal neutron beam	5.0 %	Service reference numbers: RN01, RN02, and RN04. Fluences are converted to ambient dose equivalent or personal dose equivalent using accepted conversion coefficients. For broad energy range neutron fields from sources the uncertainties in the neutron dose equivalent values reflect uncertainties in the source spectra rather than the conversion coefficients, which are assumed to be exact. Service conforms to ISO Standard 8529 Parts 1 to 3.	
	Energy: 70 keV to 17 MeV Monoenergetic fields	4.0 %		
	Energy: broad energy range from radionuclide sources Dose equivalent rates:			
	^{241}Am-Be: 1 µSv h^{-1} to 400 µSv h^{-1} at 1m from the source	8.1 %		
	^{252}Cf: 2 µSv h^{-1} to 280 µSv h^{-1} at 1m from the source	2.4 %		
Fast neutron personal dosemeter proficiency testing	Energy: broad energy range from radionuclide sources Dose equivalent rates:		Service reference number: RN04. In accordance with HSE Measurement Protocol for Performance Testing of Dosimetry Services for External, Whole Body Fast Neutron Radiation, June 2001.	
	^{241}Am-Be: 1 µSv h^{-1} to 400 µSv h^{-1} at 1m from the source	8.1 %		
	^{252}Cf: 2 µSv h^{-1} to 280 µSv h^{-1} at 1m from the source	2.4 %		

Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
RADIATION DOSIMETRY				Teddington
Protection level dosemeters Air kerma rate				
X-rays	ISO 4037 narrow spectrum (generating potential 8 to 250 keV) 350 μGy h^{-1} to 100 $mGyh^{-1}$	1.5 %	Service reference number: RD02 Calibration of protection level ionisation chamber with volumes ranging from 35 cm^3 to 10 litres connected to a suitable secondary standard electrometer.	
γ-radiation	^{60}Co 1 μGyh^{-1} to 0.3 Gyh^{-1} ^{137}Cs 1 μGyh^{-1} to 0.3 Gyh^{-1} ^{241}Am 8 μGyh^{-1} to 0.3 $mGyh^{-1}$	1.2 % 1.2 % 1.5 %		
X-ray generating potential	Generating potential 25 to 150 kVp	1.5 %	Service reference number: RD04. Calibration of penetrameters and kVp meters.	
Therapy level dosemeters				
Measurement of air kerma rate				
X-rays	Half value layers 0.024 to 20 mm Al (generating potential 8 to 280 kVp)	1.2 %	Service reference number: RD01 Calibration of NE2561, NE2611, for Farmer type and soft x-ray chambers ionisation with a suitable secondary standard electrometer.	
γ-radiation	^{60}Co	1.2 %	Calibration of NE2561, NE2611, for Farmer type ionisation with a suitable secondary standard electrometer.	
Measurement of absorbed dose to water				
γ-radiation	^{60}Co	1.4 %	Calibration of NE2561, NE2611, for Farmer type ionisation with a suitable secondary standard electrometer.	
Photons	TPR_{10}^{20}: 0.568 to 0.775 Generating potential 4 to 18 MeV	1.4 %		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k=2)	Remarks	Location Code
RADIATION DOSIMETRY (cont'd)				Teddington
High dose dosimetry				
Absorbed dose to water	^{60}Co Dose: 5 Gy to 100 kGy	2.2 %	Service reference number: RD07 High dose irradiation service.	
	^{60}Co Dose: 2 kGy to 55 kGy	2.2 % to 2.9 % depending on the dose	Service reference number: RD05 Dichromate dosimetry service.	
