Schedule of Accreditation

issued by

United Kingdom Accreditation Service

2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

UKAS CALIBRATION **0478** **Accredited to ISO/IEC 17025:2017**	**NPL Management Ltd** **Issue No:** 148 **Issue date:** 22 January 2025	
	Hampton Road **Teddington** **Middlesex** **TW11 0LW**	**Contact: Customer Helpline** **Tel: +44 (0)20 8943 7070** **Fax: +44 (0)20 8614 0482** **E-Mail: measurement_services@npl.co.uk** **quality@npl.co.uk** **Website: www.npl.co.uk**

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 Maqba, Customer Services Manager Tel: +44 (0)20 8943 6796 Fax: +44 (0)20 8614 0482 Email: tahir.maqba@npl.co.uk	Calibration Chemical Density and Volume Dimensional Electromagnetic Fibre optics Flow Force Humidity Mass Optical Pressure Radiological Temperature Time and Frequency Ultrasonics Underwater Acoustics	Teddington
Address Wraysbury Reservoir Coppermill Road Wraysbury Middlesex TW19 5NW	**Local contact** Mr J Ablitt Tel: +44 (0)20 8943 6695 Email: justin.ablitt@npl.co.uk	Calibration Underwater Acoustics	Wraysbury

Site activities performed away from the locations listed above:

Location details	Activity	Location Code
Customer's sites or premises The customer's 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 Chemical *(Environmental air quality monitoring instruments)*	Customers' sites

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CALIBRATION AND MEASUREMENT CAPABILITY (CMC)

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
DC VOLTAGE *Service Reference ED01*			Direct comparison against Josephson Junction array.	Teddington
Standard cells, not thermostated	1.018 V nominal	0.090 µV/V	Measured in a thermostated air enclosure at 20 °C.	
Standard cells in a thermostated enclosure	1.018 V nominal	0.090 µV/V		
Electronic reference standards	1.0 V 1.018 V 10 V	0.14 µV/V 0.14 µV/V 0.020 µV/V	Supplementary data can be supplied showing detailed behaviour of standard cells or electronic devices.	
DC RESISTANCE			Using build up technique referred to quantum Hall resistor.	
Service Reference ED02	0.1 mΩ 1 mΩ 10 mΩ 100 mΩ 1 Ω 10 Ω 25 Ω 100 Ω 1 kΩ 10 kΩ	2.5 µΩ/Ω 0.85 µΩ/Ω 0.80 µΩ/Ω 0.18 µΩ/Ω 0.060 µΩ/Ω 0.050 µΩ/Ω 0.050 µΩ/Ω 0.050 µΩ/Ω 0.050 µΩ/Ω 0.060 µΩ/Ω	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	0.080 µΩ/Ω 0.12 µΩ/Ω 0.20 µΩ/Ω 0.40 µΩ/Ω	2-terminal resistors at temperatures between 17 °C and 25 °C and at or less than 1 mW power dissipation. Values >10 kΩ are not measured in oil.	
	1 GΩ	1.6 µΩ/Ω	Measured in a 2-terminal configuration, in air, at 20 °C or 23 °C.	
Temperature Coefficient	α β	0.0020 µΩ/Ω K^{-1} 0.0010 µΩ/Ω 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 *30 mA to 50 A* *20 A to 100 A*	 0.50 µΩ/Ω to 5.0 µΩ/Ω 5.0 µΩ/Ω to 10 µΩ/Ω	Using ratio techniques.	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)		Remarks	Location Code
AC RESISTANCE *Service Reference ED02*				Using AC bridge techniques.	Teddington
Specific values	1 Ω *40 Hz to 1 kHz* *1 kHz to 2 kHz* *2 kHz to 3 kHz* *3 kHz to 5 kHz* *5 kHz to 10 kHz* *20 kHz*	 5.0 μΩ/Ω 4.0 μΩ/Ω 5.0 μΩ/Ω 6.0 μΩ/Ω 15 μΩ/Ω 50 μΩ/Ω		The uncertainties quoted for AC resistance may depend on the type and construction of the resistor	
Other values	10 Ω to 10 kΩ *40 Hz to 400 Hz* *400 Hz to 2 kHz* *2 kHz to 3 kHz* *3 kHz to 5 kHz* *5 kHz to 10 kHz* *20 kHz*	 1.0 μΩ/Ω 0.50 μΩ/Ω 1.2 μΩ/Ω 1.8 μΩ/Ω 6.0 μΩ/Ω 50 μΩ/Ω		*Exceptions:* 10 Ω, 40 Hz: 1.5 μΩ/Ω 100 Ω, 400 Hz to 1.59 kHz: 0.60 μΩ/Ω 100 Ω, 1.59 kHz to 2 kHz: 0.80 μΩ/Ω 100 Ω, 2 kHz to 3 kHz: 1.5 μΩ/Ω 10 kΩ,10 kHz: 8.0 μΩ/Ω	
Time constant (τ)	0 ns to ± 200 ns	10 ns		All nominal values and frequencies shown above.	
AC CURRENT RATIO *Service Reference ED07*				Using current comparator.	
Current Transformers		*Ratio error*	*Phase error*		
Ratio and phase error	0.25 A to 0.5 A *50 Hz*	0.001%	10 μrad	The CMCs apply to compensated current transformers only.	
	5 A to 1000 A *50 Hz to 400 Hz*	0.001%	10 μrad		
	1000 A to 5000 A *50 Hz to 60 Hz*	0.001%	10 μrad	1 A or 5 A secondary.	
	5 kA to 10 kA *50 Hz*	0.002%	20 μrad		
	50 Hz to 400 Hz Class 0.01, 0.02 and 0.03 Class 0.1 and higher	 0.001% 0.003%	 10 μrad 30 μrad	The CMCs apply to measurements carried out on uncompensated current transformers in accordance with BS EN 61869-2:2012 at unity or 0.8 power factor as specified or required.	
Current Transducers					
with output voltage greater than 0.10V	*50 Hz*	0.050 %			

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Issue No: 148 **Issue date:** 22 January 2025

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Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
AC/DC TRANSFER VOLTAGE *Service Reference ED11*			Build up technique against known AC/DC transfer standard.	Teddington

CMCs for AC/DC Transfer Voltage, at Specific Values, expressed as an Expanded Uncertainty (k = 2) [10^{-6} of value]

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

Voltage	*Frequency*										
	10 Hz	20 Hz to 5 kHz	10 kHz	20 kHz	50 kHz	100 kHz	200 kHz	300 kHz	500 kHz	700 kHz	1 MHz
1 mV	66	66	66	66	71	85	120	180	260	480	800
2 mV	66	57	57	57	59	71	99	140	190	330	510
5 mV	28	28	28	28	33	48	83	120	180	290	460
10 mV	28	28	28	28	33	46	78	110	170	260	410
20 mV	28	28	28	28	31	46	78	110	160	250	370
70 mV	26	26	26	26	31	41	76	110	160	250	370
100 mV	7.0	7.0	7.0	7.0	9.0	14	24	36	58	82	120
200 mV	7.0	7.0	7.0	7.0	9.0	14	24	36	58	82	120
300 mV	6.0	6.0	6.0	6.0	7.0	11	20	29	48	68	96
500 mV	6.0	6.0	6.0	6.0	7.0	10	16	23	38	54	76
1 V	6.0	6.0	6.0	6.0	7.0	7.0	13	17	25	38	51
2 V	6.0	6.0	6.0	6.0	6.0	7.0	10	12	17	27	38
3 V	6.0	6.0	6.0	6.0	6.0	7.0	10	12	17	27	38
4 V	6.0	6.0	6.0	6.0	6.0	6.0	8.0	9.0	13	21	31
5 V	6.0	6.0	6.0	6.0	6.0	6.0	8.0	9.0	13	21	31
10 V	6.0	6.0	6.0	6.0	6.0	6.0	8.0	10	15	22	32
20 V	6.0	6.0	6.0	6.0	6.0	7.0	9.0	11	16	25	34
30 V	6.0	6.0	6.0	6.0	6.0	7.0	11				
50 V	7.0	7.0	7.0	7.0	7.0	10	14				
70 V	7.0	7.0	7.0	7.0	7.0	10	14				
100 V	7.0	7.0	7.0	7.0	7.0	10	14				
200 V	8.0	8.0	8.0	10	13	22					
300 V	8.0	8.0	8.0	10	13	22					
500 V	11	9.0	10	15	24	42					
600 V	11	9.0	10	19	29	52					
700 V	11	9.0	10	19	29	52					
1 kV	11	9.0	11	23	33	62					

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
AC/DC TRANSFER CURRENT *Service Reference ED11*			Build up technique against known AC/DC transfer standard.	Teddington

CMCs for AC/DC Transfer Current, at Specific Values, expressed as an Expanded Uncertainty (k = 2) [10^{-6} of value]
For intermediate points the uncertainty will be determined using linear interpolation between the adjacent points.

Current	*Frequency*												
	10 Hz	20 Hz	40 Hz	100 Hz	400 Hz	1 kHz	2 kHz	5 kHz	10 kHz	20 kHz	50 kHz	70 kHz	100 kHz
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	Expanded Measurement Uncertainty (k = 2)		Remarks	Location Code
AC VOLTAGE RATIO				Using AC bridge and build up techniques.	Teddington
Service Reference ED13					
<u>Inductive Voltage Dividers</u>		Voltage ratio uncertainty with respect to input voltage ($\times 10^{-8}$)			
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 100 Hz to 200 Hz; 30 V otherwise.	
	40 Hz	16	17		
	60 Hz	16	17		
	80 Hz	12	14		
	100 Hz	9.3	11		
	120 Hz	7.1	8.4		
	200 Hz	6.1	7.7		
	300 Hz	6.1	6.9		
	400 Hz	6.1	6.9		
	600 Hz	6.1	6.9		
	800 Hz	6.1	6.9		
	1000 Hz	6.1	6.9		
	1300 Hz	6.1	6.9		
	1592 Hz	6.1	6.9		
	2000 Hz	6.8	8.0		
	3000 Hz	9.1	9.9		
	4000 Hz	14	14		
	5000 Hz	21	21		
	HF System			Normal operating range: Minimum voltage: 1 V Maximum voltage: 30 V	
	5 kHz	21	21		
	8 kHz	30	30		
	10 kHz	38	38		
	20 kHz	72	75		
	30 kHz	120	120		
	40 kHz	180	190		
	50 kHz	280	300		
	80 kHz	630	650		
	100 kHz	990	1000		
	120 kHz	1500	1600		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
AC POWER *Service Reference ED06*			Using phantom load terchniques.	Teddington
Sinusoidal waveforms	*40 Hz to 400 Hz:* Current 2 mA to 130 A Voltage 1 V to 1000 V	40 µW/VA 25 µW/VA	20 °C and 23 °C at unity power factor 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 µW/VA	20 °C and 23 °C	
Voltage Response of Wattmeters	1 V to 1000 V	25 µW/VA	20 °C and 23 °C	
Auxiliary DC Voltage	DC, 1 V to 10 V	5.0 µV/V	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 µW/VA 25 µW/VA	20 °C and 23 °C at zero power factor 20 °C and 23 °C at unity power factor *Uncertainties increase at other power factors*	
CALIBRATION OF EN 61000 HARMONIC AND FLICKER ANALYSERS *Service Reference ED17*				
Sinusoidal waveforms				
Current accuracy	100 mA to 20 A, *50 Hz*	40 µA/A		
Current frequency response	100 mA to 20 A *50 Hz to 2 kHz*	150 µA/A		
Voltage accuracy	1 V to 1000 V, *50 Hz*	30 µV/V		
Power measurements	Ranges as in *AC Power* above	45 x 10^{-6} 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 µA/A	Steady-state, burst fluctuating or smoothly fluctuating harmonics	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)		Remarks	Location Code
CALIBRATION OF EN 61000 HARMONIC AND FLICKER ANALYSERS (continued)					Teddington
Flicker (Pst)	0.95 Pst to 1.05 Pst Square or sine wave modulated, 230 V 50 Hz sine wave	0.30 % of Pst reading			
	0.95 Pst to 2.05 Pst Complex waveforms, 230 V 50 Hz sine wave	0.20 % of Pst reading			
CAPACITANCE and DISSIPATION FACTOR *Service Reference ED04*				Using Coaxial bridge techniques. 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.	
		C	D		
Fused-silica dielectric capacitors	1 pF	0.90 µF/F	7.0×10^{-6}	Measurements are normally made at 1 kHz or 1.592 kHz. Other frequencies between 20 Hz and 100 kHz may be used but the uncertainty will be increased in a complex manner that varies with frequency and capacitance.	
	10 pF	0.70 µF/F	6.0×10^{-6}		
	100 pF	0.90 µF/F	7.0×10^{-6}		
Other types of capacitor	1 pF	4.0 µF/F	1.0×10^{-5}		
	10 pF to 1 nF	3.0 µF/F	7.0×10^{-6}		
Four-terminal pair capacitors	1 pF to 1 nF	100 µF/F	1.0×10^{-5}		
	10 nF to 100 nF	30 µF/F	2.0×10^{-5}		
	1 µF	60 µF/F	2.0×10^{-5}		
	10 µF	100 µF/F	2.0×10^{-5}		
	100 µF	100 µF/F	2.0×10^{-5}		
	1 mF	2 mF/F	2.0×10^{-4}		
General Radio Type 1417	1 µF to 10 mF	0.10 % to 0.50 %	0.0010 to 0.005	100 Hz, 120 Hz and 1 kHz	
	100 mF to 1 F	0.30 % to 1.0 %	0.0030 to 0.010	100 Hz and 120 Hz	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
SELF-INDUCTANCE *Service Reference ED05*			Using AC bridge techniques.	Teddington

Expanded uncertainty in μH/H 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			20000	1000	1000	2500	3500
2 μH			10000	1000	1000	2200	3000
3 μH			6100	1000	1000	2200	2600
5 μH			3500	600	600	1100	1500
10 μH	3500	2500	2000	310	350	620	930
20 μH	1800	1300	1000	150	160	320	460
30 μH	1200	840	670	110	120	190	260
50 μH	700	500	400	100	100	160	200
100 μH	300	200	150	75	80	120	150
200 μH	250	180	100	75	85	110	150
300 μH	250	180	100	85	85	120	150
500 H	220	160	100	80	80	100	150
1 mH	180	150	95	70	75	100	150
2 mH	180	150	100	75	80	110	150
3 mH	180	150	100	85	85	120	150
5 mH	180	160	100	80	80	110	150
10 mH	180	150	100	70	70	100	130
20 mH	180	150	100	75	75	110	130
30 mH	180	150	100	85	85	110	150
50 mH	200	160	100	80	80	160	200
100 mH	190	150	85	70	70	140	200
200 mH	230	200	90	75	75	200	300
400 mH	240	200	90	75	75	200	380
500 mH	240	210	90	80	80	200	400
1 H	140	110	85	70	70	200	400
2 H	140	110	85	70	70		
5 H	140	110	85	80	85		
10 H	140	110	85	80	85		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks
MUTUAL INDUCTANCE *Service Reference ED05*	*At 1 kHz:* 100 μH 1 mH 5 mH 10 mH 100 mH	 150 μH/H 100 μH/H 80 μH/H 70 μH/H 70 μH/H	Measurements can also be made at frequencies of 20 Hz and 50 Hz but the uncertainties may be increased.

