


# Schedule of Accreditation

issued by

## United Kingdom Accreditation Service

21 - 47 High Street, Feltham, Middlesex, TW13 4UN, UK

 <p><b>UKAS</b> CALIBRATION</p> <p><b>0478</b></p> <p>Accredited to <b>ISO/IEC 17025:2005</b></p>	<h3>National Physical Laboratory</h3> <p><b>Issue No: 048    Issue date: 23 December 2009</b></p>	
	<p><b>Hampton Road</b> <b>Teddington</b> <b>Middlesex</b> <b>TW11 0LW</b></p>	<p><b>Contact: Customer Helpline</b> <b>Tel: +44 (0)20-8943 6880</b> <b>Fax: +44 (0)20-8943 6458</b> <b>E-Mail: enquiry@npl.co.uk</b> <b>Website: www.npl.co.uk</b></p>
<p><b>Calibration performed by the Organisations at the locations specified below</b></p>		

### Locations covered by the organisation and their relevant activities

#### Laboratory locations:

Location details	Activity	Location code														
<p><b>Address</b> National Physical Laboratory Hampton Road Teddington Middlesex TW11 0LW</p> <p><b>Local contact</b> Miss Julia Symm  Tel: +44 (0) 20 8943 6880 Fax: +44 (0) 20 8943 6458 Email: enquiry@npl.co.uk</p>	<p><u>Calibration</u></p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">Acoustics</td> <td style="width: 50%;">Mass</td> </tr> <tr> <td>Chemical</td> <td>Optical</td> </tr> <tr> <td>Dimensional</td> <td>Pressure</td> </tr> <tr> <td>Electromagnetic</td> <td>Radiological</td> </tr> <tr> <td>Fibre optics</td> <td>Temperature</td> </tr> <tr> <td>Force</td> <td>Time and Frequency</td> </tr> <tr> <td>Humidity</td> <td>Ultrasonics</td> </tr> </table>	Acoustics	Mass	Chemical	Optical	Dimensional	Pressure	Electromagnetic	Radiological	Fibre optics	Temperature	Force	Time and Frequency	Humidity	Ultrasonics	Teddington
Acoustics	Mass															
Chemical	Optical															
Dimensional	Pressure															
Electromagnetic	Radiological															
Fibre optics	Temperature															
Force	Time and Frequency															
Humidity	Ultrasonics															
<p><b>Address</b> Wraysbury Reservoir Coppermill Road Wraysbury Middlesex TW19 5NW</p> <p><b>Local contact</b> Mr G Hayman  Tel: +44 (0) 20 8943 7172 Email: gary.hayman@npl.co.uk</p>	<p><u>Calibration</u></p> <p>Underwater Acoustics</p>	Wraysbury														

#### Site activities performed away from the locations listed above:

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



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DETAIL OF ACCREDITATION

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



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



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Measured Quantity Instrument or Gauge	Range	Best Measurement Capability Expressed as an Expanded Uncertainty ( $k=2$ )	Remarks	Location Code								
AC/DC TRANSFER VOLTAGE				Teddington								
AC/DC Transfer Voltage, at Specific Values, expressed as an Expanded Uncertainty ( $k=2$ ) [ $\pm$ ppm] <i>For intermediate points the uncertainty will be determined using linear interpolation between the adjacent points.</i>												
Voltage	Frequency (Hz)											
	10	20 to 5k	10 k		20 k	50 k	100 k	200 k	300 k	500 k	700 k	1 M
1 mV	26	26	26		28	36	58	100	160	260	460	780
2 mV	26	26	26		26	30	47	80	120	190	310	490
5 mV	26	26	26		26	30	45	77	110	180	270	440
10 mV	26	26	26		26	30	42	72	100	170	240	370
20 mV	26	26	26		26	30	42	71	100	160	230	340
70 mV	26	26	26		26	30	41	70	100	160	230	330
100 mV	6	6	6		6	8	13	24	36	58	82	120
200 mV	6	6	6		6	8	13	24	36	58	82	120
300 mV	5	5	5		5	6	11	20	29	48	67	96
500 mV	5	5	5		5	6	9	16	23	38	54	76
1 V	5	5	5		5	6	7	12	16	25	37	51
2 V	5	5	5		5	5	6	9	12	17	26	38
3 V	5	5	5		5	5	6	9	12	17	26	38
4 V	5	5	5		5	5	6	7	9	13	20	31
5 V	5	5	5		5	5	6	7	9	13	20	31
10 V	6	6	6		6	6	7	9	10	15	23	33
20 V	7	7	7		7	7	7	10	13	16	27	35
30 V	7	7	7		7	7	8	12				
50 V	8	7	7		7	8	11	15				
70 V	8	7	7		7	8	12	15				
100 V	8	7	7		7	8	11	15				
200 V	9	8	8		10	13	22					
300 V	9	8	8	10	13	22						
500 V	14	10	11	14	23	42						
600 V	14	10	11	18	28	52						
700 V	14	10	11	18	28	52						
1 kV	14	10	12	23	32	62						
AC/DC TRANSFER VOLTAGE (High Frequency)		1 V 3 MHz 10 MHz 20 MHz 30 MHz 50 MHz 70 MHz 100 MHz				51 ppm 64 ppm 140 ppm 300 ppm 600 ppm 0.11% 0.21%						



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Measured Quantity Instrument or Gauge	Range		Best Measurement Capability Expressed as an Expanded Uncertainty ( $k=2$ )	Remarks	Location Code								
AC VOLTAGE					Teddington								
AC Voltage, at Specific Values, expressed as an Expanded Uncertainty ( $k=2$ ) [ $\pm$ ppm] <i>For intermediate points the uncertainty will be determined using linear interpolation between the adjacent points.</i>													
Voltage	Frequency (Hz)												
	10	20 to 5k	10 k	20 k		50 k	100 k	200 k	300 k	500 k	700 k	1 M	
500 mV	7	7	7	7		10	13	20	29	43	62	86	
1 V	7	7	7	9		11	13	17	22	30	43	59	
2 V	7	7	7	7		9	11	14	18	22	31	43	
3 V	7	7	7	7		7	8	11	15	20	29	40	
4 V	7	7	7	7		7	7	9	11	15	22	33	
5 V	7	7	7	7		7	7	9	11	15	22	33	
10 V	8	7	7	7		7	8	10	11	17	25	34	
20 V	8	8	8	8		8	9	11	14	18	28	37	
30 V	8	8	8	8		8	9	13					
50 V	9	9	9	9		9	12	16					
70 V	9	9	9	9		9	12	16					
100 V	9	9	9	9		9	12	16					
200 V	10	9	9	11		14	22						
300 V	10	9	9	11		14	22						
500 V	14	11	12	15		23	42						
600 V	14	11	12	19		28	52						
700 V	14	11	12	19	28	52							
1 kV	14	11	12	23	33	62							
AC/DC TRANSFER CURRENT													
AC/DC Transfer Current, at Specific Values, expressed as an Expanded Uncertainty ( $k=2$ ) [ $\pm$ ppm] <i>For intermediate points the uncertainty will be determined using linear interpolation between the adjacent points.</i>													
Current	Frequency (Hz)												
	10	20	40	100	400	1 k	2 k	5 k	10 k	20 k	50 k	70 k	100 k
1 mA	31	30	30	30	30	30	30	30	30	31	31	33	35
2 mA	17	17	16	16	16	16	16	16	17	18	19	22	25
3 mA	12	12	12	12	12	12	12	12	13	14	16	19	22
5 mA	11	10	10	10	10	10	10	10	12	13	15	19	22
10 mA	11	10	10	10	10	10	10	10	12	13	15	19	22
20 mA	11	10	10	10	10	10	10	10	12	13	15	19	22
30 mA	11	10	10	10	10	10	10	10	12	13	15	19	22
50 mA	11	10	10	10	10	10	10	10	12	13	15	19	22
0.1 A	14	13	12	12	12	12	12	12	12	13	20	23	42
0.2 A	23	20	16	16	16	16	16	16	16	17	28	33	61
0.25 A	23	20	16	16	16	16	16	16	16	17	28	33	61
0.3 A	30	26	16	17	16	18	16	17	15	24	43	52	81
0.5 A	30	26	16	17	16	18	16	17	15	24	43	52	81
1 A	38	31	19	19	19	20	17	18	17	33	53	62	100
2 A	47	37	22	20	21	22	20	21	20	43	63	83	120
2.5 A	47	37	22	20	21	22	20	21	20	43	63	83	120
3 A	55	43	25	23	24	24	23	21	22	53	83	100	160
5 A	55	43	25	23	24	24	23	21	22	53	83	100	160
10 A	63	49	27	25	26	26	25	26	23	62	100	120	200
20 A	72	56	31	28	30	29	28	29	28	73	120	140	240