	^{60}Co, ^{137}Cs, photons generated above 2 MeV and electrons generated above 4 MeV. Dose: 20 Gy to 100 kGy	2.6 %	Service reference number: RD06 Alanine dosimetry service	
RADIOACTIVITY METROLOGY				
RR/0101 – Standards of Radioactivity (activity concentration, Bq/g^{-1}): Solutions (or solid substrates spiked directly with such solutions) of α-particle, β-particle, X-ray and γ-ray emitting radionuclides measured by absolute techniques.	400 Bq g^{-1} - 15 GBq g^{-1}, depending on radionuclide	0.30 %	Procedures directly supporting this work are: **RMS005** – Standards of Radioactivity Solutions **RMT026** – 4π β-γ Coincidence Counting Using an Atmospheric Pressure Proportional Counter	
RR/0101a – Standards of Radioactivity (activity concentration, Bq g^{-1}): Solutions (or solid substrates spiked directly with such solutions) of α-particle, β-particle, X-ray and γ-ray emitting radionuclides measured by secondary techniques.	4 kBq g^{-1} - 15 GBq g^{-1}, depending on radionuclide	0.30 %	Procedures directly supporting this work are: **RMT006** - Measurement of a Gamma Spectrometry Sample **RMT007** - Analysis of a Gamma Spectrometry Sample **RSP014** - Ionisation Chamber Calibration Factors **RMT031** - Activity Assay Using Ionisation Chambers **RMT009** - Secondary Standardisation of Radionuclides using CIEMAT/NIST Technique	
RR/0102 - Standards of Radioactivity (activity concentration, Bq g^{-1}): Solutions (or solid substrates spiked directly with such solutions) of α-particle, β-particle or X-ray emitting radionuclides measured by absolute techniques.	4 kBq g^{-1} – 20 MBq g^{-1}	0.50 %	Procedures directly supporting this work are: **RMS005** - Standards of Radioactivity Solutions **N135** - Liquid Scintillation-□ Coincidence Counting **RMT026** - 4π β-γ Coincidence Counting Using an Atmospheric Pressure Proportional Counter	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
RADIOACTIVITY METROLOGY (cont'd)				Teddington
RR/0102a - Standards of Radioactivity (activity concentration, Bq g^{-1}): Solutions (or solid substrates spiked directly with such solutions) of α-particle, β-particle and X-ray emitting radionuclides measured by secondary liquid scintillation techniques	100 Bq g^{-1} - 500 kBq g^{-1}	0.20 %	Procedures directly supporting this work are: **RMT009** - Secondary Standardisation of Radionuclides using CIEMAT/NIST Technique **RMT012** - Dilution check by liquid scintillation counting	
RR/0201 – Standard of Radioactivity (activity concentration, Bq m^{-3}): Gaseous radionuclides other than radon	0.04 MBq m^{-3} – 30 GBq m^{-3}	1.0%	Procedures directly supporting this work are: **RMT034** –Standardisation of Gaseous Radionuclides Other Than Radon and Carbon-11	
RR/0203 - Instrument Calibration (response to activity concentration, Bq m^{-3}): Customer supplied radioactivity-in-air monitors (other than radon)	40 kBq m^{-3} - 150 MBq m^{-3}	5.0 %	Procedures directly supporting this work are: RMT03 - Calibration of Tritium-In-Air Monitors	
RR/0301 – Wide Area Reference Source Calibration (surface particle emission rate, particles s^{-1}): Customer supplied radioactive surface contamination sources	10 - 10000 particles s^{-1}	0.50 % for alpha 1.0 % for beta	Procedures directly supporting this work are: **RMS008** - RR0300 Calibration Service **RMT004** - Measurement of a Wide Area Reference Source by the Primary Large Area Proportional Counter **RQC004** - Quality Checks of the Large Area Proportional Counter **RSP008** - Setting of the Alpha and Beta Counting Thresholds	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
RADIOACTIVITY METROLOGY (cont'd)				