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	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
MAGNETIC QUANTITIES *Service Reference MT41*				Teddington
DC MAGNETIC FIELD STRENGTH AND MAGNETIC FLUX DENSITY				
	0.8 mA/m (1 nT) to 16 A/m (20 µT)	0.15 % + 0.4 mA/m (0.5 nT)	Using fluxgate magnetometer.	
	16 A/m (20 µT) to 72 A/m (90 µT)	0.0030 %	Using ptoton resonace magnetometer.	
	72 A/m (90 µT) to 280 A/m (350 µT)	0.050 %	Resonance method.	
	280 A/m (350 µT) to 40 kA/m (50 mT)	0.20 %	Using Hall effect gaussmeter.	
	40 kA/m (50 mT) to 10.5 MA/m (13 T)	0.0015 %	Using NMR gaussmeter.	
AC MAGNETIC FIELD STRENGTH AND MAGNETIC FLUX DENSITY			Comparison against reference coils.	
	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 %		
MAGNETIC FIELD STRENGTH TO CURRENT RATIO				
Standard solenoids and Helmholtz coils	1 A/m/A to 20 000 A/m/A *DC* *12 Hz to 60 Hz* *60 Hz to 20 kHz*	 0.015 % 0.050 % 0.25 %	Using reference magnetometer and residual field cancellation technique.	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
MAGNETIC QUANTITIES (continued)				Teddington
TURN AREA (effective area)			Using standard solenoid or Helmholtz coils.	
Search coils	0.0029 m^2 to 17 m^2 *12 Hz to 60 Hz*	 0.090 %		
	0.0001 m^2 to 200 m^2 *60 Hz to 20 kHz* *20 kHz to 50 kHz* *50 kHz to 120 kHz*	 0.25 % 0.40 % 0.70 %		
NORMAL DC MAGNETIZATION CURVES AND HYSTERESIS LOOPS				
Ring specimens	H = 0.1 kA/m to 10 kA/m B = 0.05 T to 2.5 T	0.30 % 0.30 %	In accordance with EN 60404 Part 4: 1997 and IEC 60404 Part 4:2008.	
Bar or rod specimens	H = 0.1 kA/m to 200 kA/m B = 0.05 T to 2.5 T	0.30 % 0.30 %	In accordance with EN 60404 Part 4: 1997 and IEC 60404 Part 4:2008.	
DC DEMAGNETIZATION CURVE FOR HARD MAGNETIC MATERIALS				
Remanence	B_r = 0.02 T to 2 T	0.30 %		
Coercivity	H_{CB} = 0.03 to 1.2 MA/m H_{CJ} = 0.03 to 1.6 MA/m	0.40 % 0.40 %	In accordance with BS EN 60404 Part 5: 2007 and IEC 60404 Part 5: 2007.	
Maximum energy product	$(B.H)_{max}$ = 1 to 400 kJ/m^3	0.50 %		
DC RELATIVE MAGNETIC PERMEABILITY, μ_r				
For low magnetic Permeability materials	$(\mu_r - 1)$ = 0.001 to 1.5 $(\mu_r - 1)$ = 0.0002 to 0.001	0.20 % 2.2 %	In accordance with BS EN 60404 Part 15: 2012	
Permeability measuring instruments and indicators	$(\mu_r - 1)$ = 0.001 to 1.5	0.20 %	The uncertainty may be increased depending on the characteristics of the device being calibrated	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
MAGNETIC QUANTITIES (continued)				Teddington
MAGNETIC DIPOLE MOMENT	0.06 Am^2 to 1000 Am^2	0.11 %	Using detection coil and integrating fluxmeter.	
SPECIFIC TOTAL POWER LOSS	0.02 W/kg to 400 W/kg		For strips: f >400 Hz IEC 60404-2 BS EN 60404-2	
	At 50 Hz to 2000 Hz J = 0.1 T to 1.3 T	0.40 %		
	At 50 Hz to 1000 Hz J = 1.3 T to 1.5 T J = 1.5 T to 1.7 T J = 1.7 T to 1.8 T J = 1.8 T to 1.9 T	 0.40 % 0.55 % 0.75 % 1.0 %	f = 400 Hz to 1 kHz IEC 60404-10 BS EN 10252 For sheets: IEC 60404-3 BS EN 10280	
Soft magnetic materials in ring form only	0.02 W/kg to 120 W/kg *50 Hz to 100 kHz* J = 1 mT to 100 mT	0.65 %		
SPECIFIC APPARENT POWER	0.06 VA/kg to 450 VA/kg		For oriented and non-oriented materials	
	At 50 Hz to 2000 Hz J = 0.1 T to 1.3 T	0.60 %		
	At 50 Hz to 1000 Hz J = 1.3 T to 1.5 T J = 1.5 T to 1.7 T J = 1.7 T to 1.8 T J = 1.8 T to 1.9 T	 0.70 % 1.3 % 2.7 % 5.0 %		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
MAGNETIC QUANTITIES (continued)				Teddington
APPARENT POWER	0.06 VA/kg to 400 VA/kg		Method of measurement: For strips: IEC 60404 Part 2:2008 BS EN 60404-2: 1998 For sheets: IEC 60404 Part 3:2010 BS EN 10280: 2001	
Soft magnetic materials in ring form only	*50 Hz to 100 kHz* J = 1 mT to 100 mT	1.1 %		
AC PERMEABILITY (rms or peak values)				
Oriented and non-oriented materials	μ_r = 500 to 200 000 *At 50 Hz and 60 Hz* B = 0.5 T to 2.2 T H = 0.5 kA/m to 10 kA/m	0.45 %		
AC MAGNETIC FIELD STRENGTH (rms or peak values)			Method of measurement (for strips) in accordance with IEC 60404 Part 2: 2008, BS EN 60404 Part 2:1998 and (for sheets), IEC 60404 Part 3:2010 BS EN 10280: 2001.	
Oriented and non-oriented materials	*At 50 Hz and 60 Hz* H = 0.5 kA/m to 10 kA/m	0.45 %		
AC CONDUCTIVITY *Service Reference MT41*				
AC conductivity reference materials	2 MS/m to 60 MS/m (3.45 $\%_{IACS}$ to 103 $\%_{IACS}$) *60 kHz, 20°C*	0.70 %	Calibration of sets of reference materials produced by NPL.	
AC conductivity instruments	2 MS/m to 60 MS/m (3.45 $\%_{IACS}$ to 103 $\%_{IACS}$) *60 kHz, 20°C*	0.70 %	Using materials of known conductivity.	
DC RESISTIVITY AND CONDUCTIVITY *Service Reference MT41*				
Resistivity: Soft magnetic sheet materials	1.4×10^{-7} Ω·m to 7.0×10^{-7} Ω·m *Temperature 20 °C* *Test Current ≥ 0.5 A*	0.20 %	Four point resistivity measurement of electrical steel strip samples in accordance with IEC 60404-13.	
Resistivity: Soft magnetic sheet materials	1.4×10^{-7} Ω·m to 7.0×10^{-7} Ω·m *Temperature -40 °C to +200 °C* *Test Current ≥ 0.5 A*	0.25 %	Four point resistivity measurement of electrical steel strip samples.	
Electrical conductivity: Metallic bars of length >200 mm	0.58 MS/m to 65 MS/m (1.0 $\%_{IACS}$ to 112 $\%_{IACS}$) *Temperature 20 °C*	0.20 %	Resistivity determined from resistance, cross-sectional area and knife edge separation.	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
DC RESISTIVITY AND CONDUCTIVITY (continued)				
Electrical conductivity: Metallic bars, sheet, wires, reference materials	0.58 MS/m to 65 MS/m (1.0 $\%_{IACS}$ to 112 $\%_{IACS}$) *Temperature -40 °C to +200 °C*	0.25 %	Resistivity determined from resistance, cross-sectional area and knife edge separation. Also includes similar methodology using the Van der Pauw technique.	
POWER FLUX DENSITY *CW SIGNALS* *Service Reference EF01*				
	0.11 nW/cm^2 to 170 mW/cm^2 *10 Hz to 10 kHz*	0.68 dB	TEM Cells The maximum frequency and power flux density level is determined by the size of the probe.	
	0.11 nW/cm^2 to 265 mW/cm^2 *10 kHz to 300 MHz*	0.68 dB		
			Anechoic Chambers The Listed Field levels are derived from the lowest unsaturated maximum power in each range. The achievable level may be up to 20 % greater than the stated limit.	
	0.03 nW/cm^2 to 38 mW/cm^2 *240 MHz to 270 MHz*	0.65 dB	All probes and small active dipoles	
	0.03 nW/cm^2 to 65 mW/cm^2 *270 MHz to 350 MHz*	0.65 dB	All probes and small active dipoles	
	0.03 nW/cm^2 to 87 mW/cm^2 *350 MHz to 500 MHz*	0.65 dB	All probes and small active dipoles	
	0.03 nW/cm^2 to 37 mW/cm^2 *450 MHz to 550 MHz*	0.62 dB	All probes and small active dipoles	
	0.03 nW/cm^2 to 72 mW/cm^2 *550 MHz to 750 MHz*	0.62 dB	All probes and small active dipoles	
	0.03 nW/cm^2 to 72 mW/cm^2 *750 MHz to 950 MHz*	0.62 dB	All probes and small active dipoles	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
POWER FLUX DENSITY (continued)				
	0.03 nW/cm^2 to 38 mW/cm^2 *950 MHz to 1200 MHz*	0.62 dB	All probes and small active dipoles	
	0.03 nW/cm^2 to 138 mW/cm^2 *1100 MHz to 1250 MHz*	0.47 dB	All probes and small active dipoles	
	0.03 nW/cm^2 to 170 mW/cm^2 *1250 MHz to 1700 MHz*	0.47 dB	All probes and small active dipoles	
	0.03 nW/cm^2 to 227 mW/cm^2 *1700 MHz to 2600 MHz*	0.47 dB	All probes and small active dipoles	
	0.7 nW/cm^2 to 569 mW/cm^2 *2.45 GHz to 2.7 GHz*	0.40 dB	All probes and small active dipoles	
	0.7 nW/cm^2 to 921 mW/cm^2 *2.7 GHz to 8.2 GHz*	0.40 dB	All probes and small active dipoles	
	0.7 nW/cm^2 to 694 mW/cm^2 *8.2 GHz to 18 GHz*	0.40 dB	All probes and small active dipoles	
	1.7 μW/cm^2 to 92 mW/cm^2 *18 GHz to 40 GHz*	0.35 dB	All probes and small active dipoles	
	0.11 μW/cm^2 to 10 mW/cm^2 *40 GHz to 48 GHz*	0.35 dB	All probes and small active dipoles	
	0.12 μW/cm^2 to 0.1 mW/cm^2 *48 GHz to 50 GHz*	0.35 dB	All probes and small active dipoles	
	0.2 μW/cm^2 to 0.52 mW/cm^2 *50 GHz to 75 GHz*	0.42 dB	All probes and small active dipoles	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
FIELD STRENGTH *CW SIGNALS* *Service Reference EF01*				
Electric Field			<u>TEM Cells</u> The maximum frequency and field strength level is determined by the size of the probe.	
	0.02 V/m to 800 V/m *10 Hz to 10 kHz*	0.68 dB		
	0.02 V/m to 1000 V/m *10 kHz to 300 MHz*	0.68 dB		
	Anechoic Chambers The Listed Field levels are derived from the lowest unsaturated maximum power in each range. The achievable level may be up to 20 % greater than the stated limit.			
	0.01 V/m to 380 V/m *240 MHz to 270 MHz*	0.65 dB	All probes and small active dipoles	
	0.01 V/m to 500 V/m *270 MHz to 350 MHz*	0.65 dB	All probes and small active dipoles	
	0.01 V/m to 575 V/m *350 MHz to 500 MHz*	0.65 dB	All probes and small active dipoles	
	0.01 V/m to 375 V/m *450 MHz to 550 MHz*	0.62 dB	All probes and small active dipoles	
	0.01 V/m to 520 V/m *550 MHz to 750 MHz*	0.62 dB	All probes and small active dipoles	
	0.01 V/m to 520 V/m *750 MHz to 950 MHz*	0.62 dB	All probes and small active dipoles	
	0.01 V/m to 380 V/m *950 MHz to 1200 MHz*	0.62 dB	All probes and small active dipoles	
	0.01 V/m to 720 V/m *1100 MHz to 1250 MHz*	0.47 dB	All probes and small active dipoles	
	0.01 V/m to 800 V/m *1250 MHz to 1700 MHz*	0.47 dB	All probes and small active dipoles	
	0.01 V/m to 920 V/m *1700 MHz to 2600 MHz*	0.47 dB	All probes and small active dipoles	
	0.05 V/m to 1460 V/m *2.45 GHz to 2.7 GHz*	0.40 dB	All probes and small active dipoles	
	0.05 V/m to 1860 V/m *2.7 GHz to 8.2 GHz*	0.40 dB	All probes and small active dipoles	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
Electric Field (continued)	0.05 V/m to 1610 V/m *8.2 GHz to 18 GHz*	0.40 dB	All probes and small active dipoles	
	2.5 V/m to 590 V/m *18 GHz to 40 GHz*	0.35 dB	All probes and small active dipoles	
	0.6 V/m to 194 V/m *40 GHz to 48 GHz*	0.35 dB	All probes and small active dipoles	
	0.7 V/m to 23 V/m *48 GHz to 50 GHz*	0.35 dB	All probes and small active dipoles	
	0.8 V/m to 44 V/m *50 GHz to 75 GHz*	0.42 dB	All probes and small active dipoles	
Magnetic Field			<u>TEM Cells</u> The maximum frequency and field strength level are determined by the size of the probe.	
	0.05 mA/m to 2.1 A/m *10 Hz to 100 Hz*	1.4 dB	Electrically small probes	
	0.05 mA/m to 2.1 A/m *100 Hz to 500 Hz*	0.76 dB	Electrically small probes	
	0.05 mA/m to 2.1 A/m *500 Hz to 10 kHz*	0.68 dB	Electrically small probes	
	0.05 mA/m to 2.1 A/m *10 kHz to 300 MHz*	0.68 dB	Electrically small probes	
	The field levels shown below are derived from the lowest unsaturated maximum power in each range. The achievable level may be up to 20 % greater than the stated limit.		<u>Anechoic Chambers</u>	
	0.03 mA/m to 1.0 A/m *240 MHz to 270 MHz*	0.65 dB	All probes and small active dipoles	
	0.03 mA/m to 1.3 A/m *270 MHz to 350 MHz*	0.65 dB	All probes and small active dipoles	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
FIELD STRENGTH CW SIGNALS (continued)				
Magnetic Field (continued)	0.03 mA/m to 1.5 A/m *350 MHz to 500 MHz*	0.65 dB	All probes and small active dipoles	
	0.03 mA/m to 1.0 A/m *450 MHz to 550 MHz*	0.62 dB	All probes and small active dipoles	
	0.03 mA/m to 1.4 A/m *550 MHz to 750 MHz*	0.62 dB	All probes and small active dipoles	
	0.03 mA/m to 1.4 A/m *750 MHz to 950 MHz*	0.62 dB	All probes and small active dipoles	
	0.03 mA/m to 1.0 A/m *950 MHz to 1200 MHz*	0.62 dB	All probes and small active dipoles	
	0.03 mA/m to 1.9 A/m *1100 MHz to 1250 MHz*	0.47 dB	All probes and small active dipoles	
	0.03 mA/m to 2.1 A/m *1250 MHz to 1700 MHz*	0.47 dB	All probes and small active dipoles	
	0.03 mA/m to 2.4 A/m *1700 MHz to 2600 MHz*	0.47 dB	All probes and small active dipoles	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
POWER FLUX DENSITY PULSE SIGNALS *Service Reference EF01*	The field levels shown below are derived from the lowest unsaturated maximum power in each range. The achievable level may be up to 20 % greater than the stated limit.		Pulse repetition frequency 200 Hz to 20 kHz. Pulse width 3 µs to 100 µs for f_c between 240 MHz and 2.6 GHz. Pulse width 1 µs to 100 µs for f_c between 2.45 GHz and 18 GHz.	Teddiongton
Power Flux Density and free space equivalent Magnetic Flux Density			Temperature 23 °C ± 2 °C	
	97 µW/cm^2 to 38 mW/cm^2 *240 MHz to 270 MHz*	0.65 dB	Coaxial systems	
	97 µW/cm^2 to 65 mW/cm^2 *270 MHz to 350 MHz*	0.65 dB		
	97 µW/cm^2 to 87 mW/cm^2 *350 MHz to 500 MHz*	0.65 dB		
	97 µW/cm^2 to 37 mW/cm^2 *450 MHz to 550 MHz*	0.63 dB		
	97 µW/cm^2 to 72 mW/cm^2 *550 MHz to 750 MHz*	0.63 dB		
	97 µW/cm^2 to 72 mW/cm^2 *750 MHz to 950 MHz*	0.63 dB		
	97 µW/cm^2 to 47 mW/cm^2 *950 MHz to 1200 MHz*	0.63 dB		
	97 µW/cm^2 to 138 mW/cm^2 *1100 MHz to 1250 MHz*	0.49 dB		
	97 µW/cm^2 to 170 mW/cm^2 *1250 MHz to 1700 MHz*	0.49 dB		
	97 µW/cm^2 to 227 mW/cm^2 *1700 MHz to 2600 MHz*	0.49 dB		
	0.6 mW/cm^2 to 5100 mW/cm^2 *2.45 GHz to 2.7 GHz*	0.42 dB	Waveguide systems	
	0.6 mW /cm^2 to 3450 mW/cm^2 *2.7 GHz to 8.2 GHz*	0.42 dB		
	0.5 mW /cm^2 to 5900 mW/cm^2 *8.2 GHz to 18 GHz*	0.42 dB		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
POWER FLUX DENSITY PULSE SIGNALS Service Reference EF01 (continued)				Teddiongton
Electric Field	19.1 V/m to 380 V/m *240 MHz to 270 MHz*	0.65 dB	Coaxial systems	
	19.1 V/m to 500 V/m *270 MHz to 350 MHz*	0.65 dB		
	19.1 V/m to 575 V/m *350 MHz to 500 MHz*	0.65 dB		
	19.1 V/m to 375 V/m *450 MHz to 550 MHz*	0.63 dB		
	19.1 V/m to 520 V/m *550 MHz to 750 MHz*	0.63 dB		
	19.1 V/m to 520 V/m *750 MHz to 950 MHz*	0.63 dB		
	19.1 V/m to 420 V/m *950 MHz to 1200 MHz*	0.63 dB		