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



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AC POWER <i>Sinusoidal waveforms</i>	<i>40 Hz to 400 Hz:</i>  Current 2 mA to 130 A Voltage 1 V to 1000 V	40 ppm of full scale  25 ppm of full scale	20°C and 23°C at unity power factor  20°C and 23°C at zero power factor  <i>Uncertainties increase at other power factors</i>	Teddington
Current Response of Wattmeters	2 mA to 20 A	30 ppm of full scale	20°C and 23°C	
Voltage Response of Wattmeters	1 V to 1000 V	25 ppm of full scale	20°C and 23°C	
Auxiliary DC Voltage	DC, 1 V to 10 V	5 ppm of value	20°C and 23°C	
AC REACTIVE VOLT- AMPERES <i>Sinusoidal waveforms</i>	<i>50 Hz to 400 Hz:</i>  Current 2 mA to 130 A Voltage 1 V to 1000 V	40 ppm of full scale  25 ppm of full scale	20°C and 23°C at zero power factor  20°C and 23°C at unity power factor  <i>Uncertainties increase at other power factors</i>	
CALIBRATION OF EN 61000 HARMONIC AND FLICKER ANALYSERS <i>Sinusoidal waveforms</i>				
Current accuracy Current frequency response Voltage accuracy	100 mA to 20 A, 50 Hz 100 mA to 20 A, 50 Hz to 2 kHz 1 V to 1000 V, 50 Hz	40 ppm 150 ppm 30 ppm		
Power measurements  <i>Non-sinusoidal waveforms</i>	Ranges as in AC Power above	45 ppm of full-scale	At unity power factor	
Harmonic measurements for current waveforms	Peak values 1A to 10 A 50 Hz fundamental; harmonics up to 2 kHz	200 ppm	Steady-state, burst fluctuating or smoothly fluctuating harmonics	
Flicker (Pst)	Square or sine wave modulated, 230 V 50 Hz sine wave  Complex waveforms, 230 V 50 Hz sine wave	0.3% of Pst reading  0.2% of Pst reading	See the <a href="#">NPL web site</a> for details about these complex waveforms.	



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CAPACITANCE and DISSIPATION FACTOR  <u>Fused-silica dielectric capacitors</u>  <u>Other types of capacitor</u>  <u>General Radio Type 1417</u>  <u>Dissipation Factor Standard</u>	<i>At 1 kHz and 1.592 kHz</i>  10 pF 100 pF  1 nF 1 kHz 1.592 kHz 10 kHz 100 kHz  <i>At 1 kHz and 1.592 kHz</i>  1 pF to 10 pF 10 pF to 1 nF 1 nF to 100 nF 100 nF to 1 $\mu$ F  1 $\mu$ F to 10 mF <i>100 Hz, 120 Hz and 1 kHz</i>  100 mF to 1 F <i>100 Hz and 120 Hz</i>	<table border="0"> <tr> <td align="center">C</td> <td align="center">D</td> </tr> <tr> <td>0.7 ppm</td> <td><math>6 \times 10^{-6}</math></td> </tr> <tr> <td>0.9 ppm</td> <td><math>7 \times 10^{-6}</math></td> </tr> <tr> <td>3 ppm</td> <td><math>20 \times 10^{-6}</math></td> </tr> <tr> <td>3 ppm</td> <td><math>20 \times 10^{-6}</math></td> </tr> <tr> <td>5 ppm</td> <td><math>20 \times 10^{-6}</math></td> </tr> <tr> <td>200 ppm</td> <td><math>1 \times 10^{-4}</math></td> </tr> <tr> <td>4 ppm</td> <td><math>10 \times 10^{-6}</math></td> </tr> <tr> <td>3 ppm</td> <td><math>7 \times 10^{-6}</math></td> </tr> <tr> <td>30 ppm</td> <td><math>20 \times 10^{-6}</math></td> </tr> <tr> <td>60 ppm</td> <td><math>20 \times 10^{-6}</math></td> </tr> <tr> <td>0.1% to 0.5%</td> <td>0.001 to 0.005</td> </tr> <tr> <td>0.3% to 1%</td> <td>0.003 to 0.01</td> </tr> <tr> <td>0.0 to 0.001 1 kHz</td> <td><math>20 \times 10^{-6}</math></td> </tr> <tr> <td>0.0 to 0.005 50 Hz</td> <td><math>20 \times 10^{-6}</math></td> </tr> </table>	C	D	0.7 ppm	$6 \times 10^{-6}$	0.9 ppm	$7 \times 10^{-6}$	3 ppm	$20 \times 10^{-6}$	3 ppm	$20 \times 10^{-6}$	5 ppm	$20 \times 10^{-6}$	200 ppm	$1 \times 10^{-4}$	4 ppm	$10 \times 10^{-6}$	3 ppm	$7 \times 10^{-6}$	30 ppm	$20 \times 10^{-6}$	60 ppm	$20 \times 10^{-6}$	0.1% to 0.5%	0.001 to 0.005	0.3% to 1%	0.003 to 0.01	0.0 to 0.001 1 kHz	$20 \times 10^{-6}$	0.0 to 0.005 50 Hz	$20 \times 10^{-6}$	Capacitance and dissipation factor measurements are normally carried out between 20°C and 23°C but may exceptionally be carried out at any temperature between 18°C and 25°C.  These measurements can be made at frequencies from 20 Hz to 100 kHz, depending on value, but with increased uncertainties.	<b>Teddington</b>
	C	D																																
	0.7 ppm	$6 \times 10^{-6}$																																
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SELF-INDUCTANCE								
<i>Expanded uncertainty at 95% confidence level (<math>k=2</math>) for the frequencies shown</i>								
Nominal value	20 Hz	50 Hz	100 Hz 400 Hz	1 kHz	1.592 kHz 2 kHz	5 kHz	10 kHz	Teddington
1 $\mu$ H			2.0%	0.10%	0.10%	0.25%	0.35%	
2 $\mu$ H			1.0%	0.10%	0.10%	0.22%	0.30%	
3 $\mu$ H			0.61%	0.10%	0.10%	0.22%	0.26%	
5 $\mu$ H			0.35%	600 ppm	600 ppm	0.11%	0.15%	
10 $\mu$ H	0.35%	0.25%	0.20%	310 ppm	350 ppm	620 ppm	930 ppm	
20 $\mu$ H	0.18%	0.13%	0.10%	150 ppm	160 ppm	320 ppm	460 ppm	
30 $\mu$ H	0.12%	840 ppm	670 ppm	110 ppm	115 ppm	190 ppm	260 ppm	
50 $\mu$ H	700 ppm	500 ppm	400 ppm	100 ppm	100 ppm	160 ppm	200 ppm	
100 $\mu$ H	300 ppm	200 ppm	150 ppm	75 ppm	80 ppm	120 ppm	150 ppm	
200 $\mu$ H	250 ppm	180 ppm	100 ppm	75 ppm	85 ppm	110 ppm	150 ppm	
300 $\mu$ H	250 ppm	180 ppm	100 ppm	85 ppm	85 ppm	120 ppm	150 ppm	
500 $\mu$ H	220 ppm	160 ppm	100 ppm	80 ppm	80 ppm	100 ppm	150 ppm	
1 mH	180 ppm	150 ppm	95 ppm	70 ppm	75 ppm	100 ppm	150 ppm	
2 mH	180 ppm	150 ppm	100 ppm	75 ppm	80 ppm	110 ppm	150 ppm	
3 mH	180 ppm	150 ppm	100 ppm	85 ppm	85 ppm	120 ppm	150 ppm	
5 mH	180 ppm	160 ppm	100 ppm	80 ppm	80 ppm	110 ppm	150 ppm	
10 mH	180 ppm	150 ppm	100 ppm	70 ppm	70 ppm	100 ppm	130 ppm	
20 mH	180 ppm	150 ppm	100 ppm	75 ppm	75 ppm	110 ppm	130 ppm	
30 mH	180 ppm	150 ppm	100 ppm	85 ppm	85 ppm	110 ppm	150 ppm	
50 mH	200 ppm	160 ppm	100 ppm	80 ppm	80 ppm	160 ppm	200 ppm	
100 mH	185 ppm	150 ppm	85 ppm	70 ppm	70 ppm	140 ppm	200 ppm	
200 mH	230 ppm	200 ppm	90 ppm	75 ppm	75 ppm	200 ppm	300 ppm	
400 mH	240 ppm	200 ppm	90 ppm	75 ppm	75 ppm	200 ppm	380 ppm	
500 mH	240 ppm	210 ppm	90 ppm	80 ppm	80 ppm	200 ppm	400 ppm	
1 H	140 ppm	110 ppm	85 ppm	70 ppm	70 ppm	200 ppm	400 ppm	
2 H	140 ppm	110 ppm	85 ppm	70 ppm	70 ppm	380 ppm	800 ppm	
5 H	140 ppm	110 ppm	85 ppm	80 ppm	85 ppm			
10 H	140 ppm	110 ppm	85 ppm	80 ppm	85 ppm			
NOTE								
Inductance measurements are normally carried out between 20°C and 23°C but may exceptionally be carried out at any temperature between 18°C and 25°C. The DC resistance of an inductor can also be reported as an indication of its temperature. Inductance measurements may be made at other frequencies between 20 Hz and 10 kHz but the uncertainties may be increased.								
MUTUAL INDUCTANCE (single value only)	At 1 kHz:							
	1 mH		100 ppm					
	5 mH		80 ppm					
	10 mH		70 ppm					
	100 mH		70 ppm					