RR/0501 - Standards of Radioactivity (activity concentration, Bq g^{-1}): Solutions (or solid substrates spiked directly with such solutions) of Environmental level standards of radioactivity	0.001 Bq g^{-1} - 100 kBq g^{-1}, depending on radionuclide	0.50 %	Procedures directly supporting this work are: **RMS007** - Production of the NPL Mixed Radionuclide Solution **RMS009** - Production of Environmental Radioactivity Standards	Teddington
RR/0601 - Standards of Radioactivity (activity concentration, Bq g^{-1}): Solutions of ^{3}H standards for ^{3}H measurement proficiency test	10 Bq g^{-1} - 1 kBq g^{-1}	1.0 %	In accordance with HSE Measurement Protocol for Performance Testing of the Determination of Tritium in Water (1993) Procedures directly supporting this work are: **RMS012** - Performance Testing of the Determination of Tritium in Water **RMS013** - Data Analysis of Assigned Value Comparison Exercise Results for Performance Testing of the Determination of Tritium in Water	Teddington
RR/0701 - Artefact calibration (activity content, Bq): Gelatine capsules (^{131}*I only*), brachytherapy wires (^{192}*Ir only*), brachytherapy seeds (^{125}*I only*) or solutions (or solid substrates spiked directly with such solutions) of α-particle, β-particle, X-ray and γ-ray emitting radionuclides measured by primary or secondary techniques.	400 Bq g^{-1} - 15 GBq g^{-1}, depending on radionuclide	0.30 %	Procedures directly supporting this work are: **RMT031** - Activity Assay using Ionisation Chambers **RSP014 -** Ionisation Chamber Calibration Factors **RMS001 -** Calibration of Customer Supplied Sources (Gamma Emitters) **RMS002** - Calibration of Customer Supplied Sources (Beta Emitters) **RMT006** - Measurement of a Gamma Spectrometry Sample **RMT007** - Analysis of a Gamma Spectrometry Sample **RMT026** - 4π β-γ Coincidence Counting Using an Atmospheric Pressure Proportional Counter **RMT009** - Secondary Standardisation of Radionuclides using CIEMAT/NIST Technique **RMT012** - Dilution check by liquid scintillation counting	Teddington

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k=2)	Remarks	Location Code
RADIOACTIVITY METROLOGY (cont'd)				Teddington
RR/1201 - Calibration of impurity content of radionuclide solutions by high resolution gamma spectrometry (activity concentration, Bq g^{-1} or activity concentration, Bq ml^{-1})	10 Bq g^{-1} - 100 kBq g^{-1} or 10 Bq ml^{-1} - 100 kBq ml^{-1}	0.30 %	Procedures directly supporting this work are: **RMS003** - Impurity checks for IBA Molecular (UK) Ltd **RMT006** - Measurement of a Gamma Spectrometry Sample **RMT007** - Analysis of a Gamma Spectrometry Sample	
MASS				
Specific values	Nominal value (g)	(mg)		
	50 000	2.5		
	20 000	1.0	The stated best measurement capability relates to measurements made on standards that are constructed in accordance with the principles contained in OIML Recommendation III for weights of Class E1. Intermediate values of weights can be calibrated to an uncertainty equal to the greater of the uncertainties associated with the next higher and lower nominal values in the table.	
	10 000	0.40		
	5 000	0.20		
	3 000	0.20		
	2 000	0.070		
	1 000	0.030		
	500	0.015		
	300	0.010		
	200	0.0070		
	100	0.0040		
	50	0.0030		
	30	0.0030		
	20	0.0015		
	10	0.0010		
	5	0.00060		
	3	0.00060		
	2	0.00030		
	1 to 0.001	0.00020		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
PRIMARY REFERENCE GAS MIXTURES (PRGM) AND CALIBRATED GAS MIXTURES (CGM)				Teddington
PRIMARY REFERENCE GAS MIXTURES (PRGM) Preparation of synthetic gas mixtures by gravimetry in accordance with ISO 6142:2001; verification by analysis.				
CALIBRATED GAS MIXTURES (CGM) Certification of synthetic gas mixtures by analysis.				
The laboratory also has ISO Guide 34 accreditation for production and certification of Primary Reference Gas Mixtures. Accredited certified reference material producer number 4002.				