	19.1 V/m to 720 V/m *1100 MHz to 1250 MHz*	0.49 dB		
	19.1 V/m to 800 V/m *1250 MHz to 1700 MHz*	0.49 dB		
	19.1 V/m to 925 V/m *1700 MHz to 2600 MHz*	0.49 dB		
	47 V/m to 4350 V/m *2.45 GHz to 2.7 GHz*	0.42 dB	Waveguide systems	
	47 V/m to 3600 V/m *2.7 GHz to 8.2 GHz*	0.42 dB		
	44 V/m to 4700 V/m *8.2 GHz to 18 GHz*	0.42 dB		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (*k* = 2)	Remarks	Location Code
POWER FLUX DENSITY PULSE SIGNALS Service Reference EF01 (cont'd)				**Teddington**
Magnetic Field	50.7 mA/m to 1.0 A/m *240 MHz to 270 MHz*	0.65 dB	Coaxial systems	
	50.7 mA/m to 1.3 A/m *270 MHz to 350 MHz*	0.65 dB		
	50.7 mA/m to 1.5 A/m *350 MHz to 500 MHz*	0.65 dB		
	50.7 mA/m to 1.0 A/m *450 MHz to 550 MHz*	0.63 dB		
	50.7 mA/m to 1.4 A/m *550 MHz to 750 MHz*	0.63 dB		
	50.7 mA/m to 1.4 A/m *750 MHz to 950 MHz*	0.63 dB		
	50.7 mA/m to 1.1 A/m *950 MHz to 1200 MHz*	0.63 dB		
	50.7 mA/m to 1.9 A/m *1100 MHz to 1250 MHz*	0.49 dB		
	50.7 mA/m to 2.1 A/m *1250 MHz to 1700 MHz*	0.49 dB		
	50.7 mA/m to 2.4 A/m *1700 MHz to 2600 MHz*	0.49 dB		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
ANTENNA GAIN and ANTENNA FACTOR *Service Reference EF03*			All measurements are performed at 23 °C Antenna Factor is calculated from the antenna gain The uncertainties apply to calibrations covering a waveguide bandwidth.	**Teddington**
Waveguide Feed	0 dB to 23 dB *2.6 GHz to 3.95 GHz*	0.050 dB	Waveguide No 10	
	0 dB to 24 dB *3.3 GHz to 4.9 GHz*	0.050 dB	Waveguide No 11A	
	0 dB to 25 dB *3.95 GHz to 5.85 GHz*	0.050 dB	Waveguide No 12	
	0 dB to 26 dB *5.4 GHz to 8.2 GHz*	0.050 dB	Waveguide No 14	
	0 dB to 27 dB *7.05 GHz to 10.0 GHz*	0.050 dB	Waveguide No 15	
	0 dB to 28 dB *8.2 GHz to 12.4 GHz*	0.050 dB	Waveguide No 16	
	0 dB to 29 dB *10.0 GHz to 15.0 GHz*	0.050 dB	Waveguide No 17	
	0 dB to 29 dB *12.4 GHz to 18.0 GHz*	0.040 dB	Waveguide No 18	
	0 dB to 31 dB *18.0 GHz to 26.5 GHz*	0.040 dB	Waveguide No 20	
	0 dB to 33 dB *26.5 GHz to 40.0 GHz*	0.040 dB	Waveguide No 22	
	0 dB to 34 dB *33 GHz to 50 GHz*	0.060 dB	Waveguide No 23	
	0 dB to 35 dB *40 GHz to 60 GHz*	0.10 dB	Waveguide No 24	
	0 dB to 36 dB *50 GHz to 75 GHz*	0.10 dB	Waveguide No 25	
	0 dB to 37 dB *75 GHz to 110 GHz*	0.10 dB	Waveguide No 27	
Coaxial Feed	0 dB to 28 dB *1 GHz to 18 GHz*	0.050 dB	50 Ω APC-7 or Type N connectors	
	0 dB to 28 dB *1 GHz to 26.5 GHz*	0.050 dB	50 Ω 3.5 mm connector	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
ANTENNA GAIN and ANTENNA FACTOR (continued)				Teddington
Coaxial Feed (continued)	0 dB to 28 dB *1 GHz to 40 GHz*	0.090 dB	50 Ω 2.92 mm connector	
	0 dB to 28 dB *2.6 GHz to 50 GHz*	0.10 dB	50 Ω 2.4 mm connector	
			Devices fitted with coaxial connectors other than those listed may be calibrated but the uncertainties may be increased	
EMC ANTENNA CALIBRATION *Service Reference EF04*				
			Calibrations to meet the requirements of ANSI C63.5:2017 and CISPR 16-1-6	
			Includes the calibration of antennas supplied with fitted pre-amplifiers	
Waveguide Feed	0 dB to 21 dB *2.6 GHz to 3.95 GHz*	0.70 dB	Waveguide No 10	
	0 dB to 22 dB *3.3 GHz to 4.9 GHz*	0.70 dB	Waveguide No 11A	
	0 dB to 23 dB *3.95 GHz to 5.85 GHz*	0.70 dB	Waveguide No 12	
	0 dB to 24 dB *5.4 GHz to 8.2 GHz*	0.70 dB	Waveguide No 14	
	0 dB to 25 dB *7.05 GHz to 10.0 GHz*	0.70 dB	Waveguide No 15	
	0 dB to 26 dB *8.2 GHz to 12.4 GHz*	0.70 dB	Waveguide No 16	
	0 dB to 27 dB *10.0 GHz to 15.0 GHz*	0.70 dB	Waveguide No 17	
	0 dB to 28 dB *12.4 GHz to 18.0 GHz*	0.70 dB	Waveguide No 18	
	0 dB to 30 dB *18.0 GHz to 26.5 GHz*	0.70 dB	Waveguide No 20	
	0 dB to 31 dB *26.5 GHz to 40.0 GHz*	0.70 dB	Waveguide No 22	
	0 dB to 31 dB *43.5 GHz to 45.5 GHz*	0.70 dB	Waveguide No 23	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	
Coaxial Feed	-30 dB to 30 dB *1 GHz to 40 GHz*	0.80 dB (0.60 dB for conical log spiral antennas)	50 Ω connectors APC-7, Type N, SMA, 3.5 mm, 2.92 mm, 2.4 mm For coaxially fed antennas the antenna factor is calculated from the antenna gain. Devices fitted with coaxial connectors other than those listed above may be calibrated but the uncertainties may be increased. The connector must only be used within the manufactures' specified frequency limit.	Teddington
CALIBRATION OF MAGNETIC LOOP ANTENNAS Service reference EF02 Magnetic Antenna Factor	Loop sensitivity: +110 dB to -40 dB 5 Hz to 100Hz 100Hz to 80 MHz	 1.5 dB 1.0 dB	Calibration of passive and active loop antennas using a Crawford TEM Cell with spectrum analysers or test receivers. The results may be expressed in terms of dB(pT/μV) or dB(S/m). Loop diameters between 4 cm and 90 cm may be accommodated.	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
ANTENNA COMPLEX REFLECTION COEFFICIENT	0 to 0.5, real and imaginary parts, higher reflections with increased uncertainty.		The uncertainties for complex reflection coefficient apply to both real and imaginary parts. All measurements are performed at 23 °C	Teddington
Waveguide feed	*2.6 GHz to 3.95 GHz*	0.0080	Waveguide No 10	
	3.3 GHz to 4.9 GHz	0.0080	Waveguide No 11A	
	3.95 GHz to 5.85 GHz	0.0080	Waveguide No 12	
	5.4 GHz to 8.2 GHz	0.0080	Waveguide No 14	
	7.05 GHz to 10 GHz	0.0080	Waveguide No 15	
	8.2 GHz to 12.4 GHz	0.0080	Waveguide No 16	
	10 GHz to 15 GHz	0.0080	Waveguide No 17	
	12.4 GHz to 18 GHz	0.0080	Waveguide No 18	
	18 GHz to 26.5 GHz	0.0080	Waveguide No 20	
	26.5 GHz to 40 GHz	0.0080	Waveguide No 22	
	33 GHz to 50 GHz	0.013	Waveguide No 23	
	40 GHz to 60 GHz	0.015	Waveguide No 24	
	50 GHz to 75 GHz	0.015	Waveguide No 25	
	75 GHz to 110 GHz	0.015	Waveguide No 27	
7 mm coaxial feed	*1 GHz to 1.5 GHz*	0.015	50 Ω Type N connectors	
	1.5 GHz to 18 GHz	0.011	50 Ω Type N connectors	
	1 GHz to 8.2 GHz	0.013	50 Ω GPC-7 connectors	
	8.2 GHz to 18 GHz	0.018	50 Ω GPC-7 connectors	
3.5 mm coaxial feed	*1 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 GHz to 26.5 GHz	0.029	50 Ω GPC-3.5 connectors	
2.92 mm coaxial feed	*1 GHz to 26.5 GHz*	0.028	50 Ω 2.92 mm connectors	
	26.5 GHz to 40 GHz	0.043	50 Ω 2.92 mm connectors	
2.4 mm coaxial feed	*1 GHz to 26.5 GHz*	0.021	50 Ω 2.4 mm connectors	
	26.5 GHz to 40 GHz	0.041	50 Ω 2.4 mm connectors	
	40 GHz to 50 GHz	0.056	50 Ω 2.4 mm connectors	
			Devices fitted with coaxial connectors other than those listed above may be calibrated but the uncertainties may be increased.	
ANTENNA FACTOR *Service Reference: EF06*	-30 dB/m to +80 dB/m		Calibrations to meet the requirements of ARP 958, ANSI C63.5 (2006 & 2017), CISPR 16-1-6.	
Linear dipole	*20 MHz to 500 MHz*	0.35 dB	Defined height, tuned element	
	500 MHz to 1000 MHz	0.50 dB		
Linear dipole	*20 MHz to 40 MHz*	0.70 dB	Free-space, tuned element	
	40 MHz to 1000 MHz	0.50 dB		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (*k* = 2)	Remarks	Location Code
ANTENNA FACTOR (continued)	-30 dB/m to +80 dB/m		Calibrations to meet the requirements of ARP 958, ANSI C63.5 2017, CISPR 16-1-6.	Teddington
Biconical antenna	20 MHz to 300 MHz	0.50 dB	Free-space or defined height (vs. SRDs)	
Mini-Biconical antenna	300 MHz to 6 GHz	0.50 dB	Free-space	
LPDA antenna	80 MHz to 200 MHz	0.70 dB	Free-space	
LPDA antenna	200 MHz to 6 GHz	0.50 dB	Free-space	
Biconical, Hybrid and LPDA	30 MHz to 1 GHz	1.0 dB	Standard Site method, horizontal ANSI C63.5 2017	
Hybrid antenna	20 MHz to 6 GHz	0.70 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	
DUAL ANTENNA FACTOR			For use in NSA measurements	
Biconical, LPDA and hybrid antennas	30 MHz to 1000 MHz	1.0 dB	Standard Site method, horizontal polarisation	
Biconical, LPDA and hybrid antennas	30 MHz to 1000 MHz	1.5 dB	Standard Site method, vertical polarisation	
Antenna Balance (Symmetry)	*30 MHz to 300 MHz* For values within ± 2 dB	0.25 dB	ANSI C 63.5 2017 and CISPR 16-1-4	
REFLECTION COEFFICIENT *S11*	Gamma: 0 to 1 *0.3 MHz to 6 GHz*	 0.050	50 Ω Type N connectors. Devicess with other coaxial connectors can be calibrated but the uncertainty may be increased.	
VSWR (Derived from S11)	*0.3 MHz to 6 GHz*		Uncertainty will be increased for VSWR >5	
	For VSWR value = 1.1	0.031		
	For VSWR value = 1.2	0.033		
	For VSWR value = 2.5	0.15		
	For VSWR value = 3	0.19		
	For VSWR value = 5	0.44		
Rod antenna *Service Reference: EF11*	100 Hz to 100 MHz	1.0 dB 1.2 dB	Plane wave E-field ECSM	
RADIATION PATTERNS *Service Reference: EF13*	Gain < +10 dBi			
	500 MHz to 18 GHz	0.35 dB	From 0 dB to -6 dB, relative to maximum level.	
	500 MHz to 18 GHz	1.0 dB	From -6 dB to -15 dB, relative to maximum level.	
	Note: other parameters may be derived from pattern data, such as Directivity and Efficiency. The uncertainty is related to the change in gain relative to its maximum value.			
E-field emitters	30 MHz to 6 GHz	1.5 dB	Radiated, depends on SNR	
CNE, Comb Generator etc.	10 kHz to 6 GHz	1.0 dB	Conducted	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
ATTENUATION *Service Reference EG03*			Comparison with inductive voltage divider using down-conversion techniques.	Teddington
Coaxial Line	0 dB to 100 dB		50 Ω 14 mm Coaxial Line (GR-900 connector) up to 8 GHz. 50 Ω 7 mm Coaxial Line: Standard N-Type connector up to 12.4 GHz; Precision N-type 3.5mm, 2.92 mm, 2.4 mm and GPC-7 connectors to 18 GHz.	
	0.5 MHz to 18 GHz	(0.00060 dB per 10 dB) + 0.00060 dB		
	100 dB to 120 dB *0.5 MHz to 100 MHz*	0.00080 dB per 10 dB		
	120 dB to 130 dB *0.5 MHz to 100 MHz*	(0.0010 dB per 10 dB) + 0.010 dB		
			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 those which have been allowed for in this Schedule.	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
RF POWER *Service Reference EG04*			The uncertainties for waveguide and coaxial systems may be increased for devices fitted with other coaxial or waveguide connector types e.g. GPC-7, 3.5 mm, 2.92 mm, 2.4 mm etc. to account for adaptor corrections. Or if the SVRC of the submitted item is ≥ |0.1|. Measurements can be provided as either Absolute, DC or RF referenced.	**Teddington**
Absolute power in coaxial line	0.1 mW to 10 mW (-10 dBm to +10 dBm)	0.25 mW/W	Measurement of a reference power output of a power source at nominal 50 MHz which has 50 Ω type N connector. Direct power measurement method with standard power sensor. Absolute value of magnitude of the source voltage reflection coefficient should be ≤ |0.1|.	
Source voltage reflection coefficient (SVRC)	-0.1≤ SVRC ≤ +0.1	0.010	Measurement at nominal 50 MHz which has 50 Ω type N connector. Reflection Phase should be 0° ± 40° or 180° ± 40°.	
Calibration factor and effective efficiency - guided wave systems	Nominal power range 0.1 mW to 10 mW (-10 dBm to 10 dBm)			
	18.0 GHz to 26.5 GHz *26.5 GHz to 40.0 GHz* *40 GHz to 50 GHz* *50.0 GHz to 75 GHz* *75 GHz to 110.0 GHz*	5.0 mW/W 5.0 mW/W 9.0 mW/W 12.0 mW/W 16.0 mW/W	Waveguide No 20 Waveguide No 22 Waveguide No 23 Waveguide No 25 Waveguide No 27	
Calibration factor and effective efficiency - coaxial line system	Nominal power range 0.01 mW to 10 mW (-10 dBm to +10 dBm) *10 kHz to 1 MHz* *1 MHz to 10 MHz* *10 MHz to 100 MHz* *100 MHz to 4 GHz* *4 GHz to 8 GHz* *8 GHz to 12 GHz* *12 GHz to 15 GHz* *15 GHz to 18 GHz*	 5.5 mW/W 5.5 mW/W 2.0 mW/W 3.2 mW/W 3.4 mW/W 4.1 mW/W 5.2 mW/W 6.0 mW/W	Calibration of 7 mm power sensors and thermistor mounts against the NPL 7 mm calorimeter. 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 (GPC-7, 3.5 mm 2.92 mm, 2.4 mm).	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
COMPLEX REFLECTION COEFFICIENT (in support of Attenuation and Power calibrations)			Using VNA techniques	Teddington
Magnitude	0 to 1.0			
	2.6 GHz to 3.95 GHz	0.0040	Waveguide No 10	
	3.3 GHz to 4.9 GHz	0.0040	Waveguide No 11A	
	3.95 GHz to 5.85 GHz	0.0040	Waveguide No 12	
	5.85 GHz to 8.2 GHz	0.0040	Waveguide No 14	
	7.05 GHz to 10.0 GHz	0.0040	Waveguide No 15	
	8.2 GHz to 12.4 GHz	0.0040	Waveguide No 16	
	10.0 GHz to 15.0 GHz	0.0040	Waveguide No 17	
	12.4 GHz to 18.0 GHz	0.0040	Waveguide No 18	
	18.0 GHz to 26.5 GHz	0.0040	Waveguide No 20	
	26.5 GHz to 40.0 GHz	0.0040	Waveguide No 22	
	40.0 GHz to 50 GHz	0.0040	Waveguide No 23	
	60.0 GHz to 62 GHz	0.0040	Waveguide No 25	
	75 GHz to 110 GHz	0.0040	Waveguide No27	
	10 kHz to 18 GHz	0.0040	50 Ω APC-7 or Type N Connectors.	
	10 kHz to 26.5 GHz	0.0050	50 Ω 3.5 mm connectors. Measurements may be made up to 33 GHz however the uncertainties may be increased.	
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°	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
TIME AND FREQUENCY *Service Reference TT02*				Teddington
Characterisation of GPS disciplined oscillators and frequency standards				
Time offset	From UTC (NPL)	1.5 ns		
Time offset	From UTC	6.3 ns		
Frequency	5 MHz and 10 MHz	7.5×10^{-15} *Minimum measurement period 24 hours.*	Calibration of frequency standards with a 1 pulse per second output can also be undertaken.	
Time delay (coaxial cables)	0 ns to 300 ns	1.0 ns	For cable characterisation in support of GPSDO calibration.	
Service Reference TT04 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. Calibration of frequency standards with a 1 pps output can also be undertaken.	Customers' sites
Time offset	Weekly values relative to UTC (NPL)	20 ns		
Time offset	Weekly values relative to estimated UTC	40 ns		
Time offset	Post-processed values relative to corrected UTC data	5 ns		
Frequency	5 MHz and 10 MHz	1.0×10^{-13} *Minimum measurement period 24 hours.*		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code