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DC MAGNETIC FIELD STRENGTH AND MAGNETIC FLUX DENSITY	0.8 mA/m (1 nT) to 16 A/m (20 $\mu$ T)	0.15% + 0.5 nT		Teddington	
	16A/m (20 $\mu$ T) to 72 A/m (90 $\mu$ T)	0.003%			
	72 A/m (90 $\mu$ T) to 40 kA/m (50 mT)	0.2%			
	40 kA/m (50 mT) to 10.5 MA/m (13T)	0.0015%			
AC MAGNETIC FIELD STRENGTH AND MAGNETIC FLUX DENSITY	8 mA/m (10 nT) to 17.5 kA/m (22 mT) 10 Hz to 60 Hz	0.25%			
	8 mA/m (10 nT) to 80 A/m (100 $\mu$ T) 60 Hz to 20 kHz	0.25%			
	8 mA/m (10 nT) to 40 A/m (50 $\mu$ T) 20 kHz to 50 kHz	0.4%			
	8 mA/m (10 nT) to 15.9 A/m (20 $\mu$ T) 50 kHz to 120 kHz	0.7%			
	<u>Standard solenoids and Helmholtz coils</u>	DC	0.015%		
		12 Hz to 60 Hz	0.05%		
		60 Hz to 20 kHz	0.25%		
	<u>Search coils</u>	12 Hz to 60 Hz	0.09%		
60 Hz to 20 kHz		0.25%			
20 kHz to 50 kHz		0.4%			
50 kHz to 120 kHz		0.7%			
NORMAL MAGNETIZATION CURVES AND HYSTERESIS LOOPS					
	<u>Ring specimens</u>	H = 0.1 kA/m to 10 kA/m (DC) B = 0 to 2.5 T (DC)	0.4% 0.4%	In accordance with EN 60404 Part 4:1997 and IEC 60404 Part 4:1995	
	<u>Bar or rod specimens</u>	H = 0.1 kA/m to 200 kA/m (DC) B = 0 to 2.5 T (DC)	0.4% 0.4%	In accordance with EN 60404 Part 4:1997 and IEC 60404 Part 4:1995	



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COERCIVITY <u>Soft magnetic materials</u> <u>(Relay steel)</u>	$H_{c1}$ up to 500 A/m (DC)	0.3%	In accordance with BS 6404 Part 7:1986 and IEC 60404 Part 7:1982	Teddington
DEMAGNETIZATION CURVE FOR HARD MAGNETIC MATERIALS				
Remanence	Up to 2T (DC)	0.3%	In accordance with BS 6404 Part 5:1995 and IEC 60404 Part 5:1993	
Coercivity	$H_{cB}$ up to 1.2 MA/m (DC) $H_{cJ}$ up to 1.6 MA/m (DC)	0.4% 0.4%		
Maximum energy product	Up to 400 kJ/m <sup>3</sup> (DC)	0.5%		
RELATIVE MAGNETIC PERMEABILITY, $\mu_r$ <u>For low magnetic permeability materials</u>	$(\mu_r - 1)$ from 0.001 to 1.5 (DC) $(\mu_r - 1)$ from 0.0002 to 0.001 (DC)	0.2% 2.2%	In accordance with BS 5884:1987	
<u>Permeability measuring instruments and indicators</u>	$(\mu_r - 1)$ from 0.001 to 1.5 (DC)	0.2%	The uncertainty may be increased depending on the characteristics of the device being calibrated	
MAGNETIC DIPOLE MOMENT	0.06 Am <sup>2</sup> to 1 kAm <sup>2</sup>	0.11%		
POWER LOSS Specific total power loss of Epstein strips and of sheets 500 mm square	At 50 Hz and 60 Hz		Method of measurement: For strips: IEC 60404 Part 2:1996 BS 6404 Part 2:1996 For sheets: IEC 60404 Part 3:1992 BS 6404 Part 3:1992	
<u>Non-oriented material</u> <u>Oriented material</u>	Up to J = 1.3 T Up to J = 1.7 T	0.65% 0.65%		
<u>Non-oriented material</u> <u>Oriented material</u>	J = 1.3 T to 1.7 T J = 1.7 T to 1.8 T	0.75% 0.75%		
For Epstein strips only	At 400 Hz			
<u>Non-oriented material</u> <u>Oriented material</u>	Up to J = 1.3 T Up to J = 1.7 T	0.7% 0.7%	Measurements can be made at frequencies up to 16 kHz but with an increase in uncertainty using IEC 60404 Part 10:1988 BS EN 10252:1997	
<u>Non-oriented material</u> <u>Oriented material</u>	J = 1.3 T to 1.7 T J = 1.7 T to 1.8 T	1.8% 1.8%		



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POWER LOSS (continued)				Teddington
<u>Soft magnetic materials in ring form only</u>	J = 100 mT 50 Hz to 100 kHz	0.65%		
APPARENT POWER				
<u>Non-oriented (isotropic) material</u>	At 50 Hz and 60 Hz  Up to J = 1.3 T J = 1.3 T to 1.5 T J = 1.5 T to 1.7 T	1.1% 1.5% 2.6%	Method of measurement:  For strips: IEC 60404 Part 2:1996  For sheets: IEC 60404 Part 3:1992 BS 6404 Part 3:1992	
<u>Oriented (isotropic) material</u>	At 50 Hz and 60 Hz  Up to J = 1.5 T J = 1.5 T to 1.8 T	1.1% 2.6%		
<u>Soft magnetic materials in ring form only</u>	J = 100 mT 50 Hz to 100 kHz	1.1%		
AC PERMEABILITY	50 Hz and 60 Hz, rms or peak values			
<u>Oriented (non-isotropic) and non-oriented (isotropic) materials</u>	B = 0.5 T to 2.2 T H = 0.5 kA/m to 10 kA/m	0.45%		
AC MAGNETIC FIELD STRENGTH	50 Hz and 60 Hz, rms or peak values			
<u>Oriented (non-isotropic) and non-oriented (isotropic) materials</u>	H = 0.5 kA/m to 10 kA/m	0.45%		
AC CONDUCTIVITY				
<u>AC conductivity reference materials</u>	2 MS/m to 60 MS/m 10 kHz to 100 kHz, 20°C	0.7%	Calibration of sets of reference materials produced by NPL.	



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POWER FLUX DENSITY	0.01 to 3000 W/m <sup>2</sup> 10 Hz to 300 MHz	0.68 dB	Electrically small probes	Teddington
	0.01 to 650 W/m <sup>2</sup> 180 MHz to 2.5 GHz	0.80 dB	Electrically small probes	
	0.01 to 660 W/m <sup>2</sup> 10 Hz to 180 MHz	0.68 dB	All probes and small active dipoles	
	0.01 to 660 W/m <sup>2</sup> 250 MHz to 500 MHz	0.65 dB	All probes and small active dipoles	
	500 MHz to 1.1 GHz	0.62 dB	All probes and small active dipoles	
	1.1 GHz to 2.4 GHz	0.47 dB	All probes and small active dipoles	
	0.01 to 950 W/m <sup>2</sup> 2.4 GHz to 18 GHz	0.40 dB	All probes and small active dipoles	
0.01 to 663 W/m <sup>2</sup> 18 GHz to 40 GHz	0.35 dB	All probes and small active dipoles		
0.5 to 50 W/m <sup>2</sup> 43.5 GHz to 45.5 GHz	0.35 dB	All probes and small active dipoles		
FIELD STRENGTH  Electric Field	0.05 V/m to 1000 V/m 10 Hz to 300 MHz	0.68 dB	Electrically small probes	
	0.05 V/m to 600 V/m 180 MHz to 2.5 GHz	0.80 dB	Electrically small probes	
	0.05 V/m to 600 V/m 10 Hz to 180 MHz	0.68 dB	All probes and small active dipoles	
	0.05 V/m to 200 V/m 250 MHz to 500 MHz	0.65 dB	All probes and small active dipoles	
	500 MHz to 1.1 GHz	0.62 dB	All probes and small active dipoles	
	1.1 GHz to 2.4 GHz	0.47 dB	All probes and small active dipoles	
	0.05 V/m to 600 V/m 2.4 GHz to 18 GHz	0.40 dB	All probes and small active dipoles	
0.2 V/m to 500 V/m 18 GHz to 40 GHz	0.35 dB	All probes and small active dipoles		
15 V/m to 140 V/m 43.5 GHz to 45.5 GHz	0.35 dB	All probes and small active dipoles		



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

The uncertainties apply to  
calibrations covering a  
waveguide bandwidth.