Gas mixtures can be prepared and calibrated from pure materials to nmol/mol levels. Some examples are listed below. Gas mixtures include those listed in the BIPM CMC tables: http://kcdb.bipm.org/appendixc/QM/GB/QM_GB_4.pdf				
SYNTHETIC NATURAL GAS MIXTURES	Amount fraction %mol/mol	Amount fraction %mol/mol		
Nitrogen	0.02 to 25.2	0.18 % relative + 0.00038	PRGM and CGM	
Carbon dioxide	0.04 to 25.0	0.20 % relative + 0.00045		
Methane	55.0 to 99.9	0.018 % relative + 0.0020		
Ethane	0.008 to 18	0.28 % relative + 0.000080		
Propane	0.008 to 8.0	0.30 % relative + 0.000080		
i-Butane	0.004 to 1.7	0.40 % relative + 0.000040		
n-Butane	0.004 to 1.7	0.40 % relative + 0.000040		
neo-Pentane	0.0005 to 0.5	0.80 % relative + 0.000015		
i-Pentane	0.0025 to 0.6	0.40 % relative + 0.000030		
n-Pentane	0.0025 to 0.6	0.40 % relative + 0.000030		
n-Hexane	0.0008 to 0.5	0.40 % relative + 0.000018		
Helium	0.001 to 0.5	0.95 % relative + 0.000050		
	Amount fraction µmol/mol	Amount fraction µmol/mol		
Benzene	5 to 500	1.1 % relative + 0.030		
Toluene	5 to 250	1.1 % relative + 0.030		
Cyclohexane	10 to 400	1.1 % relative + 0.030		
Methylcyclohexane	10 to 400	1.1 % relative + 0.030		
n-Heptane	10 to 500	1.1 % relative + 0.040		
n-Octane	5 to 10	1.3 % relative + 0.025		
	10 to 200	1.1 % relative + 0.040		
n-Nonane	1 to 10	1.6 % relative + 0.0090		
	10 to 120	1.2 % relative + 0.048		
n-Decane	1 to 20	1.6 % relative + 0.013		

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
PRIMARY REFERENCE GAS MIXTURES (PRGM) AND CALIBRATED GAS MIXTURES (CGM) (continued)				Teddington
SYNTHETIC FUEL GAS MIXTURES	Amount fraction %mol/mol	Amount fraction %mol/mol		
Nitrogen	0.1 to 95	0.30 % relative + 0.0020	PRGM and CGM	
Carbon monoxide	0.1 to 11	0.48 % relative + 0.0016		
Carbon dioxide	0.3 to 8	0.48 % relative + 0.0016		
Oxygen	0.2 to 2.5	0.78 % relative + 0.0005		
Hydrogen	1 to 70	0.38 % relative + 0.0025		
Helium	5 to 10	0.40 % relative + 0.030		
Methane	1 to 85	0.33 % relative + 0.0015		
Ethane	0.3 to 35	0.35 % relative + 0.0010		
Ethene	0.1 to 12	0.35 % relative + 0.00030		
Ethyne	0.025 to 2	0.40 % relative + 0.00025		
Propane	0.1 to 18	0.40 % relative + 0.00020		
Propene	0.04 to 7	0.45 % relative + 0.00010		
i-Butane	0.1 to 4	0.40 % relative + 0.00025		
n-Butane	0.1 to 6	0.40 % relative + 0.00025		
1-Butene	0.015 to 1.55	0.45 % relative + 0.00020		
i-Butene	0.018 to 1.2	0.50 % relative + 0.00020		
t-2-Butene	0.015 to 0.85	0.45 % relative + 0.00013		
c-2-Butene	0.015 to 0.35	0.45 % relative + 0.00013		
1,3-Butadiene	0.01 to 0.65	0.55 % relative + 0.00015		
i-Pentane	0.05 to 0.8	0.45 % relative + 0.00020		
n-Pentane	0.05 to 0.8	0.45 % relative + 0.00020		
SULPUR ODORANT GAS MIXTURES	Amount fraction µmol/mol	Amount fraction µmol/mol		
Hydrogen sulphide	0.4 to 5,000	<u>PRGM</u>	Matrix gas: Methane or nitrogen	
Carbonyl sulphide	0.4 to 5,000	1.0 % relative + 0.0050		
Carbon disulphide	0.4 to 200	(All components)		
Dimethyl sulphide	0.4 to 200			
Ethyl methyl sulphide	0.4 to 200			
Diethyl sulphide	0.4 to 200	<u>CGM</u>		
Methyl mercaptan [Methanethiol]	0.4 to 200	1.2 % relative + 0.0050 (All components)		
Ethyl mercaptan [Ethanethiol]	0.4 to 200			
i-propyl mercaptan [2-propanethiol]	0.4 to 200			
n-propyl mercaptan [1-propanethiol]	0.4 to 200			
Tert-butyl mercaptan [2-methyl-2-propanethiol]	0.4 to 200			
Tetrahydrothiophene [THT]	0.4 to 200			

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
PRIMARY REFERENCE GAS MIXTURES (PRGM) AND CALIBRATED GAS MIXTURES (CGM) (continued)				
BINARY GAS MIXTURES	Amount fraction		CGM	Teddington