Primary Impedance Measurement System *(PIMMS)*
Service Reference EG02

NOTES

For the linear voltage reflection and transmission coefficient measurands (i.e. complex-valued *S*-parameters) described in this section of the Schedule, the uncertainty 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. The corresponding *k* value will not be less than 2.5.

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.

Voltage Reflection Coefficient Magnitude (|VRC|) in 50 Ω coaxial systems. Measurements may be made using other 50 Ω coaxial connector types, but the quoted uncertainties may be increased.

Connector Type	|VRC|	Frequency (GHz)															
		0.01	0.02	0.04	0.045	0.05	0.07	0.09	0.1	0.2	0.3	0.5	1.0	1 to 7.5	7.5 to 8.5	8.5 to 18	18 to 26.5
7-16	0 to 0.5				0.002	0.002	0.002	0.002	0.002	0.002	0.0015	0.0015	0.001	0.001			
7-16	0.5 to 0.7				0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.002	0.002	0.002	0.002			
7-16	0.8				0.003	0.003	0.003	0.003	0.003	0.003	0.0025	0.0025	0.0025	0.0025			
7-16	0.9				0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.003	0.003	0.003	0.003			
7-16	1.0				0.004	0.004	0.004	0.004	0.004	0.004	0.0035	0.0035	0.0035	0.0035			
GR900	0 to 0.5				0.002	0.002	0.002	0.002	0.002	0.002	0.0015	0.0015	0.001	0.001	0.001		
GR900	0.5 to 0.7				0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.002	0.002	0.002	0.002	0.002		
GR900	0.8				0.003	0.003	0.003	0.003	0.003	0.003	0.0025	0.0025	0.0025	0.0025	0.0025		
GR900	0.9				0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.003	0.003	0.003	0.003	0.003		
GR900	1.0				0.004	0.004	0.004	0.004	0.004	0.004	0.0035	0.0035	0.0035	0.0035	0.0035		
GPC-7	0 to 0.6	0.0055	0.0045	0.004	0.004	0.004	0.004	0.0035	0.0035	0.0035	0.003	0.003	0.0025	0.0025	0.0025	0.0025	
GPC-7	0.6 to 0.8	0.0055	0.005	0.0045	0.0045	0.0045	0.0045	0.004	0.004	0.004	0.0035	0.0035	0.003	0.003	0.003	0.003	
GPC-7	0.9	0.006	0.0055	0.005	0.005	0.005	0.005	0.0045	0.0045	0.0045	0.004	0.004	0.004	0.0035	0.0035	0.0035	
GPC-7	1.0	0.0065	0.0055	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.0045	0.0045	0.0045	0.004	0.004	0.004	
Type-N	0 to 0.6	0.0055	0.0045	0.004	0.004	0.004	0.004	0.0035	0.0035	0.0035	0.003	0.003	0.0025	0.0025	0.0025	0.0025	
Type-N	0.6 to 0.8	0.0055	0.005	0.0045	0.0045	0.0045	0.0045	0.004	0.004	0.004	0.0035	0.0035	0.003	0.003	0.003	0.003	
Type-N	0.9	0.006	0.0055	0.005	0.005	0.005	0.005	0.0045	0.0045	0.0045	0.004	0.004	0.004	0.0035	0.0035	0.0035	
Type-N	1.0	0.0065	0.0055	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.0045	0.0045	0.0045	0.004	0.004	0.004	
3.5 mm	0 to 0.8				0.01	0.0095	0.009	0.0085	0.008	0.007	0.007	0.0065	0.006	0.005	0.005	0.005	0.005
3.5 mm	0.8 to 1.0				0.01	0.01	0.0095	0.009	0.0085	0.0075	0.0075	0.007	0.0065	0.0055	0.0055	0.0055	0.0055