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



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ANTENNA GAIN (cont'd)				Teddington
<u>EMC Antennas</u>				
Waveguide Feed	0 to 30 dB 18.0 GHz to 26.5 GHz	0.7 dB	Waveguide No 20	
	0 to 31 dB 26.5 GHz to 40.0 GHz	0.7 dB	Waveguide No 22	
	0 to 31 dB 43.5 GHz to 45.5 GHz	0.7 dB	Waveguide No 23	
Coaxial Feed	0 to 28 dB 1 GHz to 18 GHz	0.8 dB (0.6 dB for conical log spiral antennas)	50 Ω APC-7 or Type N connectors	
	0 to 30 dB 1 GHz to 26.5 GHz	0.8 dB (0.6 dB for conical log spiral antennas)	50 Ω 3.5 mm connectors	
	0 to 30 dB 18 GHz to 40 GHz	0.8 dB	50 Ω 2.92 mm connectors	
ANTENNA COMPLEX REFLECTION COEFFICIENT			The uncertainties for complex reflection coefficient apply to both real and imaginary parts. All measurements are performed at 23°C	
Waveguide feed	0 to 0.5, real and imaginary parts			
	2.6 GHz to 3.95 GHz	0.008	Waveguide No 10	
	3.3 GHz to 4.9 GHz	0.008	Waveguide No 11A	
	3.95 GHz to 5.85 GHz	0.008	Waveguide No 12	
	5.85 GHz to 8.2 GHz	0.008	Waveguide No 14	
	7.05 GHz to 10.0 GHz	0.008	Waveguide No 15	
	8.2 GHz to 12.4 GHz	0.008	Waveguide No 16	
	10.0 GHz to 15.0 GHz	0.008	Waveguide No 17	
	12.4 GHz to 18.0 GHz	0.008	Waveguide No 18	
	18.0 GHz to 26.5 GHz	0.008	Waveguide No 20	
	26.5 GHz to 40.0 GHz	0.008	Waveguide No 22	
	33.0 GHz to 50.0 GHz	0.013	Waveguide No 23	
7 mm coaxial feed	0 to 0.5, real and imaginary parts			
	1.0 GHz to 1.5 GHz	0.015	50 Ω Type N connectors	
	1.5 GHz to 18.0 GHz	0.011	50 Ω Type N connectors	
	1.0 GHz to 8.2 GHz	0.013	50 Ω GPC-7 connectors	
	8.2 GHz to 18.0 GHz	0.018	50 Ω GPC-7 connectors	

For coaxially fed antennas the antenna factor is calculated from the antenna gain.



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



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



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



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



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RISETIME	5 ps to 50 ps 50 ps to 1 ns	1.3 ps 0.5% + 3 ps	Calibration of oscilloscope sampling heads	Teddington
	300 ps to 10 ns	0.2% + 20 ps	Calibration of real-time digital oscilloscopes	
	11 ps to 60 ps 60 ps to 10 ns	0.9 ps 0.5% + 1.4 ps	Calibration of pulse generators	
Pulse Amplitude	50 mV to 800 mV 800 mV to 1 V	0.3% 0.5%		
Pulse Aberrations (e.g. pre-shoot, overshoot, pulse settling error)	Pulse settling error Others	0.05% of amplitude 0.1% of amplitude	The quoted uncertainty will depend on the measurement bandwidth and the type and position of the aberration. Generally the assigned uncertainty will not be larger than 1%.	
<b>TIME AND FREQUENCY</b>				
Characterisation of GPS disciplined oscillators and frequency standards				
Time offset	From UTC (NPL)	2 ns		
Time offset	From UTC	10 ns		
Frequency	5 MHz and 10 MHz	$5 \times 10^{-14}$	The stated uncertainty can only be attained over a minimum period of 24 hours. Calibration of frequency standards with a 1 pps output can also be undertaken.	
Time delay (coaxial cables)	Up to 300 ns	1 ns	For cable characterisation in support of GPSDO calibration.	
Remote characterisation of GPS disciplined oscillators and frequency standards				
Time offset	Weekly values relative to UTC (NPL)	20 ns	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.	
Time offset	Weekly values relative to estimated UTC	40 ns		
Time offset	Post-processed values relative to corrected UTC data	28 ns	The stated uncertainty for frequency can only be attained over a minimum period of 24 hours. Calibration of frequency standards with a 1 pps output can also be undertaken.	
Frequency	5 MHz and 10 MHz	$1 \times 10^{-13}$		
				Customers' sites



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



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



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



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Measured Quantity Instrument or Gauge	Range	Best Measurement Capability Expressed as an Expanded Uncertainty ( $k=2$ )	Remarks	Location Code
<b>LENGTH</b>				
Gauge blocks: millimetre	As BS EN ISO 3650:1999 Up to 10 mm Above 10 up to 25 mm Above 25 up to 50 mm Above 50 up to 75 mm Above 75 up to 100 mm	0.026 $\mu\text{m}$ 0.026 to 0.027 $\mu\text{m}$ 0.027 to 0.033 $\mu\text{m}$ 0.033 to 0.041 $\mu\text{m}$ 0.041 to 0.049 $\mu\text{m}$	Measurement of central length by interferometry. Measured twice, wrung to a platen by each of the two measuring faces in turn, and the mean of these two measurements stated on the certificate.	<b>Teddington</b>
Gauge blocks: inch	As BS 4311:2007 Up to 0.4 in Above 0.4 in up to 1 in 2 in 3 in 4 in	1.00 $\mu$ inch 1.00 to 1.07 $\mu$ inch 1.30 $\mu$ inch 1.60 $\mu$ inch 1.95 $\mu$ inch		
Long gauge blocks: millimetre	As BS EN ISO 3650:1999 Grades K and O  Above 100 up to 1000 mm	$\sqrt{0.049^2 + (0.083 \times L)^2}$ $\mu\text{m}$  i.e., 0.050 to 0.100 $\mu\text{m}$	Measurement of length by absolute interferometry of long gauge blocks of length $L$ (in metres) to the stated standards.	
	As BS EN ISO 3650:1999 Grades K and O  Above 100 up to 1000 mm	0.116 + (0.263 $\times L$ ) $\mu\text{m}$  i.e., 0.143 to 0.379 $\mu\text{m}$	Measurement of length by interferometric comparison of long gauge blocks of length $L$ (in metres) to the stated standards.	
Length bars: millimetre	As BS 5317:1976 Reference and calibration grades  Up to 100 mm	$\sqrt{0.065^2 + (0.42 \times L)^2}$ $\mu\text{m}$ i.e. 0.065 to 0.078 $\mu\text{m}$	Measurement of length by absolute interferometry of length bars of length $L$ (in metres) to the stated standards.	
	Above 100 up to 1200 mm	$\sqrt{0.049^2 + (0.083 \times L)^2}$ $\mu\text{m}$ i.e. 0.050 to 0.111 $\mu\text{m}$		
	Above 100 up to 1200 mm	0.116 + (0.263 $\times L$ ) $\mu\text{m}$ i.e. 0.143 to 0.432 $\mu\text{m}$	Measurement of length by interferometric comparison of length bars of length $L$ (in metres) to the stated standards.	



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Measured Quantity Instrument or Gauge	Range	Best Measurement Capability Expressed as an Expanded Uncertainty ( $k=2$ )	Remarks	Location Code
LENGTH (cont'd)				<b>Teddington</b>
Length bars: Inch	As BS 1790:1961 Reference and calibration grades From 0.5 in up to 4 in  Above 4 in up to 48 in	$\sqrt{2.56^2 + (0.42 \times L)^2}$ $\mu$ inch i.e. 2.57 to 3.07 $\mu$ inch  $\sqrt{1.9^2 + (0.083 \times L)^2}$ $\mu$ inch i.e. 1.93 to 4.42 $\mu$ inch	Measurement of length by absolute interferometry of length bars of length $L$ (in inches) to the stated standards.	
	Above 4 in up to 48 in	4.57 + (0.263 x $L$ ) $\mu$ inch i.e. 5.62 to 17.2 $\mu$ inch	Measurement of length by interferometric comparison of long gauge blocks of length $L$ (in inches) to the stated standards.	
Thermal expansion coefficient at 20°C	Expansion coefficient $9 \times 10^{-6} \text{ K}^{-1}$ to $13 \times 10^{-6} \text{ K}^{-1}$	$(0.004 + 11/L + 0.000007L)$ $\times 10^{-6} \text{ K}^{-1}$ , where $L$ is length of gauge block or length bar in millimetres.	The uncertainty applies to the measurement of the linear coefficient of thermal expansion, at 20 °C, of long series gauge blocks and length bars above 100 mm, up to 1200 mm (4 inch to 48 inch) which comply with the following standards:	
			Reference and calibration grades of BS 1790:1961 (inch). Reference and calibration grades of BS 5317:1976 (millimetre). Grades K, 0 of ISO 3650:1998.	
Thread measuring cylinders	From 0.1 mm up to 5 mm diameter	$0.08 + (0.001 \times \text{diameter in mm})$ $\mu\text{m}$	As BS 3777:1964 BS 5590:1978 and specials	
Plain plug gauges (parallel) reference cylinders and rollers	From 0.1 mm up to 100 mm diameter  Above 100 mm up to 150 mm diameter	$0.07 + (0.0011 \times \text{diameter in mm})$ $\mu\text{m}$  $0.05 + (0.0014 \times \text{diameter in mm})$ $\mu\text{m}$		
Plain setting rings (parallel)	From 3 mm up to 250 mm diameter	$0.07 + (0.0005 \times \text{diameter in mm})$ $\mu\text{m}$	As BS 4064:1966 and BS 4065:1966 Grade AA, and equivalent quality setting rings	
Stage micrometers and graticules	Up to 150 mm	0.5 $\mu\text{m}$		
Linewidth standards	From 0.5 $\mu\text{m}$ to 10 $\mu\text{m}$ Above 10 $\mu\text{m}$ to 50 $\mu\text{m}$	0.05 $\mu\text{m}$ 0.1 $\mu\text{m}$		