Nitric oxide in nitrogen	100 nmol/mol to 10 μmol/mol	1.0 % relative		Teddington
Sulphur dioxide in synthetic air or nitrogen	100 nmol/mol to 10 μmol/mol	2.0 % relative		Teddington
Nitrogen dioxide in nitrogen	100 nmol/mol to 10 μmol/mol	3.0 % relative		Teddington
OZONE PHOTOMETERS				Teddington
Ozone in synthetic Air	0 nmol/mol to 100 nmol/mol 100 nmol/mol to 1 μmol/mol	3.0 nmol/mol 3.0 % relative		Teddington
GAS FLOW METERS				Teddington
Flow Ratio Determination	Flow ratio 0 % to 100 % Individual flow rates from 10 cm3/min to 20 L/min	0.60 %		Teddington
ACOUSTICS			All tests are carried out at temperatures specified in procedures and in the relevant standards	Teddington
PISTONPHONES & SOUND CALIBRATORS				Teddington
Sound pressure level of pistonphones and sound calibrators	70 dB to 130 dB (SPL) *31.5 Hz to 16 kHz*	Examples at 124 dB, 250 Hz Microphone type LS1P 0.04 dB WS1P 0.06 dB LS2P 0.04 dB WS2P 0.05 dB WS3P 0.06 dB	Using measurement microphones according to IEC 61094-1:1992 and IEC 61094-4:1995 Insert voltage technique using standard microphone for microphone types: LS1, WS1, LS2, WS2 Voltage ratio technique for microphone type WS3	Teddington
Periodic testing of sound calibrators	IEC 60942:2003 70 dB to 130 dB (SPL) 31.5 Hz to 16 kHz	See remarks	Periodic testing of class LS, clas 1 and class 2 sound calibrators	Teddington

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
ACOUSTICS (continued)				
MICROPHONES				
Free-field sensitivity of microphones	31.5 Hz - 5 kHz 6.3 kHz - 10 kHz 12.5 kHz	0.2 dB 0.3 dB 0.4 dB	Free field sensitivity measured by substitution using a standard microphone in a duct and free-field room	
Free field sensitivity of microphone systems	31.5 Hz - 5 kHz 6.3 kHz - 10 kHz 12.5 kHz	0.2 dB 0.3 dB 0.5 dB		
Pressure sensitivity level of a laboratory standard microphone			As per IEC 61094-2:1992	
Type LS1 including type WS1 converted to LS1 configuration using an adaptor specified by the manufacturer	63 Hz to 2.5 kHz 3.15 kHz to 4 kHz 5 kHz to 8 kHz 10 kHz	0.03 dB 0.04 dB 0.05 dB 0.10 dB		
Type LS2 including type WS2 converted to LS2 configuration using an adaptor specified by the manufacturer	63 Hz to 5 kHz 6.3 kHz 8 kHz 10 kHz 12.5 kHz 16 kHz 20 kHz	0.03 dB 0.04 dB 0.05 dB 0.06 dB 0.08 dB 0.09 dB 0.18 dB		
Pressure sensitivity level of laboratory standard or working standard microphone, type LS2 or WS2 respectively	63 Hz to 5 kHz 6.3 kHz 8 kHz 10 kHz 12.5 kHz	0.07 dB 0.08 dB 0.09 dB 0.10 dB 0.11 dB	Simultaneous calibration using a reference microphone	
System sound pressure level response of:				
Reference coupler	125 Hz to 8 kHz	0.2 dB	Comparison using a standard microphone	
Artificial ear	125 Hz to 8 kHz	0.2 dB	Comparison using a standard microphone	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
ACOUSTICS (continued) MICROPHONES (cont'd)				Teddington
Output of reference earphones for checking output of air conduction system				
Reference coupler Artificial ear	125 Hz to 8 kHz 125 Hz to 8 kHz	See remarks	Application of known voltage to earphone & quoting the standard deviation of the measurements performed	
Force response of mechanical coupler system	250 Hz to 4 kHz	0.3 dB	Response to application of known force	
Output of reference bone vibrators for checking output of bone conduction system	250 Hz to 4 kHz	See remarks	Application of known voltage to bone vibrator & quoting the standard deviation of he measurements performed	
ULTRASONICS				