Location Code: Teddington

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
Primary Impedance Measurement System *(PIMMS)* (continued)				Teddington

Voltage Reflection Coefficient Magnitude (|VRC|) in waveguide systems

Waveguide size	Frequency (GHz) 5.4 to 8.2	8.2 to 12.4	12.4 to 18	18 to 26.5	26.5 to 40
R70	0.001				
R100		0.001			
R140			0.0015		
R220				0.0015	
R320					0.003

Voltage Transmission Coefficient Magnitude (|VTC|) in 50 Ω coaxial systems

Connector Type	|VTC| and corresponding insertion loss (dB)	Frequency	Minimum uncertainty (VTC)
7-16	1 (0 dB)	10 MHz to 7.5 GHz	0.00040
7-16	0.316 (10 dB)	10 MHz to 7.5 GHz	0.00035
7-16	0.1 (20 dB)	10 MHz to 7.5 GHz	0.00020
7-16	0.0316 (30 dB)	10 MHz to 7.5 GHz	0.00010
7-16	0.01 (40 dB)	10 MHz 100 MHz	0.00010
7-16	0.01 (40 dB)	100 MHz to 7.5 GHz	0.00005
7-16	0.00316 (50 dB)	10 MHz to 100 MHz	0.00010
7-16	0.00316 (50 dB)	100 MHz to 7.5 GHz	0.00004
14 mm	1 (0 dB)	45 MHz to 8.5 GHz	0.00040
14 mm	0.316 (10 dB)	45 MHz to 8.5 GHz	0.00035
14 mm	0.1 (20 dB)	45 MHz to 8.5 GHz	0.00020
14 mm	0.0316 (30 dB)	45 MHz to 8.5 GHz	0.00010
14 mm	0.01 (40 dB)	45 MHz 100 MHz	0.00010
14 mm	0.01 (40 dB)	100 MHz to 8.5 GHz	0.00005
14 mm	0.00316 (50 dB)	45 MHz to 100 MHz	0.00010
14 mm	0.00316 (50 dB)	100 MHz to 8.5 GHz	0.00004
Type-N	1 (0 dB)	10 MHz to 18 GHz	0.00040
Type-N	0.316 (10 dB)	10 MHz to 18 GHz	0.00035
Type-N	0.1 (20 dB)	10 MHz to 18 GHz	0.00020
Type-N	0.0316 (30 dB)	10 MHz to 18 GHz	0.00010
Type-N	0.01 (40 dB)	10 MHz to 100 MHz	0.00010
Type-N	0.01 (40 dB)	100 MHz to 18 GHz	0.00005
Type-N	0.00316 (50 dB)	10 MHz to 100 MHz	0.00010
Type-N	0.00316 (50 dB)	100 MHz to 18 GHz	0.00004
3.5 mm	1 (0 dB)	45 MHz to 26.5 GHz	0.0010
3.5 mm	0.316 (10 dB)	45 MHz to 26.5 GHz	0.00040
3.5 mm	0.1 (20 dB)	45 MHz to 100 MHz	0.00025
3.5 mm	0.1 (20 dB)	100 MHz to 26.5 GHz	0.00020
3.5 mm	0.0316 (30 dB)	45 MHz to 100 MHz	0.00015
3.5 mm	0.0316 (30 dB)	100 MHz to 26.5 GHz	0.00010
3.5 mm	0.01 (40 dB)	45 MHz to 100 MHz	0.00006
3.5 mm	0.01 (40 dB)	100 MHz to 26.5 GHz	0.00005
3.5 mm	0.00316 (50 dB)	45 MHz to 100 MHz	0.00010
3.5 mm	0.00316 (50 dB)	100 MHz to 26.5 GHz	0.00004

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
Primary Impedance Measurement System *(PIMMS)* (continued)				Teddington
Voltage Transmission Coefficient Magnitude (|VTC|) in waveguide systems				
Waveguide size	|VTC| and corresponding insertion loss (dB)	Frequency	Minimum uncertainty (VTC)	
R100	1 (0 dB)	8.2 GHz to 12.4 GHz	0.0010	
R100	0.316 (10 dB)	8.2 GHz to 12.4 GHz	0.00040	
R100	0.1 (20 dB)	8.2 GHz to 12.4 GHz	0.00020	
R100	0.0316 (30 dB)	8.2 GHz to 12.4 GHz	0.00010	
R100	0.01 (40 dB)	8.2 GHz to 12.4 GHz	0.00006	
R100	0.00316 (50 dB)	8.2 GHz to 12.4 GHz	0.00004	
R140	1 (0 dB)	12.4 GHz to 18 GHz	0.0025	
R140	0.316 (10 dB)	12.4 GHz to 18 GHz	0.00075	
R140	0.1 (20 dB)	12.4 GHz to 18 GHz	0.00030	
R140	0.0316 (30 dB)	12.4 GHz to 18 GHz	0.00010	
R140	0.01 (40 dB)	12.4 GHz to 18 GHz	0.00006	
R140	0.00316 (50 dB)	12.4 GHz to 18 GHz	0.00004	
R220	1 (0 dB)	18 GHz to 26.5 GHz	0.0030	
R220	0.316 (10 dB)	18 GHz to 26.5 GHz	0.00075	
R220	0.1 (20 dB)	18 GHz to 26.5 GHz	0.00030	
R220	0.0316 (30 dB)	18 GHz to 26.5 GHz	0.00010	
R220	0.01 (40 dB)	18 GHz to 26.5 GHz	0.00006	
R220	0.00316 (50 dB)	18 GHz to 26.5 GHz	0.00004	
R320	1 (0 dB)	26.5 GHz to 40 GHz	0.0030	
R320	0.316 (10 dB)	26.5 GHz to 40 GHz	0.00075	
R320	0.1 (20 dB)	26.5 GHz to 40 GHz	0.00030	
R320	0.0316 (30 dB)	26.5 GHz to 40 GHz	0.00010	
R320	0.01 (40 dB)	26.5 GHz to 40 GHz	0.00006	
R320	0.00316 (50 dB)	26.5 GHz to 40 GHz	0.00004	
Mechanically-derived characteristic impedance of the following coaxial lines:				
7-16	49.8 Ω to 50.2 Ω	0.009 Ω	Based on measurements of the diameters of airline conductors, these and associated uncertainties will also be reported. These measurements are made using air gauging techniques.	
14 mm	49.8 Ω to 50.2 Ω	0.010 Ω		
Type-N	27.7 Ω to 28.3 Ω	0.018 Ω		
Type-N or GPC-7	49.6 Ω to 50.4 Ω	0.016 Ω		
Type-N	74.4 Ω to 75.6 Ω	0.031 Ω		
Type-N	99.2 Ω to 100.8 Ω	0.078 Ω		
3.5 mm	49.2 Ω to 50.8 Ω	0.038 Ω		
2.92 mm	48.9 Ω to 50.9 Ω	0.048 Ω		
2.4 mm	48.9 Ω to 51.4 Ω	0.063 Ω		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)		Remarks	Location Code
LOW FREQUENCY COMPLEX REFLECTION COEFFICIENT *Service Reference EG02*				Using VNA techniques.	Teddington
Voltage Reflection Coefficient Magnitude (|VRC|) in 50 Ω coaxial systems, using the following connector types:				The capabilities are shown as a representative selection of values, each of which represents an expanded uncertainty at a level of confidence of approximately 95 %. Intermediate values may also be reported, with linear interpolation of the uncertainties. Each value represents the uncertainty applied equally and simultaneously to *both* the Real and Imaginary parts of the *S*-parameter. The uncertainty therefore defines a circular region, in the appropriate complex *S*-parameter plane, centred on the measured, quoted, mean value with radius equal to the stated expanded uncertainty. The corresponding k value will not be less than 2.5.	
		9 kHz to 10 MHz	10 MHz to 100 MHz		
GPC-7	0	0.0022	0.0022		
GPC-7	0.05	0.0022	0.0022		
GPC-7	0.13	0.0022	0.0022		
GPC-7	0.33	0.0021	0.0020		
GPC-7	1	0.0031	0.0027		
GR900 / 14 mm	0	0.0030	0.0030		
GR900 / 14 mm	0.05	0.0030	0.0030		
GR900 / 14 mm	0.13	0.0030	0.0030		
GR900 / 14 mm	0.33	0.0030	0.0025		
GR900 / 14 mm	1	0.0050	0.0030		
Type-N	0	0.0030	0.0030		
Type-N	0.05	0.0030	0.0030		
Type-N	0.13	0.0030	0.0030		
Type-N	0.33	0.0030	0.0025		
Type-N	1	0.0050	0.0030		
3.5 mm	0	0.0034	0.0034	Measurements may be made using other 50 Ω coaxial connector types, but the quoted uncertainties may be increased.	
3.5 mm	0.05	0.0034	0.0034		
3.5 mm	0.13	0.0033	0.0033		
3.5 mm	0.33	0.0031	0.0031		
3.5 mm	1	0.0044	0.0042		
2.92 mm / K-Connector	0	0.011	0.011		
2.92 mm / K-Connector	0.05	0.011	0.011		
2.92 mm / K-Connector	0.13	0.011	0.011		
2.92 mm / K-Connector	0.33	0.010	0.010		
2.92 mm / K-Connector	1	0.011	0.011		
2.4 mm	0	0.0096	0.0095		
2.4 mm	0.05	0.0096	0.0095		
2.4 mm	1	0.0096	0.0092		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
LENGTH			All linear calibrations may be given in inch units	Teddington
Gauge blocks: millimetre *Service Reference: LD01*	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	Q[19, 0.21 *L*] nm, *L* in mm 20 nm 20 nm to 22 nm 22 nm to 25 nm 25 nm to 29 nm	Measurement of central length by interferometry for gauges of length *L* (in mm, or inch). 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.	
	0.5 mm to 100 mm	32 nm	Measurement of flatness of measuring faces by interferometry	
	0.5 mm to 100 mm	50 nm	Measurement of variation in length by interferometry	
Gauge blocks: inch *Service Reference: LD01*	As BS 4311:2007 0.01 inch to 0.4 inch 0.4 in to 1 inch 2 inch 3 inch 4 inch	Q[0.75, 0.21 *L*] μ inch, *L* in inch 0.76 μ inch 0.76 μ inch to 0.78 μ inch 0.86 μ inch 0.98 μ inch 1.13 μ inch		
	0.01 inch to 4 inch	1.26 μ inch	Measurement of flatness of measuring faces by interferometry	
	0.01 inch to 4 inch	1.97 μ inch	Measurement of variation in length by interferometry	
Gauge blocks: millimetre *Service Reference: LD01*	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	Q[32 ,0.76 *L*] nm, *L* in mm 32 nm to 33 nm 33 nm to 37 nm 37 nm to 50 nm 50 nm to 66 nm 66 nm to 83 nm	Measurement of central length by mechanical comparison with gauge block of similar size, for gauges of length *L* (in mm)	
	0.5 mm to 100 mm	40nm	Measurement of variation in length by mechanical comparison	
Gauge blocks: inch *Service Reference: LD01*	As BS 4311:2007 0.01 inch to 0.4 inch 0.4 inch to 1 inch 2 inch 3 inch 4 inch	Q[1.26, 0.76 *L*] μ inch, *L* in inch 1.26 μ inch to 1.30 μ inch 1.30 μ inch to 1.47 μ inch 1.97 μ inch 2.60 μ inch 3.29 μ inch		
	0.01 inch to 4 inch	1.57 μ inch	Measurement of variation in length by mechanical comparison	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
LENGTH (continued)				Teddington
Long gauge blocks: millimetre *Service Reference: LD02*	As BS EN ISO 3650:1999 Grades K, 0 and 1 Above 100 mm to 1000 mm	(120 + 0.26 *L*) nm, *L* in mm 147 nm to 383 nm	Measurement of central length by interferometric comparison of long gauge blocks of length *L* (in mm) to the stated standards.	
Length bars: millimetre *Service reference: LD02*	As BS 5317:1976; Reference and calibration grades			
	10 mm to 100 mm	Q[60, 0.21 *L*] nm, *L* in mm *i.e.* 61 nm to 64 nm	Measurement of length by absolute interferometry of length bars of length *L* (in mm).	
	Above 100 mm to 1200 mm	(120 + 0.26 *L*) nm, *L* in mm *i.e.* 146 nm to 436 nm	Measurement of length by interferometric comparison of length bars of length *L* (in mm)	
Length bars: Inch *Service Reference: LD02*	As BS 1790:1961; Reference and calibration grades			
	0.5 inch to 4 inch	Q[2.36, 0.21 *L*] μ inch, *L* in inch *i.e.* 2.37 μ inch to 2.51 μ inch	Measurement of length by absolute interferometry of length bars of length *L* (in inches).	
	Above 4 inch to 48 inch	(4.57 + 0.26 *L*) μ inch, *L* in inch	Measurement of length by interferometric comparison of long gauge blocks of length *L* (in inches) to the stated standards	
Length bars and long gauge blocks: millimetre (and inch) *Service Reference: LD05*	As BS EN ISO 3650:1999 Grades K and 0	Q[49, 0.083 L] nm, L in mm, or Q[1.9, 0.083 *L*] μ inch, *L* in inch	Measurement of central length by absolute interferometry of long gauge blocks of length *L* (in mm, on inch) to the stated standards.	
	Above 100 mm to 1000 mm, above 4 inch up to 48 inch	59 nm	Measurement of variation in length by interferometry	
	Above 100 mm to 1000 mm, above 4 inch up to 48 inch	32 nm	Measurement of deviation from flatness by interferometry	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
LENGTH (continued)				Teddington
Gauge blocks and length bars Thermal expansion coefficient at 20 °C *Service Reference: LD03*	Expansion coefficient 9×10^{-6} K^{-1} to 13×10^{-6} K^{-1}	($0.004 + 11/L + 0.000\ 007L$) $\times 10^{-6}$ K^{-1}, L in mm	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 *Service Reference: LD04*	210 mm to 1020 mm	($100 + 0.23\ L$) nm, L in mm		
Thread measuring cylinders *Service Reference: LD07*	0.05 mm to 5 mm diameter	($0.080 + 0.0010\ D$) µm D: diameter in mm	As BS 3777:1964 BS 5590:1978 and specials	
External cylinder Plain plug gauges (parallel) reference cylinders and rollers *Service Reference: LD07*	0.1 mm to 100 mm diameter 100 mm to 150 mm diameter	($0.070 + 0.0011\ D$) µm, D in mm ($0.050 + 0.0014\ D$) µm, D in mm		
Plain setting rings (parallel) *Service Reference: LD07*	3 mm to 250 mm diameter	($0.070 + 0.0005\ D$) µm, D in mm	As BS 4064:1966 and BS 4065:1966 Grade AA, and equivalent quality setting rings	
Stage micrometers and graticules *Service Reference: LR04*	0 mm to 50 mm 50 mm to 100 mm 100 mm to 150 mm	0.20 µm 0.30 µm 0.40 µm		
Linewidth standards *Service Reference: LR03*	0.5 µm to 10 µm 10 µm to 50 µm	0.050 µm 0.10 µm		
Reference stage graticules for image analysers *Service Reference: LR07*	Grid sizes 0 to 400 µm × 400 µm Spot sizes 3 µm to 48 µm	 0.10 µm 0.10 µm		
Reference master screw plug and ring gauges to API specification 7 *Service Reference: LD06*	0 inch to 9 inch diameter Stand off	 0.00034 inch		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
LENGTH (continued) Receiver and position gauges, jigs and fixtures *Service Reference: LD10*	1200 mm × 1000 mm × 700 mm	(0.36 + L/866) µm, L in mm 0.70 µm (using substitution method) 0.40 µm (using reversal method)	Measurements made using a coordinate measuring machine. Uncertainty may be evaluated by numerical (Monte Carlo) methods.	**Teddington**