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<b>LENGTH (cont'd)</b>				<b>Teddington</b>
Reference stage graticules for image analysers	Grid sizes Up to 400 x 400 µm Spot sizes From 3 to 48 µm	0.1 µm  0.1 µm		
Reference master screw plug and ring gauges (taper) to API specifications 5B and 7	Up to 20 in diameter	Pitch diameters 0.00037 in Major diameter 0.0002 in Minor diameter 0.0006 in Pitch 0.00012 in Taper 0.00011 in Flank angle 6 minutes of arc Stand off 0.00034 in		
<b>ANGLE</b>				
Indexing tables	From 0 to 360 degrees	0.04 seconds of arc		
Precision polygons	Up to 12 sides, excluding 7 and 11 sides	0.11 seconds of arc		
Combination angle gauges	Up to 45 degrees	0.3 seconds of arc	As MOY/SCMI/18and MOY/SCMI/45	
Autocollimators <i>Visual and photoelectric</i> <i>High-resolution electronic</i>	Up to 10 minutes of arc Up to 60 seconds of arc	0.06 seconds of arc 0.03 seconds of arc		
<b>FORM</b>				
Roundness reference standards	Up to 100 mm diameter	0.005 µm		
<b>OTHER MEASURING INSTRUMENTS, EQUIPMENT AND MACHINES</b>				
Laser frequency (Vacuum wavelength)	Nominal wavelengths From 500 nm up to 2.0µm	1 6-parts in 10 <sup>13</sup>		
Laser interferometer systems	Up to 45 m  <i>Compensated</i> <i>Uncompensated</i>	$\sqrt{0.08^2 + (0.2 \times L)^2}$ µm $\sqrt{0.08^2 + (0.12 \times L)^2}$ µm	<i>L</i> = length (m) <i>L</i> = length (m)	
Extensometer calibration rigs	Displacements up to 1000 mm	32 + (3.5 x <i>R</i> ) nm where <i>R</i> is the extension in mm		



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INFRA-RED	<i>Thermal Radiation</i>	0.002 (, <0.1) 0.001 (, >0.9)		
Wavenumber, $\nu$ for QA checks on mid-IR spectrophotometers	<i>Nominal Values:</i> 3060.0 $\text{cm}^{-1}$ 2849.5 $\text{cm}^{-1}$ 1942.9 $\text{cm}^{-1}$ 1601.2 $\text{cm}^{-1}$ 1583.0 $\text{cm}^{-1}$ 1154.5 $\text{cm}^{-1}$ 1028.3 $\text{cm}^{-1}$	0.3 $\text{cm}^{-1}$ 0.4 $\text{cm}^{-1}$ 0.4 $\text{cm}^{-1}$ 0.3 $\text{cm}^{-1}$ 0.3 $\text{cm}^{-1}$ 0.3 $\text{cm}^{-1}$ 0.3 $\text{cm}^{-1}$	Calibrated Artefact: Matt polystyrene film nominally 0.04 mm thick  Each film is individually calibrated at all seven selected transmittance minima  Films are measured in a spectrophotometer with a nominal sample compartment temperature of $30^{\circ}\text{C} \pm 5^{\circ}\text{C}$	
PHOTOMETRY				
Luminous intensity (tungsten lamps)	1 to 100 cd 100 to 1000 cd 1000 to 10000 cd	0.7% 0.6% 0.7%	The actual measurement uncertainty quoted on certificates depends critically on the lamp repeatability or the meter performance. The best measurement capability relates to that which can be achieved using specially designed transfer standards and, in the case of sources, assumes that the correlated colour temperature or spectral power distribution is known. For illuminance/luminance meters, the calibration only applies for a tungsten source at a correlated colour temperature of 2856 K.	Teddington
Illuminance (tungsten lamps and illuminance meters)	0.1 to 500 lux 500 to 5000 lux 5000 to 20000 lux 20000 to 50000 lux	0.9% 0.8% 0.9% 1.0%		
Luminance (tungsten sources and luminance meters)	1 to 100 $\text{cd m}^{-2}$ 100 to 1000 $\text{cd m}^{-2}$ 1000 to 10000 $\text{cd m}^{-2}$	1.3% 1.2% 1.3%		
Correlated colour temperature (tungsten lamps and colour temperature meters)	2000 to 3200 K	10 K		
Luminous flux (tungsten lamps)	1 to 100 lumen 100 to 20000 lumen	0.9% 0.7%		



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<b>SPECTRORADIOMETRY OF SOURCES</b>					
Relative and absolute spectral irradiance of tungsten and tungsten halogen sources	250 nm to 400 nm 300 nm to 400 nm 400 nm to 800 nm 800 nm to 1600 nm 1600 nm to 2500 nm	5.5% to 3.5% 3.5% to 2.6% 2.6% to 1.7% 1.7% to 2.0% 2.0% to 2.8%	For lamps rated 50 W to 5000 W (nominal), correlated colour temperature in the range 2600 K to 3250 K.	Teddington	
Relative and absolute spectral radiance of tungsten and tungsten halogen based sources	300 nm to 400 nm 400 nm to 800 nm 800 nm to 1600 nm 1600 nm to 2500 nm	3.5% to 2.7% 2.7% to 1.8% 1.8% to 2.1% 2.1% to 3.0%	For lamps rated 50 W to 5000 W (nominal), correlated colour temperature in the range 2600 K to 3250 K.		
<b>RADIOMETRY</b>					
Spectral responsivity of laser power meters	100 pW to 1 mW 350 to 1600 nm	0.04%	At laser wavelength or peak wavelength of bandpass filter.		
Spectral responsivity	200 to 240 nm 240 to 380 nm 380 to 405 nm 405 to 920 nm 920 to 1800 nm	1.0% 0.8% 0.3% 0.1% 0.3%			



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<b>COLORIMETRY AND SPECTROPHOTOMETRY - REGULAR TRANSMITTANCE</b>				
Regular transmittance	0.001%T to 100%T <i>Wavelength range (nm):</i> 200 ≤ λ ≤ 210 210 < λ ≤ 310 310 < λ ≤ 800 800 < λ ≤ 3000	Absolute uncertainty for 90%T, 60%T and 0.001%T: 0.50%, 0.30% and 0.000027% 0.30%, 0.15% and 0.000018% 0.30%, 0.15% and 0.000011% 0.30%, 0.30% and 0.000022%		Teddington
Optical density	0 D to 5.0 D <i>Wavelength range (nm):</i> 200 ≤ λ ≤ 210 210 < λ ≤ 310 310 < λ ≤ 800 800 < λ ≤ 3000	Absolute uncertainty for 0.05D, 0.22 D and 5.0 D: 0.0024 D, 0.0022 D and 0.0116 D 0.0014 D, 0.0011 D and 0.0077 D 0.0014 D, 0.0011 D and 0.0048 D 0.0014 D, 0.0022 D and 0.0097 D	Optical density is equivalent to absorbance (A) and is calculated from regular transmittance using the formula D = log <sub>10</sub> (100/%T).	
Wavelength of absorption peaks	200 to 3000 nm	0.1 nm		
Colour data: CIELAB L* a* b*	0 to 100 -200 to 200 -200 to 200	0.05 0.05 0.05	Colour data is normally given for the CIE 2° and 10° observers and CIE Standard Illuminants A, C and D65. Other Standard Illuminants on request.	
Colour data: CIE x, y, u', v'	0 to 1	0.0002		
Luminous transmittance Y	0% to 100%Y	0.15% for 60%Y		
<b>COLORIMETRY AND SPECTROPHOTOMETRY - DIFFUSE REFLECTANCE</b>				
Spectral diffuse reflectance; specular included and specular excluded geometries	0% to 100%R <i>Wavelength range (nm):</i> 200 ≤ λ ≤ 315 315 < λ ≤ 460 460 < λ ≤ 800 800 < λ ≤ 2000 2000 < λ ≤ 2500	Absolute uncertainty:  1.6% for white, 0.60% for black (0.05 + 0.0055R)% (0.05 + 0.0035R)% 1.6% for white, 0.35% for black 2.1% for white, 0.65% for black	Best measurement capability is for measurement against similar NPL masters, and examples are given covering the range from 'white' samples to 'black' samples. Higher uncertainties may apply where no similar master exists.	
Spectral radiance factor (see Notes 1 and 2)	0% to 102%R <i>Wavelength range (nm):</i> 200 ≤ λ ≤ 315 315 < λ ≤ 800 800 < λ ≤ 2000 2000 < λ ≤ 2500	Absolute uncertainty:  1.6% for white, 0.60% for black (0.05 + 0.007R)% 2.3% for white, 0.30% for black 2.8% for white, 0.70% for black	Radiance factor results are expressed relative to the perfect reflecting (Lambertian) diffuser. A result >100% implies that the sample reflects more radiation at 45° than a Lambertian diffuser. See also the remark above.	