Reference hydrophone sensitivity	1 MHz to 8 MHz 9 MHz to 12 MHz 13 MHz to 16 MHz 17 MHz to 20 MHz 21 MHz to 30 MHz 31 MHz to 40 MHz	6 % 7 % 8 % 11 % 12 % 15 %	Free field sensitivity determined through substitution using a secondary hydrophone in a non-linearly distorted sound field	
End of cable hydrophone receive sensitivity	25 Hz to 400 Hz	0.5 dB	By comparison to a microphone using an air-pistonphone	
Free field sensitivity of reference measuring hydrophones/projectors	1 kHz to 2 kHz 2 kHz to 500 kHz	0.7 dB 0.5 dB	Using three-transducer spherical wave reciprocity method in a laboratory tank	
Free field sensitivity of reference measuring hydrophones	1 kHz to 2 kHz 2 kHz to 1 MHz	0.9 dB 0.7 dB	By comparison with NPL reference hydrophone in a laboratory tank	
Directional response of transducers and hydrophones	1 kHz to 1 MHz	0.21 dB	Normalised response versus angle. XY, XZ and YZ responses available. Performed in a laboratory tank	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
UNDERWATER ACOUSTICS				Wraysbury
Projector sensitivity	250 Hz to 350 kHz From noise limit to 210 dB re 1 µPa/V at 1 m	0.9 dB	Using calibrated hydrophone method in an open-water test facility	Wraysbury
Hydrophone sensitivity	250 Hz to 350 kHz From -250 to -100 dB re. 1 V/µPa	0.9 dB	Using calibrated projector method in an open-water test facility	Wraysbury
Complex admittance	250 Hz to 350 kHz		For underwater electro acoustic transducers only. Undertaken in open-water test facility.	Wraysbury
conductance susceptance capacitance		(2 % + 10) µS (2 % + 10) µS (2 % + 20) µS		Wraysbury
FORCE				Teddington
Proving devices, load cells and other force-measuring devices in compression and tension modes	*50 N Machine* 1.5 N to 50 N *500 N Machine* 25 N to 500 N *2.5 kN Machine* 25 N to 2.5 kN *20 kN Machine* 0.5 kN to 20 kN *120 kN Machine* 2.5 kN to 120 kN *1.2 MN Machine* 10 kN to 1.2 MN *5 MN Machine* 100 kN to 5 MN	0.0020 % 0.0020 % 0.0010 % 0.0010 % 0.0010 % 0.0010 % 0.050 %	Calibrations can be performed in accordance with BS EN ISO 376:2004, ASTM E74-06, ISO 376:2004 and BS 8422:2003 standard and supplementary calibrations A, B, E, L & R. Forces can be applied incrementally and decrementally thus permitting the determination of hysteresis errors.	Teddington
Strain Cylinders	200 kN to 2 MN	See remarks	Strain cylinders compared with a reference strain cylinder in a 3 MN compression machine in accordance with BS EN 12390-4:2000.	Teddington
Voltage Ratio				Teddington
Calibration of AC and DC voltage ratio meters used with strain gauge force transducers	0.01 mV/V to 0.05 mV/V 0.05 mV/V to 1.0 mV/V 1.0 mV/V to 2.5 mV/V 2.5 mV/V to 10 mV/V	0.010 % 0.0050 % 0.0070 % 0.0050 %	Ratio meters are compared to a reference resistance network using a precision digital voltmeter to measure the voltage ratios generated	Teddington

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
PRESSURE				Teddington
Gas Pressure (absolute)				
Determination of effective area of deadweight testers	3.5 kPa to 16 kPa 16 kPa to 700 kPa 700 kPa to 7 MPa	0.0023 % 0.0021 % 0.0025 % + 0.25 ppm/MPa		
Calibration of pressure indicating instruments	75 kPa to 110 kPa	5.0 Pa		
Gas Pressure (gauge)				
Determination of effective area of deadweight testers	3.5 kPa to 16 kPa 16 kPa to 700 kPa 700 kPa to 7 MPa 7 MPa to 21 MPa	0.0023 % 0.0021 % 0.0025 % + 0.25 ppm/MPa 0.0028 % + 0.25 ppm/MPa		
Oil Pressure (gauge)				
Determination of effective area of deadweight testers	500 kPa to 200 MPa 200 MPa to 500 MPa	0.0031 % + 0.24 ppm/MPa 0.0038 % + 0.24 ppm/MPa		
FIBRE OPTICS			Measurements carried out at 23 ± 2 °C, unless stated otherwise	
Mode field diameter	3.5 μm to 13 μm	0.60 %	Single-mode fibre from 1250 nm to 1625 nm.	