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
ANGLE *Service Reference: LD08*				Teddington
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	5 mm to 100 mm diameter	0.0050 µm		
Reference Sphere Diameter *Service Reference: LD07*	10 mm to 50 mm diameter	0.11 µm		
Back vertex focal length or power of a lens. *Service Reference: LR02*	± 0.01 *D* to ± 25 *D*	0.0010 *D* to 0.010 *D* *D*: dioptre	Phase shifting interferometer and length measuring interferometer traceable to dimensional standards used to measure vertex of the back surface of a lens to the corresponding focus.	
Radius of curvature and sphericity of optical quality surfaces. *Service Reference: LR02*	4 mm to 1000 mm radius of curvature.	0.0020 mm, 26 nm for sphericity	Test items are calibrated for radius of curvature and departure from spherical form using a phase shifting interferometer in conjunction with a commercial laser length measuring interferometer.	
Power of small angle prisms. *Service Reference: LR02*	0 to 20 prism dioptres (0° to 12° deviation).	0.010 prism dioptres.	Measurements of small angle prisms are carried out using a phase shifting interferometer, auxiliary mirrors, a clinometer and calibration test pieces when necessary.	
Optical flatness *Service Reference: LR01*	5 mm to 33 mm 33 mm to 100 mm 100 mm to 150 mm	14 nm 17 nm 20 nm	Flatness of optical quality surfaces using a phase shifting interferometer housing a reference flat traceable to a liquid surface.	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
OTHER MEASURING INSTRUMENTS, EQUIPMENT AND MACHINES				Teddington
Laser frequency (Vacuum wavelength) *Service Reference: LL03*	Nominal wavelengths 500 nm to 2 µm	1 part in 10^{13}		
Laser interferometer systems	0 m to 45 m			
Service Reference: LL01	*Compensated*	Q[0.08, 0.2 *L*] µm, *L* in m	Using the tape bench at OPSS	
Service Reference: LL02	*Uncompensated*	Q[0.08, 0.12 *L*] µm, *L* in m		
Laser interferometer systems	0 m to 10.8 m			
Service Reference: LL01	*Compensated*	Q[0.08, 0.14 L] µm, L in m	Using the 10.8 m laser rail	
Service Reference: LL02	*Uncompensated*	Q[0.08, 0.088 L] µm, L in m		
Extensometer calibration rigs Service Reference MF06	Displacements 0 mm to 300 mm	For the First two minutes 31 + (3.1 x *R*) nm For the second two minutes 51 + (3.1 x R) nm where *R* is the extension in mm	As BS EN ISO 9513:2012 and ASTM E83-23	
INFRA-RED				
Wavenumber, v for QA checks on mid-IR spectrophotometers *Service Reference: OT21*	*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} 906.60 cm^{-1}	 0.30 cm^{-1} 0.30 cm^{-1} 0.30 cm^{-1} 0.30 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 eight selected transmittance minima. Films are measured in an FTIR spectrophotometer	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
PHOTOMETRY				Teddington
Luminous intensity (tungsten lamps) *Service Reference: OT15*	1 cd to 100 cd 100 cd to 1000 cd 1000 cd 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 CMC 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) *Service Reference: OT15*	0.1 lux to 500 lux 500 lux to 5000 lux 5000 lux to 20000 lux 20000 lux to 50000 lux	0.90 % 0.80 % 0.90 % 1.0 %		
Luminance (tungsten sources and luminance meters) *Service Reference: OT16*	(1 to 100) cd m^{-2} (100 to 1000) cd m^{-2} (1000 to 10000) cd m^{-2} (10000 to 45000) cd m^{-2} (45000 to 450000) cd m^{-2}	1.3 % 1.2 % 1.3 % 1.3 % 1.4 %		
Correlated colour temperature (tungsten lamps and colour temperature meters) *Service Reference: OT15*	2800 K to 3200 K	10 K		
Spectral responsivity of laser power meters *Service Reference: OT25*	100 pW to 1 mW *350 nm to 1600 nm*	0.040 %	At laser wavelength or peak wavelength of bandpass filter.	
Spectral responsivity *Service Reference: OT24*	200 nm to 210 nm 211 nm to 239 nm 240 nm >240 nm to 315 nm 316 nm to 404 nm 405 nm to 919 nm 920 nm to 1000 nm 1001 nm to 1400 nm 1401 nm to 1800 nm	3.2% 1.0% 0.7% 0.5% 0.3% 0.1% 0.3% 0.3% 0.3% to 0.4%*	*Where the uncertainty is stated as a range, linear interpolation may be used to find the measurement uncertainty at intermediate values, as per the CIPM-MRA-G-13 document, section 2.3 (Calibration and measurement capabilities in the context of the CIPM MRA),	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
COLORIMETRY AND SPECTROPHOTOMETRY - REGULAR TRANSMITTANCE *Service Reference: OT22*				Teddington
Regular transmittance	0.001 *T*% to 100 *T*%	Absolute uncertainty for *T*%		

	Wavelength range (nm)				
T%	200 to 209.9	210 to 349.9	350 to 800	800.1 to 1500	1500.1 to 2500
90	0.39	0.37	0.32	0.25	0.25
60	0.39	0.25	0.21	0.22	0.26
30	0.19	0.17	0.10	0.14	0.26
10	0.18	0.08	0.08	0.10	0.18
3	0.05	0.05	0.05	0.10	0.10
1	0.030	0.030	0.030	0.100	0.100
0.3	0.030	0.030	0.030	0.090	0.090
0.1	0.030	0.030	0.030	0.030	0.030
0.01	0.003	0.003	0.003	0.003	0.003
0.001	0.0003	0.0003	0.0003	0.0003	0.0003

Note: The table is for measurements relative to air. For low transmittance samples measurements may be performed relative to a calibrated reference sample of higher transmittance (i.e. cascaded) and the uncertainty $U(T\%)$ is then given by $T\%\sqrt{\left(\frac{U(T\%_{\mathrm{ref}})}{T\%_{\mathrm{ref}}}\right)^2+\left(\frac{U(T\%_{\mathrm{casc}})}{T\%_{\mathrm{casc}}}\right)^2}$ where $T\%_{\mathrm{ref}}$ and $U(T\%_{\mathrm{ref}})$ are the transmittance and associated uncertainty of the reference sample, $T\%_{\mathrm{casc}}$ is the transmittance reading with the reference filter in place and $U(T\%_{\mathrm{casc}})$ is the uncertainty associated with that transmittance reading (taken from the table above).

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
COLORIMETRY AND SPECTROPHOTOMETRY - REGULAR TRANSMITTANCE (continued) *Service Reference: OT22* Optical density	0.0000 *D* to 5.0000 *D* *Wavelength range (nm):* *200 nm to 2500 nm*	Absolute uncertainty for *D*, calculated from $U_D = D - \log_{10}[100/(T\% - U_{T\%})]$	Optical density is equivalent to absorbance (A) and is calculated from regular transmittance T% using the formula $D = \log_{10}(100/T\%)$.	Teddington
Wavelength of absorption peaks Colour data: CIELAB L* a* b* Colour data: CIE x, y, u', v' Luminous transmittance *Y*	200 to 3000 nm 0 to 100 -200 to +200 -200 to +200 0 to 1 0 %*Y* to 100 %*Y*	0.15 nm 0.050 0.050 0.050 0.0002 0.15 % for 60 %*Y*	Colour data are normally given for the CIE 2° and 10° Standard observers and CIE Standard Illuminants A, C and D65. Data for other Standard Illuminants can be provided on request. .	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
COLORIMETRY AND SPECTROPHOTOMETRY - DIFFUSE REFLECTANCE *Service Reference: OT20*				**Teddington**
Spectral diffuse reflectance; specular included and specular excluded geometries (see Note 1)	0 % R to 100 % R *Wavelength range (nm):* *350 ≤ λ ≤ 375*	2.5 % (white), 0.25 % (black) (0.25 + 0.023 R) %	Note 1: The CMCs are for measurement against similar NPL reference standards, and examples are given covering the range from 'white' samples to 'black' samples. Higher uncertainties may apply where no similar NPL reference standard is available.	
	380 ≤ λ ≤ 460	0.60 % glossy white, 0.55 % matt white 0.10 % black (0.050 + 0.0055 R) %		
	460 < λ ≤ 800	0.40 % glossy white, 0.35 % matt white 0.10 % black (0.050 + 0.0055 R) %		
	800 < λ ≤ 2000	1.6 % (white), 0.35 % (black) (0.35 + 0.013 R) %		
	2000 < λ ≤ 2500	2.1 % (white), 0.65 % (black) (0.65 + 0.015 R) %		
0°:45°a Spectral radiance factor (see Notes 1 and 2)	0 % R to 102 % R *Wavelength range (nm):* *350 ≤ λ ≤ 375*	2.5 % (white), 0.25 % (black) (0.25 + 0.023 R) %	Note 2: 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.	
	800 < λ ≤ 2000	2.3 % (white), 0.30 % (black) (0.30 + 0.020 R) %		
	2000 < λ ≤ 2500	2.8 % (white), 0.70 % (black) (0.70 + 0.021 R) %		
Colour data: CIELAB L* a* b* (See Note 3)	 0 to 100 -200 to +200 -200 to +200	 0.15 0.10 0.10	Note 3: Colour data are normally given for the CIE 2° and 10° Standard observers and CIE Standard Illuminants A, C and D65. Data for other Standard Illuminants can be provided on request.	
Colour data: CIE x, y, u', v' (See Note 3)	0 to 1	0.0002		
Luminous reflectance Y (See Note 3)	0 % to 100 %	0.55 % (white), 0.10 % (black)		

UKAS CALIBRATION **0478** **Accredited to ISO/IEC 17025:2017**	**Schedule of Accreditation** **issued by** **United Kingdom Accreditation Service** 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK **NPL Management Ltd** **Issue No:** 148 **Issue date:** 22 January 2025

Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
TEMPERATURE				Teddington
Standard resistance thermometers, fixed point calibrations *Service Reference: PM02*	-196 °C to +0.01 °C -189.3442 °C -38.8344 °C 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	0.0017 °C to 0.00016 °C 0.00050 °C 0.00035 °C 0.00011°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	Comparison at LN_2. Calibrations at measurement current.	
	0°C to 419.527°C 419.527 °C to 660.323 °C 660.323 °C to 961.78 °C	0.0020 °C 0.0020 °C to 0.0030 °C 0.0040 °C	For HTSPRTs	
Resistance thermometers, calibration by comparison *Service Reference: PM04*	-196 °C -100 °C to -80 °C -80 °C to 0 °C 0 °C to 30 °C 30 °C to 100 °C	0.0050 °C 0.010 °C 0.0060 °C 0.0030 °C 0.0050 °C	Comparison at LN_2 and in acetone. Oil and water baths.	
Resistance thermometers, by dry block calibration *Service Reference: PM04*	50 °C to 150 °C 150 °C to 420 °C	0.040 °C 0.040 °C to 0.10 °C		
Temperature indicators with resistance sensor *Service Reference: PM04*	-196 °C to +420 °C	As for sensor		
Fixed Point Cells *Service Reference: PK01*				
Triple point of Argon	-189.3442 °C	0.00050 °C	Cell compared with NPL reference cell during several realisations of the fixed point temperature using Standard Platinum Resistance Thermometers	
Triple point of Mercury	-38.8344 °C	0.00020 °C		
Melting point of Gallium	29.7646 °C	0.00020 °C		
Freezing point of Indium	156.5985 °C	0.00070 °C		
Freezing point of Tin	231.928 °C	0.00060 °C		
Freezing point of Zinc	419.527 °C	0.00090 °C		
Freezing point of Aluminium	660.323 °C	0.0025 °C		
Freezing point of Silver	961.78 °C	0.0040 °C		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
TEMPERATURE (continued)				
Fixed Point Cells (continued) *Service Reference: PK01*				
Water triple point cells	0.01 °C	0.000070 °C 0.000058 °C	By comparison with 2 cells from NPL reference batch By comparison with 5 cells from NPL reference batch	
Thermocouples *Service Reference: PM03*				
Noble metal type Pt-Rh	420 °C 962 °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 1100°C 1100 °C to 1330 °C 1330 °C to 1500 °C	0.30 °C 0.30 °C to 0.55 °C 0.55 °C to 0.72 °C	Polynomial interpolation with improved homogeneity	
	1064.18 °C 1554.8 °C 0 °C to 1100 °C with 1100 °C to 1600 °C	0.57 °C 0.85 °C 1.0 °C 1.0 °C to 1.5 °C	Wire Bridge Method Au Pd Interpolation based upon Au and Pd wire bridge measurements	
Pt-Rh (type B only)	1768.2 °C 400 °C to 1100 °C 1100 °C to 1800 °C	1.1 °C 0.30 °C 0.30 °C to 1.2 °C	Wire bridge method Pt Based upon Zn and Ag fixed points and Pt wire bridge	
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	
	0 °C to 1100 °C 1100 °C to 1330 °C 1100 °C to 1500 °C	0.20 °C 0.20 °C to 0.55 °C 0.20 °C to 0.72 °C	Interpolation	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
TEMPERATURE (continued)				Teddington
Thermocouples, Noble metal type Au-Pt	420 °C, 660 °C, 962 °C	0.050 °C		
	0 °C to 1000 °C	0.050 °C	Where Zn and Ag fixed points 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 with LN_2 and in oil and water baths	
Thermocouples, by dry block calibration	50 °C to 700 °C	0.75 °C	Calibration via comparison to the integrated reference PRT of a dry block calibrator	
Temperature indicators with thermocouple sensor *Service Reference: PM04*	-196 °C to +100 °C	As for sensor		
Compensating and extension cables *Service Reference: PM03*	-25 °C to +100 °C	As for base metals thermocouples	By comparison.	
Thermocouple fixed point cells *Service Reference: PK01*				
Cu fixed point cell (freeze)	1084 °C	0.031 °C	Certification of fixed point cells by measurement (with Pt/Pd thermocouples) against NPL National Standard fixed point cells	
Co-C fixed point cell (melt) Pd-C fixed point cell (melt)	1324 °C 1492 °C	0.44 °C 0.65 °C		
Disappearing filament pyrometers *Service Reference: PM06*	700 °C to 800 °C 800 °C to 1700 °C 1700 °C to 2800 °C	5.0 °C to 2.0 °C 2.0 °C 2.0 °C to 8.0 °C		
Infrared Thermometers *Service Reference: PM06*	-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 For temperatures above 1324 °C Eutectic Fixed Point can be used	
Blackbody Sources *Service Reference: PM06*	-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		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
HUMIDITY			Instruments with an electrical output can also be calibrated. The accreditation covers other humidity quantities derived from dew point, e.g. water vapour (partial) pressure; water vapour fraction or ratio by mass, volume or amount of substance; water vapour mass per unit volume of gas, etc.	**Teddington**
Dew-point *Service Reference: MH01*	+95 °C to +90 °C +90 °C to +80 °C +80 °C to +70 °C +70 °C to -40 °C -40 °C to -60 °C -60 °C to -75 °C -75 °C to -90 °C -90 °C to -100 °C	0.099 °C to 0.071 °C 0.071 °C to 0.032 °C 0.032 °C to 0.027 °C 0.027 °C 0.027 °C to 0.034 °C 0.034 °C to 0.10 °C 0.10 °C to 0.50 °C 0.50 °C to 1.60 °C		
Dew point in air or nitrogen at elevated pressure *Service Reference: MH07*	-60 °C to +10 °C	0.070 °C	At pressures up to 1 MPa. using the NPL Pressure Dew-point generator	
Dew point in various gases at elevated pressure *Service Reference: MH07*	-60 °C to +15 °C 0.5 μmol/mol to 1000 μmol/mol	0.12 °C 0.03 μmol/mol to 19 μmol/mol	At pressures up to 3 MPa in air, inert gases, hydrogen, methane and premade cylinder gas blends using NPL Multi-gas, Multi-pressure Primary Standard Humidity Generator	
Relative Humidity *Service Reference: MH02/MH03*	0.5 %rh to 98 %rh at temperatures from -40 °C to +100 °C	0.60 % of reading + 0.10 %rh	Calibration by comparison against NPL transfer standards	
Temperature in air *Service Reference: MH02/MH03*	-40 °C to -20 °C -20 °C to +50 °C 50 °C to 100 °C	0.080 °C 0.040 °C 0.080 °C	Calibration by comparison against reference PRTs	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
NEUTRON DOSIMETRY				Teddington
NEUTRON SOURCE EMISSION RATE *Service Reference: RN05*				
Emission rate from radionuclide neutron sources	Source emission rate (10^5 to 2×10^9) s^{-1}	1.0 % to 1.2 % depending on source	Induced ^{56}Mn activity measured using sodium iodide detectors.	
	Source emission rate (10^2 to 2×10^6) s^{-1}	1.2 % to 1.5 % depending on source	Relative measurement performed using a moderating detector assembly.	
Anisotropy of emission from radionuclide neutron sources	Source emission rate (10^5 to 10^8) s^{-1} Anisotropy factor 0.5 to 1.2	0.50 % to 1.0 % depending on source	Measurements performed using a precision long counter in a low-scatter environment.	
NEUTRON FLUENCE				
Thermal neutron fluence *Service Reference: RN01*	Energy: thermal Neutron beam Fluence rates: (10^3 to 4×10^4) $cm^{-2} s^{-1}$	1.2 % for Wescott fluence 4.0 % for ‘true’ fluence	Fast neutrons moderated in a graphite pile. Beam of thermal neutrons extracted. Fluence standard - gold foil activation Service conforms to ISO 8529 Parts 1 to 3.	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
NEUTRON FLUENCE (continued)				Teddington
Thermal neutron fluence *Service Reference: RN01*	Energy: thermal Isotropic field Fluence rates: (10^4 to 3 x 10^7) $cm^{-2}.s^{-1}$	1.0 % for Westcott fluence	Fast neutrons moderated in graphite pile. Isotropic thermal neutron fields in a small 150 cm^3 cavity. Fluence standard - gold foil activation.	
Fast neutron fluence *Service Reference: RN02*	Energy: 70 keV to 17 MeV Accelerator based Monoenergetic fields Fluence rates: (1 to 1500) $cm^{-2}.s^{-1}$ at 1 m from target	4.0 %	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 8529 Parts 1 to 3.	
Fast neutron fluence *Service Reference: RN04*	Energy: broad range Sources: ^{241}Am-Be, ^{252}Cf, ^{241}Am-B, ^{241}Am-Li, ^{241}Am-F Fluence rates: (1 to 400) $cm^{-2}.s^{-1}$ at 1 m from source	1.3 %	Fields are produced using radionuclide neutron sources of known emission rate and anisotropy. Actual fluence rate depends on particular source Service conforms to ISO 8529 Parts 1 to 3.	
NEUTRON DOSE EQUIVALENT				
Thermal neutron dose equivalents *Service Reference: RN01,*	Energy: thermal Neutron beam Dose equivalent rates: 40 μSv h^{-1} to 2.0 mSv h^{-1}	5.0 %	Fluences are converted to ambient dose equivalent or personal dose equivalent using accepted conversion coefficients from ICRU 57 or ICRU 95. 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 8529 Parts 1 to 3.	
Fast neutron dose equivalents Service Reference: RN02	Energy: 70 keV to 17 MeV Accelerator based monoenergetic fields Dose equivalent rates: 0.2 μSv h^{-1} to 2.0 mSv h^{-1}	4.0 %		
Fast neutron dose equivalents Service Reference: RN04	Energy: broad range Radionuclide sources Dose equivalent rates:			
	^{241}Am-Be: (1 to 400) μSv.h^{-1} at 1m from the source	8.1 %	Actual dose equivalent rate depends on particular source.	
	^{252}Cf: 2 μSv.h^{-1} to 3 mSv.h^{-1} at 1m from the source	2.4 %		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
NEUTRON DOSE EQUIVALENT (continued)				Teddington
Fast neutron dose equivalents *Service Reference: RN04*	241Am-B: 5 µSv h^{-1} 1m from the source	8.5%		
	241Am-F: 1.6 µSv h^{-1} 1m from the source	9.0%		
	241Am-Li: 1.8 µSv h^{-1} 1m from the source	9.0%		
<u>Protection level dosemeters</u> Air kerma rate				
X-rays *Service Reference: RD02*	ISO 4037 narrow spectrum (generating potential 8 keV to 250 keV) 350 µGy h^{-1} to 100 mGyh^{-1}	1.6 %	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 *Service Reference: RD02*	^{60}Co 1 µGyh^{-1} to 0.1 Gyh^{-1} ^{137}Cs 1 µGyh^{-1} to 0.6 Gyh^{-1}	1.7 % 1.7 %		
	^{241}Am 8 µGyh^{-1} to 0.3 mGyh^{-1}	1.7 %		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
<u>Therapy level dosemeters</u> *Service Reference RD01*				Teddington
Measurement of air kerma rate	Half value layers 0.024 mm Al to 20 mm Al (generating potential 8 kVp to 50 kVp)	1.3%	Calibration of NE2561, NE2611 and Farmer type and soft x-ray ionisation chambers	
X-rays *Service Reference RD01*	Half value layers 0.024 mm Al to 20 mm Al (generating potential 50 kVp to 280 kVp)	1.4 %	Calibration of NE2561, NE2611 and Farmer type and soft x-ray ionisation chambers.	
γ-radiation *Service Reference RD01*	^{60}Co	0.70 %	Calibration of NE2561, NE2611 and Farmer type and soft x-ray ionisation chambers.	
Measurement of absorbed dose to water				
γ-radiation *Service Reference RD01*	^{60}Co	1.3 %	Calibration of NE2561, NE2611, for Farmer type ionisation with a suitable secondary standard electrometer, if supplied.	
Photons *Service Reference RD01*	TPR_{10}^{20}: 0.568 to 0.800 Nominal beam energy ^{60}Co, 4 MV to 25 MV	1.3 %		
Electrometer Charge Display, Charge Input *Service Reference RD16*	Min 10 pC to max 1 μC Depending on electrometer model	0.10 % to 0.90 % Depending on electrometer model and input charge	Calibration of suitable secondary standard electrometer.	
Electrometer Charge & Current Display, Current Input *Service Reference RD16*	min 5 pA to max 2 µA Depending on electrometer model	0.10 % to 0.90 % depending on electrometer model and input current	Calibration of suitable secondary standard electrometer	
<u>High dose dosimetry</u>				
Absorbed dose to water *Service Reference RD07*	^{60}Co Dose: >0.9 Gy	2.2 %	High dose irradiation service.	
Service Reference RD06	^{60}Co, ^{137}Cs, photons generated above 2 MeV and electrons generated above 4 MeV. Dose: 20 Gy to 100 kGy	2.6 %	Alanine dosimetry service	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
RADIOACTIVITY METROLOGY				
RR20 – Standards of Radioactivity (activity per unit mass, Bq g^{-1}): Solutions and spiked substrates of α-particle, β-particle, X-ray and γ-ray emitting radionuclides measured by secondary techniques. *Service Reference: RR20-ICGS*	4 kBq g^{-1} to 15 GBq g^{-1}, depending on radionuclide	0.30 %	Procedures directly supporting this work are: **RMS005** – Standards of Radioactivity Solutions **RMT006** - Measurement of a Gamma Spectrometry Sample **RMT007** - Analysis of a Gamma Spectrometry Sample **RMT031** - Activity Assay Using Ionisation Chambers Results for gamma emitters may be certificated as gammas s^{-1} g^{-1} by multiplication of the measured activity per unit mass by published emission probabilities.	Teddington
RR20 - Standards of Radioactivity (activity per unit mass, Bq g^{-1}): Solutions of α-particle, β-particle and X-ray emitting radionuclides measured by secondary liquid scintillation techniques *Service Reference: RR20-LSC*	10 Bq g^{-1} to 500 kBq g^{-1}	0.20 %	Procedures directly supporting this work are: **RMS005** - Standards of Radioactivity Solutions **RMT009** - Secondary Standardisation of Radionuclides using CIEMAT/NIST Technique **RMT010** – Standardisation of Radionuclides by Alpha LSC **RMT012** - Dilution check by liquid scintillation counting RMT054 - Secondary standardisation of beta-emitting radionuclides by the TDCR technique	Teddington
RR20- Standards of Radioactivity (activity per unit mass, Bq g^{-1} or γ emission rate per unit mass, s^{-1} g^{-1}): Solutions of Environmental level standards of radioactivity *Service Reference: RR20-BATCH*	0.001 Bq g^{-1} to 100 kBq g^{-1}, 0.01 s^{-1} g^{-1} to 1000 s^{-1} g^{-1} depending on radionuclide	0.30 %	Procedures directly supporting this work are: **RMS005** – Standards of radioactivity Solutions **RMS020** – Production of Customer Certificates and Dispatch Requests **RMS007** - Production of the NPL Mixed Radionuclide Solution **RMT012** - Dilution check by liquid scintillation counting	Teddington