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<b>COLORIMETRY AND SPECTROPHOTOMETRY - DIFFUSE REFLECTANCE (cont'd)</b>					
Colour data: CIELAB L* a* b*	0 to 100 -200 to 200 -200 to 200	0.15 0.10 0.10	Colour data is normally given for the CIE 2° and 10° observers and CIE Standard Illuminants A, C and D65. Other Standard Illuminants on request.	Teddington	
Colour data: CIE x, y, u', v'	0 to 1	0.0002	Colour data is normally given for the CIE 2° and 10° observers and CIE Standard Illuminants A, C and D65. Other Standard Illuminants on request.		
Luminous transmittance Y	0% to 100%Y	0.55% for white, 0.10% for black			
<b>TEMPERATURE</b>					
Resistance thermometers, fixed point calibrations	-196 °C to -38.8344 °C -189.3442 °C -38.8344 °C to 0.01 °C 0 °C to 29.7646 °C 0 °C to 156.5985 °C 231.928 °C 419.527 °C 0 °C to 419.527 °C 419.527 °C to 660.323 °C 660.323 °C to 961.78 °C	0.0017 °C to 0.00035 °C 0.0005 °C 0.00035 °C to 0.00016 °C 0.00016 °C to 0.0003 °C 0.0003 °C to 0.0007 °C 0.0007 °C 0.0009 °C 0.001 °C 0.001 °C to 0.0025 °C 0.0025 °C to 0.004 °C			
Resistance thermometers, calibration by comparison	-196 °C -100 °C to -80 °C -80 °C to 0 °C 0 °C to 50 °C 50 °C to 100 °C	0.0017 °C 0.01 °C 0.004 °C 0.003 °C 0.005 °C	Comparison at LN <sub>2</sub> and in acetone and water baths		
Temperature indicators with resistance sensor	-196 °C to 100 °C	As for sensor			
Water triple point cells	0.01 °C	0.000084 °C	Comparison with NPL reference cells		
Diphenyl ether triple point cells	26.862 °C	0.002 °C			
Ethylene carbonate triple point cells	36.315 °C	0.002 °C			
Benzoic acid triple point cells	122.33 °C	0.005 °C			



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TEMPERATURE (cont'd)				
Thermocouples noble metal type Pt-Rh	420 °C 962 °C, 1064 °C, 1085 °C 1324 °C	0.13 °C 0.21 °C 0.53 °C	ITS-90 fixed points  Secondary fixed point Co-C derived from ITS-90	Teddington
	0 °C to 1100 °C 1100 °C to 1330 °C	0.3 °C 0.3 °C to 0.55 °C		
	1100 °C to 1600 °C	1.0 °C to 1.5 °C	Wire bridge method	
Thermocouples noble metal type Pt-Pd	420 °C 962 °C, 1085 °C	0.1 °C 0.07 °C		
Thermocouples, base- metal types	-196 °C -80 °C to 0 °C 0 °C to 50 °C 50 °C to 100 °C	0.5 °C 0.1 °C 0.05 °C 0.1 °C	Comparison at LN <sub>2</sub> and in acetone and water baths	
Temperature indicators with thermocouple sensors	-196 °C to 100 °C	As for sensor		
Compensating and extension cables	-25 °C to 100 °C	As for base-metal thermocouples		
Standard lamps, evacuated	700 °C to 1000 °C 1000 °C to 1700 °C	1.0 °C to 0.4 °C 0.4 °C to 1.0 °C		
Standard lamps, gas filled	1300 °C to 1600 °C 1600 °C to 2200 °C 2200 °C to 2650 °C	3.5 °C to 2.5 °C 2.5 °C to 4 °C 4 °C to 7 °C	Calibration current is limited to 70A	
Disappearing filament pyrometers	800 °C to 1100 °C 1100 °C to 1700 °C 1700 °C to 2800 °C	10 °C to 3 °C 3 °C to 5 °C 5 °C to 8 °C		
Infrared Thermometers	-40 °C to 200 °C 15 °C to 45 °C 200 °C to 500 °C 500 °C to 1000 °C 1000 °C to 3000 °C	0.2 °C 0.05 °C 0.3 °C 0.4 °C 0.05% of Celsius temperature	Including tympanic thermometers	
Blackbody Sources	-40 °C to 200 °C 200 °C to 500 °C 500 °C to 1000 °C 962 °C, 1064 °C, 1085 °C 1000 °C to 3000 °C	0.2 °C 0.3 °C 0.4 °C 0.06 °C 0.05% of Celsius temperature		



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<b>HUMIDITY</b>				
Dew-point	+90 °C to +80 °C +80 °C to +60 °C +60 °C to -60 °C -60 °C to -75 °C -75 °C to -90 °C	0.1 °C to 0.04 °C 0.04 °C to 0.03 °C 0.03 °C 0.03 °C to 0.1 °C 0.1 °C to 0.5 °C	The accreditation covers other humidity units directly related to dew-point, e.g. vapour pressure, PPM weight, PPM volume, g/kg etc.	Teddington
Relative Humidity	1% rh to 98% rh at temperatures -40 °C to +100 °C	0.6% of reading + 0.1 % rh		
Temperature Sensors incorporated in humidity instruments	-40 °C to +100 °C	0.08 °C		
Calibration of dew point hygrometers	-90 °C to 90 °C	0.8 °C to 0.1 °C	The calibration/evaluation of climatic chambers can be undertaken	Customer's sites
Calibration of relative humidity hygrometers	1% rh to 98% rh at temperatures with the range -40 °C to 100 °C	1% of reading		
Temperature Sensors incorporated in humidity instruments	-40 °C to + 100 °C	0.2 °C		
<b>NEUTRON DOSIMETRY</b>				
<b>NEUTRON SOURCE EMISSION RATE</b>				
Emission rate from radionuclide neutron sources	Source emission rate $10^5 \text{ s}^{-1}$ to $2 \times 10^9 \text{ s}^{-1}$	1.0% to 1.2% depending on source	Service reference number: RN05 Induced $^{56}\text{Mn}$ activity measured using sodium iodide detectors	Teddington
	Source emission rate $10^2 \text{ s}^{-1}$ to $2 \times 10^6 \text{ s}^{-1}$	1.2% to 1.5% depending on source		
Anisotropy of emission from radionuclide neutron sources	Source emission rate $10^5 \text{ s}^{-1}$ to $10^8 \text{ s}^{-1}$ Anisotropy factor 0.5 to 1.2	1.0% to 0.7% depending on source	Service reference number: RN05. Measurements performed using a precision long counter in a low-scatter environment	