Mode field noncircularly	0 % to 1 %	0.1 %	Far field scan method Petermann II definition	
Effective area	30 μm^2 to 90 μm^2	2.0 %	Far field scan method. Hankel transform	
Dispersion in single-mode optical fibre			Fibre length: 2 km to 50 km	
Dispersion	0 $ps.nm^{-1}$ to 1.3 x 10^{-5} $ps.nm^{-1}$	1.5 % added in quadrature with 0.010 $ps.nm^{-1}.km^{-1}$	Laser based system	
Zero dispersion wavelength	1250 nm to 1650 nm	0.10 nm	Laser based system	
Dispersion slope at zero dispersion wavelength	- 100 to + 100 $ps.nm^{-1}.km^{-1}$	1.5 %	Laser based systems	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
FIBRE OPTICS (cont'd)			Measurements carried out at 23 ± 2 °C, unless stated otherwise	Teddington
Optical length	0.1 km to 15 km measured in the wavelength range 1270 nm to 1650 nm.	$(0.040 + 1.7 \times 10^{-5}\ L)$	Single-mode optical fibre, pulsed time of flight technique.	
	15 km to 105 km measured at wavelengths of 1310 nm, 1550 nm & 1625 nm	$(0.10 + 1.7 \times 10^{-5}\ L)$	L is optical length in metres	
Fibre attenuation coefficient uniformity	0.17 db/km to 0.43 db/km	0.0060 dB/km	Single-mode optical fibre (length 4 km to 14 km). Measured using an optical time domain reflectometer (OTDR), 1300 nm and 1550 nm wavelength windows	
Spectral attenuation of single mode fibre	0.1 dB to 35 dB	0.020 dB	Cut-back technique Wavelength range 1200 nm to 1650 nm Measurements carried out over the temperature range 18 °C to 23 °C.	
Spectral attenuation of multimode fibre	0.1 dB to 35 dB	0.020 dB	Cut-back technique Wavelength range 800 nm to 900 nm 1250 nm to 1350 nm Measurements carried out over the temperature range 18 °C to 23 °C.	
Cut-off wavelength of optical fibre and cable	800 nm to 1600 nm	2.0 nm	Transmitted power technique Measurements carried out over the temperature range 18 °C to 23 °C.	
<u>Fibre optic test equipment</u>			Measurements carried out at 20 ± 2 °C, unless otherwise stated	
Absolute responsivity of fibre optic power meters with FC/PC connectors	*Power level:* *- 10 dBm to + 23 dBm*		Minimum customer meter resolution 2 % of stated power levels	
	850 nm ± 30 nm 1300 nm ± 25 nm	0.90 % 0.70 %	Multimode fibre	
	980 nm ± 10 nm 1300 nm ± 25 nm 1500 nm ± 30 nm 1550 nm ± 20 nm 1620 nm ± 20 nm	0.90 % 0.70 % 0.80 % 0.70 % 0.70 %	Single mode fibre	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
Fibre optic test equipment (cont'd)			Measurements carried out at 23 ± 2 °C, unless stated otherwise	Teddington
Absolute responsivity of fibre optic power meters with SC/PC connectors	*Power level:* *- 10 dBm to + 23 dBm*		Minimum customer meter resolution 2 % of stated power levels	
	850 nm ± 30 nm 980 nm ± 10 nm 1300 nm ± 25 nm	1.5 % 1.5 % 1.0 %	Multimode fibre Single mode fibre Single mode and multi mode fibre	
Absolute responsivity of fibre optic power meters with SC/PC connectors (cont'd)	*Power level:* *- 10 dBm to + 23 dBm*		Minimum customer meter resolution 2 % of stated power levels	
	1500 nm ± 30 nm 1550 nm ± 20 nm 1620 nm ± 20 nm	1.0 % 1.0 % 1.0 %	Single mode fibre	