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
RADIOACTIVITY METROLOGY (continued)				Teddington
RR20- Solid substrates (air filters) directly spiked with solutions produced by the above techniques (activity, Bq or γ emission rate, s^{-1}) *Service Reference RR20-SPIKE*	10 Bq to 500 kBq, 0.01 s^{-1} to 1000 s^{-1} depending on radionuclide	0.60 %	Procedures directly supporting this work are: **RSP013 –** Preparation of radioactive sources **RMS018**– Preparation of radioactive air filters **RMT006** - Measurement of a Gamma Spectrometry Sample **RMT007** - Analysis of a Gamma Spectrometry Sample	
RR/0203 - Instrument Calibration (response to activity concentration, Bq m^{-3}): Customer supplied radioactivity-in-air monitors (other than radon) *Service Reference RR02*	40 kBq m^{-3} to 30 GBq m^{-3}	4.0 %	Procedures directly supporting this work are: **RMT003** - 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 *Service Reference RR03*	10 particles s^{-1} to 10000 particles s^{-1}	For Alpha emitters: 0.42 % For Beta emitters with β_{max}: > 500 keV: 0.58 % 100 keV to 500 keV: 0.78 %	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	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
RADIOACTIVITY METROLOGY (continued) **RR/0701 - Artefact calibration (activity content, Bq or Activity per unit mass, Bq g^{-1}):):** Gelatine capsules (*^{131}I only*), brachytherapy wires (*^{192}Ir only*), brachytherapy seeds (*^{125}I only*) or solutions of β-particle, X-ray and γ-ray emitting radionuclides measured by secondary techniques. *Service Reference: RR07*	400 Bq to 15 GBq, 400 Bq $g^{-1}$to 15 GBq g^{-1}, depending on radionuclide	0.32%	Procedures directly supporting this work are: **RMT031** - Activity Assay using Ionisation Chambers **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	**Teddington**

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
MASS *Service Reference: MM01* Specific values	Nominal value (g)	(mg)		Teddington
	50 000	3.0		
	20 000	1.3	The stated uncertainties relate to measurements made on standards that are constructed in accordance with the principles contained in OIML Recommendation III for weights of Class E1.	
	10 000	0.57		
	5 000	0.28		
	3 000	0.16		
	2 000	0.10		
	1 000	0.046		
	500	0.024		
	300	0.015		
	200	0.010	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.	
	100	0.0060		
	50	0.0035		
	30	0.0025		
	20	0.0020		
	10	0.0015		
	5	0.00090		
	3	0.00060		
	2	0.00040		
	1 to 0.001	0.00040		
	0.0005 to 0.00005	0.00040		
DENSITY *Service Reference: MM03*	Artefacts, 1000 kg/m^3 to 9000 kg/m^3		Using the following apparatus:	
Density of solid materials	1 g to 100 g 100 g to 1 kg 1 kg to 20 kg	(4.0 to 0.50) kg/m^3 (0.50 to 0.25) kg/m^3 (3.0 to 1.0) kg/m^3	100 g hydrostatic weighing apparatus 1 kg hydrostatic weighing apparatus 20 kg hydrostatic weighing apparatus	
	Artefacts >9000 kg/m^3 1 g to 100 g 100 g to 1 kg 1 kg to 20 kg	 (4.0 to 1.0) kg/m^3 1.0 kg/m^3 (5.0 to 2.0) kg/m^3		
VOLUME Service Reference: MM03				
Volume of solid materials	0.1 cm^3 to 2500 cm^3	0.00006 cm^3 to 0.25 cm^3	Artefact density > 1000 kg/m^3	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
NPL Primary Reference Materials (NPL PRMs) AND NPL CALIBRATED GAS MIXTURES (NPL CGMs) *Service Reference: QE11, QE12 and QE13*				Teddington
NPL Primary Reference Materials (NPL PRMs) Preparation of synthetic gas mixtures by gravimetry in accordance with ISO 6142:2015; verification by analysis.				
NPL CALIBRATED GAS MIXTURES (NPL CGMs) Certification of synthetic gas mixtures by analysis.				
The laboratory also has ISO 17034:2016 accreditation for production of NPL Primary Reference Materials (NPL PRMs). Accredited certified reference material producer number 4002 https://www.ukas.com/download-schedule/4002/ReferenceMaterials/ Gas mixtures can be produced and/or calibrated as listed below or in the BIPM CMC tables:				
Gas mixtures may be produced and/or calibrated for other amount fractions and/or other combinations of the listed gases.				
SYNTHETIC NATURAL GAS MIXTURES	Amount fraction %mol/mol	Amount fraction %mol/mol		
Nitrogen	0.02 to 25.2	0.18 % relative + 0.00038	NPL PRMs and NPL CGMs	
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		
Oxygen	0.05 to 1.0	1.0% relative		
	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	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
NPL PRIMARY REFERENCE MATERIALS (NPL PRMs) AND NPL CALIBRATED GAS MIXTURES (NPL CGMs) (continued)				Teddington
SYNTHETIC FUEL GAS MIXTURES	Amount fraction %mol/mol	Amount fraction %mol/mol		
Nitrogen	0.1 to 95	0.30 % relative + 0.0020	NPL PRMs and NPL CGMs	
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	1 to 70	0.40 % relative + 0.0025		
Methane	1 to 85	0.33 % relative + 0.0015		
Ethane	0.3 to 35	0.35 % relative + 0.0010		
Ethene	0.1 to 20	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 10	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 3	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		
SULPHUR ODORANT GAS MIXTURES	Amount fraction µmol/mol	Amount fraction µmol/mol		
Hydrogen sulphide	0.4 to 5,000	<u>NPL PRM</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>NPL 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	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
NPL PRIMARY REFERENCE MATERIALS (NPL PRMs) AND NPL CALIBRATED GAS MIXTURES (NPL CGMs) (continued)				Teddington
OZONE PHOTOMETERS *Service Reference: QE85-0000*				
Ozone in synthetic Air	(0 to 0.1) x 10^{-6} mol/mol (0.1 to 1) x 10^{-6} mol/mol (1 to 10) x 10^{-6} mol/mol (10 to 50) x 10^{-6} mol/mol	3.0 nmol/mol 3.0 % 3.2% 3.5%	Calibrated using ozone standard reference photometer and for ozone amount fractions in excess of 1 part per million, an external ozone generator according to NPL in-house procedure QPDQM/B/516.	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
ULTRASONICS				Teddington
Service Reference: AW07				
End-of-cable loaded sensitivity of a hydrophone	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	6.0 % 7.0 % 8.0 % 11 % 12 % 15 %	Free field sensitivity determined through substitution using a secondary hydrophone in a non-linearly distorted sound field	
End-of-cable loaded sensitivity of a hydrophone in fine frequency range	0.5MHz to <1MHz 1 MHz to 8 MHz 9 MHz to 12 MHz 13 MHz to 16 MHz 17 MHz to 20 MHz	9.0% 8.0 % 9.0 % 10 % 11 %	Free field sensitivity determined through substitution using a secondary hydrophone in a quasi-linear tone-burst acoustic field. Lowest frequency resolution is 10 kHz.	
UNDERWATER ACOUSTICS				
Calibration of hydrophones and projectors *Service Reference: AW10*			According to IEC 60565:2006	
End of cable hydrophone receive sensitivity	25 Hz to 400 Hz	0.50 dB	By comparison to a microphone using an air-pistonphone	
Free field sensitivity of reference measuring hydrophones/projectors	5kHz to 500 kHz	0.50 dB	Using three-transducer spherical wave reciprocity method in a laboratory tank	
Free field sensitivity of reference measuring hydrophones	5 kHz to 1 MHz	0.70 dB	By comparison with NPL reference hydrophone in a laboratory tank	
Directional response of transducers and hydrophones	5 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	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
UNDERWATER ACOUSTICS (continued)				Wraysbury
Calibration of hydrophones and projectors *Service Reference: AW15*			According to IEC 60565:2006	
Projector sensitivity	250 Hz to 500 Hz 500 Hz to 1kHz 1 kHz to 350 kHz	1.2 dB 1.0 dB 0.9 dB	Using calibrated hydrophone method in an open-water test facility	
Hydrophone sensitivity	250 Hz to 500 Hz 500 Hz to 1 kHz 1 kHz to 350 kHz	1.2 dB 1.0 dB 0.9 dB	Using calibrated projector method in an open-water test facility	
Complex admittance	250 Hz to 350 kHz		For underwater electro acoustic transducers only. Undertaken in open-water test facility.	
conductance susceptance capacitance		2.0 % + 10 µS 2.0 % + 10 µS 2.0 % + 20 µS		
FORCE				Teddington
Proving devices, load cells and other force-measuring devices in compression and tension modes increasing and decreasing forces Service Reference: MF01	*1.5 N to 25 N* *25 N to 1.2 MN* *1.2 MN to 5 MN*	0.0020 % 0.0010 % 0.05%	Calibrations can be performed in accordance with, ASTM E74-18, ISO 376:2011, NPL Management Documented In-House Method' QPMAM/M/B/070, BS 8422:2003 standard and supplementary calibrations A, B, E, L and R.	
Proving devices, load cells and other force-measuring devices in compression mode increasing forces only Service Reference: MF01	*5 MN to 12 MN* *12 MN to 30 MN*	0.05 % 0.15 %		

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
FORCE (continued)				Teddington
Strain Gauged Column *Service Reference: MF03*	200 kN to 2 MN Linear dimensions 80 mm to 120 mm 180 mm to 220 mm Flatness 0.00 mm to 1 mm Parallelism 0.00 mm to 1 mm	 0.014 mm 0.021 mm 0.0034 mm 0.0034 mm	Calibration of Strain Gauged Columns in accordance with BS EN 12390-4:2019 Annexes A2 and A3. Measurement of Strain ratio, Height, Diameter, Flatness and Parallelism	
Voltage Ratio				
Calibration of DC voltage ratio meters used with strain gauge force transducers *Service Reference: MF04*	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.	
PRESSURE *Service Reference: MP03*			Calibration against pressure balance standards	
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	0.0017 % 0.0015 % $Q[p \times 0.0019\%, p^2 \times 2.5 \times 10^{-13}]$		
Calibration of pressure indicating instruments	80 kPa to 110 kPa 3.5 kPa to 7 MPa	5.0 Pa 0.0015 %		
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	0.0017 % 0.0015 % $Q[p \times 0.0025\%, p^2 \times 2.5 \times 10^{-13}]$ $Q[p \times 0.0028\%, p^2 \times 1.1 \times 10^{-12}]$		
Service reference: MP04				
Oil Pressure (gauge)				
Determination of effective area of deadweight testers	500 kPa to 200 MPa	$Q[p \times 0.0028\%, p^2 \times 2.5 \times 10^{-13}]$		

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Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
FIBRE OPTICS			Measurements carried out at 23 °C ± 2 °C, unless stated otherwise	Teddington
Mode field diameter *Service Reference: OT06-1020*	3.5 μm to 13 μm 0 % to 1 %	0.62 % 0.10 %	Single-mode fibre from 1250 nm to 1625 nm. Far field scan method Petermann II definition	
Mode field noncircularly *Service Reference: OT06-1020*				
Effective area *Service Reference: OT06-1050*	30 μm^2 to 130 μm^2	2.0 %	Far field scan method. Hankel transform	
Dispersion in single-mode optical fibre *Service Reference: OT06-1010*			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	
Optical length *Service Reference: OT06-1110*	0.1 km to 15 km measured in the wavelength range 1270 nm to 1650 nm.	(0.040 + 1.7 x 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 and 1625 nm	(0.10 + 1.7 x 10^{-5} L)	L is optical length in metres	
Fibre attenuation coefficient uniformity *Service Reference: OT06-1100*	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 *Service Reference: OT06-1060*	0.1 dB to 35 dB	0.021 dB	Cut-back technique Wavelength range 1200 nm to 1650 nm Measurements carried out over the temperature range 18 °C to 23 °C.	

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
FIBRE OPTICS (continued)				Teddington
Spectral attenuation of multimode fibre *Service Reference: OT06-1060*	0.1 dB to 35 dB	0.021 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 *Service Reference: OT06-1070*	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> *Service Reference: OT02-1010*			Measurements carried out at 20 °C ± 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	
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	1.5 %	Multimode fibre	
	980 nm ± 10 nm	1.5 %	Single mode fibre	
	1300 nm ± 25 nm	1.0 %	Single mode and multi mode fibre	
	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	

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Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
Fibre optic test equipment (continued)				
Linearity in fibre optic power meters with FC/PC, SC/PC, FC/APC and SC/APC connectors - Comparison technique	+20 dBm to +10 dBm +10 dBm to -90 dBm	0.70 % 0.30 %	Wavelength range: 830 nm to 1620 nm Single mode and multi mode fibre	Teddington
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	Teddington
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	Teddington
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	Teddington
Spectral line width (FWHM) of sources	0.07 nm to 50 nm	0.10 nm	800 nm to 1700 nm	Teddington
Output power stability of fibre optic light sources	+10 dBm to -50 dBm	0.0040 dB	Wavelength range 800 nm to 1700 nm	Teddington

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
PARTICLE COUNTERS *Service Reference: QE15-1010*				
<u>Airborne particle number concentration</u>				
Calibration factor for condensation particle counters	Particle number concentration range		Comparison with an aerosol electrometer	
	1000 cm^{-3} to 100,000 cm^{-3} 500 cm^{-3} 200 cm^{-3} 100 cm^{-3}	3.5 % 5 % 8 % 16 %		
<u>Airborne particle mobility diameter</u>				
Differential mobility analyser	80 nm to 200 nm	5.0 % to 3.5 %	Comparison with polystyrene reference nanoparticles	
<u>Airborne particle charge concentration:</u>				
Detection efficiency (η) for Faraday Cup Aerosol Electrometers	Charge concentration range 0.15 $fC.cm^{-3}$ to 3.00 $fC.cm^{-3}$	3 %	Documented in-house procedure TECHPRO0063.	
INSTRUMENTS FOR AIR QUALITY MONITORING *Service Reference: QE85-0000*				**Customers' sites**
Particulate analyser flow rate test	1 slm to 10 slm 10 slm to 40 slm	1.5 % 1.9 %		

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 measurement uncertainty 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 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 measurement uncertainty is calculated according to the procedures given in the GUM 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 measurement uncertainty in certificates issued under its accreditation.

Expression of CMCs - symbols and units

It should be noted that the percentage symbol (%) represents the number 0.01. In cases where the measurement uncertainty is stated as a percentage, this is to be interpreted as meaning percentage of the measurand.
Thus, for example, a measurement uncertainty of 1.5 % means $1.5 \times 0.01 \times q$, where q is the quantity value.

The notation Q[a, b] stands for the root-sum-square of the terms between brackets: $Q[a, b] = [a^2 + b^2]^{1/2}$