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NEUTRON FLUENCE				
Thermal neutron fluence	Energy: thermal Thermal neutron beam Fluence rates: $10^3 \text{ cm}^{-2} \text{ s}^{-1}$ to $4 \times 10^4 \text{ cm}^{-2} \text{ s}^{-1}$	1.2% for Wescott fluence 2.3% for 'true' fluence	Service reference number: RN01 Fast neutrons moderated in a graphite pile. Beam of thermal neutrons extracted. Fluence standard – gold foil activation Service conforms to ISO Standard 8529 Parts 1 to 3.	Teddington
Thermal neutron fluence	Energy: thermal Thermal neutrons in cavity -Fluence rates; $10^4 \text{ cm}^{-2} \text{ s}^{-1}$ to $3 \times 10^7 \text{ cm}^{-2} \text{ s}^{-1}$	1.0% for Westcott fluence	Service reference number: RN01. Fast neutrons moderated in graphite pile. Thermal neutrons in a small $150 \text{ cm}^3$ cavity. Fluence standard - gold foil activation.	
Fast neutron fluence	Energy: 70 keV to 5 MeV Monoenergetic fields Fluence rates: $1 \text{ cm}^{-2} \text{ s}^{-1}$ to $1500 \text{ cm}^{-2} \text{ s}^{-1}$	4%	Service reference number: RN02. Neutrons are produced using beams of protons or deuterons from a 3.5 MV Van de Graaff accelerator. Fluences measured using precision long counter. Service conforms to ISO Standard 8529 Parts 1 to 3.	
Fast neutron fluence	Energy: 13.5 MeV to 19 MeV Monoenergetic fields Fluence: $5 \times 10^8 \text{ cm}^{-2}$ to $10^{14} \text{ cm}^{-2}$	1.3%	Service reference number: RN03 Iron and aluminium foil activation for measurement of customer's field.	
Fast neutron fluence	Energy: broad energy range from sources: $^{241}\text{Am}$ -Be, $^{252}\text{Cf}$ , $^{241}\text{Am}$ -B, $^{241}\text{Am}$ -Li, $^{241}\text{Am}$ -F Fluence rates: $1 \text{ cm}^{-2} \text{ s}^{-1}$ to $400 \text{ cm}^{-2} \text{ s}^{-1}$ at 1 m from source	1.3%	Service reference number: RN04. Fields are produced using radionuclide neutron sources of known emission rate. Actual fluence rate depends on particular source Service conforms to ISO Standard 8529 Parts 1 to 3.	



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<b>NEUTRON DOSE EQUIVALENT</b>					
Thermal and fast neutron dose equivalents	Energy: thermal Thermal neutron beam	2.5%	Service reference numbers: RN01, RN02, and RN04. Fluences are converted to ambient dose equivalent or personal dose equivalent using accepted conversion coefficients. For broad energy range neutron fields from sources the uncertainties in the neutron dose equivalent values reflect uncertainties in the source spectra rather than the conversion coefficients, which are assumed to be exact. Service conforms to ISO Standard 8529 Parts 1 to 3.	<b>Teddington</b>	
	Energy: 70 keV to 5 MeV Monoenergetic fields	4.0%			
	Energy: broad energy range from radionuclide sources Dose equivalent rates: <sup>241</sup> Am-Be: 1 μSv h <sup>-1</sup> to 400 μSv h <sup>-1</sup> at 1m from the source	8.1%			
	<sup>252</sup> Cf: 2 μSv h <sup>-1</sup> to 280 μSv h <sup>-1</sup> at 1m from the source	2.4%			
Fast neutron personal dosimeter proficiency testing	Energy: broad energy range from radionuclide sources Dose equivalent rates: <sup>241</sup> Am-Be: 1 μSv h <sup>-1</sup> to 400 μSv h <sup>-1</sup> at 1m from the source	8.1%	Service reference number: RN04. In accordance with HSE Measurement Protocol for Performance Testing of Dosimetry Services for External, Whole Body Fast Neutron Radiation, June 2001.		
	<sup>252</sup> Cf: 2 μSv h <sup>-1</sup> to 280 μSv h <sup>-1</sup> at 1m from the source	2.4%			
<b>RADIATION DOSIMETRY</b>					
Protection level dosimeters Air kerma rate					
X-rays	ISO 4037 narrow spectrum (generating potential 8 to 250 keV) 350 μGy h <sup>-1</sup> to 100 mGy h <sup>-1</sup>	1.5%	Service reference number: RD02 Calibration of protection level ionisation chamber with volumes ranging from 35 cm <sup>3</sup> to 10 litres connected to a suitable secondary standard electrometer.		
γ-radiation	<sup>60</sup> Co 1 μGy h <sup>-1</sup> to 0.3 Gy h <sup>-1</sup>	1.2%			
	<sup>137</sup> Cs 1 μGy h <sup>-1</sup> to 0.3 Gy h <sup>-1</sup>	1.2%			
	<sup>241</sup> Am 8 μGy h <sup>-1</sup> to 0.3 mGy h <sup>-1</sup>	1.5%			
X-ray generating potential	Generating potential 25 to 150 kVp	1.5%	Service reference number: RD04. Calibration of penetrameters and kVp meters.		



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<u>Therapy level dosimeters</u>				Teddington
Measurement of air kerma rate				
X-rays	Half value layers 0.024 to 20 mm Al (generating potential 8 to 280 kVp)	1.2%	Service reference number: RD01 Calibration of NE2561, NE2611, for Farmer type and soft x-ray chambers ionisation with a suitable secondary standard electrometer.	
$\gamma$ -radiation	$^{60}\text{Co}$	1.2%	Calibration of NE2561, NE2611, for Farmer type ionisation with a suitable secondary standard electrometer.	
Measurement of absorbed dose to water				
$\gamma$ -radiation	$^{60}\text{Co}$	1.4%	Calibration of NE2561, NE2611, for Farmer type ionisation with a suitable secondary standard electrometer.	
Photons	TPR <sub>10</sub> <sup>20</sup> : 0.568 to 0.790 Generating potential 4 to 19 MeV	1.4%		
<u>High dose dosimetry</u>				
Absorbed dose to water	$^{60}\text{Co}$ Dose: 5 Gy to 100 kGy	2.2%	Service reference number: RD07 High dose irradiation service.	
	$^{60}\text{Co}$ Dose: 2 to 55 kGy	2.2 to 2.9% depending on the dose	Service reference number: RD05 Dichromate dosimetry service.	
	$^{60}\text{Co}$ , $^{137}\text{Cs}$ , photons generated above 2 MeV and electrons generated above 4 MeV. Dose: 20 Gy to 100 kGy	2.6%	Service reference number: RD06 Alanine dosimetry service	



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<b>RADIOACTIVITY METROLOGY</b>				
<b>RR/0101 – Standards of Radioactivity (activity concentration, Bq/g):</b> Solutions (or solid substrates spiked directly with such solutions) of $\alpha$ -particle, $\beta$ -particle, X-ray and $\gamma$ -ray emitting radionuclides measured by absolute techniques.	4 kBq – 15 GBq, depending on radionuclide	0.3 – 5%, depending on radionuclide	Procedures directly supporting this work are: <b>RMG010</b> – $4\pi\beta\text{-}\gamma$ Coincidence counting using an Atmospheric Pressure Proportional Counter <b>RMG901:</b> Record Keeping and Storage for Absolute Counting Data <b>N109</b> – Medium Pressure Proportional Counter for X-ray Counting of $^{55}\text{Fe}$ <b>N112</b> – $4\pi\beta\text{-}\gamma$ Coincidence Counting <b>N134</b> – HPPC- $\gamma$ Coincidence Counting <b>N135</b> – Liquid Scintillation- $\gamma$ Coincidence Counting	Teddington
<b>RR/0101a – Standards of Radioactivity (activity concentration, Bq/g):</b> Gelatine capsules ( $^{131}\text{I}$ only), brachytherapy wires ( $^{192}\text{Ir}$ only), brachytherapy seeds ( $^{125}\text{I}$ only) or solutions (or solid substrates spiked directly with such solutions) of $\alpha$ -particle, $\beta$ -particle, X-ray and $\gamma$ -ray emitting radionuclides measured by secondary techniques.	4 kBq – 15 GBq, depending on radionuclide	0.3 – 5%, depending on radionuclide <i>(unless specifically mentioned in the following four rows; this list may be added to from time to time)</i>	Procedures directly supporting this work are: <b>RMG001:</b> Ionisation Chamber Calibration Factors for use Within the Radioactivity Metrology Group <b>N108</b> – $\gamma$ -spectrometry <b>N110</b> – Activity assay using ionisation chambers <b>N136</b> – Photon emitting standards of radioactivity (solutions)	
		0.3 – 0.5%, depending on radionuclide  0.5 – 1%, depending on radionuclide	$^{60}\text{Co}$ , $^{106}\text{Ru}/^{106}\text{Rh}$ and $^{153}\text{Sm}$  $^{22}\text{Na}$ , $^{24}\text{Na}$ , $^{47}\text{Ca}$ , $^{46}\text{Sc}$ , $^{47}\text{Sc}$ , $^{54}\text{Mn}$ , $^{56}\text{Mn}$ , $^{59}\text{Fe}$ , $^{68}\text{Ge}/^{68}\text{Ga}$ , $^{86}\text{Rb}$ , $^{88}\text{Y}$ , $^{125}\text{Sb}$ , $^{131}\text{I}$ (solution), $^{198}\text{Au}$ and $^{241}\text{Am}$	