Absolute responsivity of fibre optic power meters with FC/APC or SC/APC connectors	*Power level:* *- 10 dBm to + 23 dBm*		Minimum customer meter resolution 2 % of stated power levels	
	1500 nm ± 30 nm 1550 nm ± 20 nm 1620 nm ± 20 nm	1.6 % 1.6 % 1.6 %	Single mode fibre	
Linearity in fibre optic power meters with FC/PC, SC/PC, FC/APC and SC/APC connectors - Comparison technique	20 dBm to 10.01 dBm + 10 dBm to - 90 dBm	0.70 % 0.30 %	Wavelength range: 830 nm to 1620 nm Single mode and multi mode fibre	
Linearity in fibre optic power meters with FC/PC, SC/PC, FC/APC and SC/APC connectors - Superposition technique	+15 dBm to - 90 dBm	0.050 %	Wavelength range: 1275 nm to 1640 nm Single mode fibre	
Effective centre wavelength of fibre optic light source with spectral line width <5 nm	800 nm to 1700 nm	0.30 nm	FC/PC connectorised fibre output	
Effective centre wavelength of fibre optic light source with spectral line width in the range 5 nm to 50 nm	800 nm to 1700 nm	1.2 nm	FC/PC connectorised fibre output	
Spectral line width (FWHM) of sources	0.07 nm to 50 nm	0.10 nm	800 nm to 1700 nm	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
Fibre optic test equipment (cont'd)				Teddington
Output power stability of fibre optic light sources	+ 10 dBm to - 50 dBm	0.0040 dB	Wavelength range 800 nm to 1700 nm	
Wavelength accuracy of a wavelength meter	1286 nm to 1355 nm 1480 nm to 1650 nm	0.13 pm	Calibration by reference to a frequency locked standard Measurements performed at 23 ± 2 °C	
Wavelength scale accuracy of an optical spectrum analyser	600 nm to 1700 nm	10 pm	Accuracy is typically limited by the instrument under test Measurements performed at 23 ± 2 °C	
PARTICLE COUNTERS				
Airborne particle number concentration				
Calibration factor for condensation particle counters	Concentration range 1000 cm^{-3} to 100,000 cm^{-3}	±7.0 %	Comparison with an aerosol electrometer	

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (*k*=2)	Remarks	Location Code
INSTRUMENTS FOR AIR QUALITY MONITORING				**Customers' sites**
Analyser Calibration	NOx 200 ppb to 2 ppm SO_2 150 ppb to 1 ppm O_3 30 ppb to 1 ppm CO 0.5 ppm to 45 ppm	4.0 %	Two point (zero and span) calibration. An assessment of uncertainty due to analyser repeatability and linearity is also undertaken.	
Determination of on site standard concentration	NOx 200 ppb to 2 ppm (NO and NO_2) SO_2 150 ppb to 1 ppm CO 0.5 ppm to 45 ppm	4.0 %		
NO_2 molybdenum converter efficiency test	100 ppb to 250 ppb NO_2	1.5 %	Reaction of NO with O_3	
Sample system collection efficiency	NO_2 50 ppb to 150 ppb SO_2 50 ppb to 150 ppb O_3 50 ppb to 150 ppb CO 6 ppm to 12 ppm	1.5 % absolute 1.0 % absolute 1.5 % absolute 1.0 % absolute		
Analyser span noise test	Range as analyser calibration	2.0 ppb		
Analyser zero noise test	NOx, NO, SO_2, O_3, CO	1.0 ppb		
Particulate analyser calibration	0 $mg.m^{-3}$ to 1 $mg.m^{-3}$	1.5 %	Using 4 pre-weighed masses	
Particulate analyser flow rate test	1 slm to 10 slm 10 slm to 40 slm	1.5 % 2.0 %	Volumetric and mass flow	
BINARY GAS MIXTURES				
Nitric oxide in nitrogen	200 nmol/mol to 2 μmol/mol	3.0 % relative		

END