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<p><b>RR/0102 - Standards of Radioactivity (activity concentration, Bq/g):</b> Solutions (or solid substrates spiked directly with such solutions) of <math>\alpha</math>-particle, <math>\beta</math>-particle or X-ray emitting radionuclides measured by absolute techniques.</p>	4 kBq/g – 20 MBq/g	<p>1 – 2%, depending on radionuclide</p> <p>2 – 5%, depending on radionuclide</p>	<p><sup>32</sup>P, <sup>42</sup>K, <sup>51</sup>Cr, <sup>56</sup>Co, <sup>58</sup>Co, <sup>65</sup>Zn, <sup>82</sup>Br, <sup>85</sup>Sr, <sup>87m</sup>Sr, <sup>89</sup>Sr, <sup>90</sup>Y, <sup>99m</sup>Tc, <sup>110m</sup>Ag, <sup>111</sup>In, <sup>113m</sup>In, <sup>113</sup>In, <sup>123</sup>I, <sup>131</sup>I (capsule), <sup>134</sup>Cs, <sup>137</sup>Cs/<sup>137m</sup>Ba, <sup>133</sup>Ba, <sup>139</sup>Ce, <sup>141</sup>Ce, <sup>144</sup>Ce/<sup>144</sup>Pr, <sup>152</sup>Eu, <sup>154</sup>Eu, <sup>155</sup>Eu, <sup>160</sup>Tb, <sup>169</sup>Yb, <sup>188</sup>Re, <sup>192</sup>Ir (solution), <sup>199</sup>Au, <sup>203</sup>Hg, <sup>201</sup>Tl, <sup>203</sup>Pb, <sup>237</sup>Np/<sup>233</sup>Pa and <sup>243</sup>Am/<sup>239</sup>Np</p> <p><sup>7</sup>Be, <sup>18</sup>F, <sup>67</sup>Ga, <sup>75</sup>Se, <sup>85</sup>Kr (gas ampoule), <sup>95</sup>Nb, <sup>99</sup>Mo/<sup>99m</sup>Tc, <sup>109</sup>Cd, <sup>125</sup>I, <sup>125</sup>I (strand of 10 seeds, Air Kerma Rate only), <sup>125</sup>I (single seed, Air Kerma Rate only), <sup>133</sup>Xe (gas ampoule), <sup>192</sup>Ir (0.3mm diameter wire, 10mm long, Air Kerma Rate and activity), <sup>192</sup>Ir (0.3mm diameter wire, 10-100mm long, Air Kerma Rate and activity), <sup>192</sup>Ir (0.6mm diameter single pin, Air Kerma Rate and activity), <sup>192</sup>Ir (0.6mm diameter hairpin, Air Kerma Rate and activity), <sup>197</sup>Hg and <sup>226</sup>Ra (et seq)</p>	Teddington
<p><b>RR/0102a - Standards of Radioactivity (activity concentration, Bq/g):</b> Solutions (or solid substrates spiked directly with such solutions) of <math>\alpha</math>-particle, <math>\beta</math>-particle and X-ray emitting radionuclides measured by secondary liquid scintillation techniques</p>	100 Bq/g – 500 kBq/g	0.5-5 %, depending on nuclide	<p>Procedures directly supporting this work are: <b>RMG010</b> – <math>4\pi\beta\text{-}\gamma</math> Coincidence counting using an Atmospheric Pressure Proportional Counter <b>RMG901</b>: Record Keeping and Storage for Absolute Counting Data <b>N109</b> – Medium Pressure Proportional Counter for X-ray Counting of <sup>55</sup>Fe <b>N112</b> – <math>4\pi\beta\text{-}\gamma</math> Coincidence Counting <b>N134</b> – HPPC-<math>\gamma</math> Coincidence Counting <b>N135</b> – Liquid Scintillation-<math>\gamma</math> Coincidence Counting</p>	
		0.2 – 5 %, depending on nuclide	<p>Procedures directly supporting this work are: <b>RMG019</b> – Secondary Standardisation of Radionuclides using the CIEMAT/NIST Technique <b>N123</b>: Operation of the Pharmacia Wallac Rackbeta Liquid Scintillation Counter</p>	



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<b>RR/0201 - Standards of Radioactivity (activity concentration, Bq/m<sup>3</sup>):</b> Gaseous radionuclides other than radon	1 MBq/m <sup>3</sup> – 1 GBq/m <sup>3</sup>	2-5%, depending on radionuclide	Procedures directly supporting this work are: <b>RMG100</b> – Calibration of Gaseous Radionuclides other than Radon	Teddington
<b>RR/0203 - Instrument Calibration (response to activity concentration, Bq/m<sup>3</sup>):</b> Customer supplied <sup>3</sup> H monitors	100 kBq/m <sup>3</sup> – 150 MBq/m <sup>3</sup>	5%	Procedures directly supporting this work are: <b>RMG022</b> – Calibration of Tritium Gas Monitors	
<b>RR/0301 - Artefact calibration (particle emission rate, particles/s):</b> Customer supplied radioactive surface contamination sources	10-10000 particles/s	1-2%, depending on radionuclide	Procedures directly supporting this work are: <b>N111</b> – Calibration of Large Area Surface Contamination Sources	
<b>RR/0501 - Standards of Radioactivity (activity concentration, Bq/g):</b> Solutions (or solid substrates spiked directly with such solutions) of Environmental level standards of radioactivity	0.3 Bq/g – 30 kBq/g, depending on radionuclide	0.5-5%, depending on radionuclide <i>(unless specifically mentioned in the following four rows; this list may be added to from time to time)</i>	Procedures directly supporting this work are: <b>N117</b> – Production of Mixed Radionuclide Solution Standards <b>N137</b> – Preparation of Environmental Radioactivity Standards  <sup>152</sup> Eu, <sup>242</sup> Pu, <sup>241</sup> Am, <sup>244</sup> Cm  <sup>14</sup> C, <sup>90</sup> Sr, <sup>99</sup> Tc, <sup>137</sup> Cs, <sup>229</sup> Th <sup>55</sup> Fe, <sup>129</sup> I, <sup>232</sup> U, <sup>238</sup> U, <sup>237</sup> Np, <sup>239</sup> Pu, <sup>243</sup> Am	
	500-10 kBq/g	Depends on nuclide	Mixed $\gamma$ -ray emitting radionuclide solution (includes <sup>57</sup> Co, <sup>60</sup> Co, <sup>85</sup> Sr, <sup>88</sup> Y, <sup>109</sup> Cd, <sup>113</sup> Sn, <sup>137</sup> Cs, <sup>139</sup> Ce, <sup>203</sup> Hg, <sup>241</sup> Am)	
<b>RR/0601 - Standards of Radioactivity (activity concentration, Bq/g):</b> Solutions of <sup>3</sup> H standards for <sup>3</sup> H measurement proficiency test	10 Bq/g – 1 kBq/g	1-2%	In accordance with HSE Measurement Protocol for Performance Testing of the Determination of Tritium in Water (1993) Procedures directly supporting this work are: <b>N122</b> – Performance Testing of the Determination of Tritium in Water <b>N123:</b> Operation of the Pharmacia Wallac Rackbeta Liquid Scintillation Counter	



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<b>RR/0701 - Artefact calibration (activity content, Bq):</b> Gelatine capsules ( <sup>131</sup> I only), brachytherapy wires ( <sup>192</sup> Ir only), brachytherapy seeds ( <sup>125</sup> I only) or solutions (or solid substrates spiked directly with such solutions) of α-particle, β-particle, X-ray and γ-ray emitting radionuclides measured by secondary techniques.	4 kBq – 15 GBq, depending on radionuclide	0.3 – 5%, depending on radionuclide <i>(unless specifically mentioned in the following four rows; this list may be added to from time to time)</i>	Procedures directly supporting this work are: <b>RMG001:</b> Ionisation Chamber Calibration Factors for use Within the Radioactivity Metrology Group <b>N108</b> – γ-spectrometry <b>N110</b> – Activity assay using ionisation chambers <b>N136</b> – Photon emitting standards of radioactivity (solutions)	Teddington
		0.3 – 0.5%, depending on radionuclide	<sup>60</sup> Co, <sup>106</sup> Ru/ <sup>106</sup> Rh and <sup>153</sup> Sm	
		0.5 – 1%, depending on radionuclide	<sup>22</sup> Na, <sup>24</sup> Na, <sup>47</sup> Ca, <sup>46</sup> Sc, <sup>47</sup> Sc, <sup>54</sup> Mn, <sup>56</sup> Mn, <sup>59</sup> Fe, <sup>68</sup> Ge/ <sup>68</sup> Ga, <sup>86</sup> Rb, <sup>86</sup> Y, <sup>125</sup> Sb, <sup>131</sup> I (solution), <sup>198</sup> Au and <sup>241</sup> Am	
		1 – 2%, depending on radionuclide	<sup>32</sup> P, <sup>42</sup> K, <sup>51</sup> Cr, <sup>56</sup> Co, <sup>58</sup> Co, <sup>65</sup> Zn, <sup>82</sup> Br, <sup>85</sup> Sr, <sup>87m</sup> Sr, <sup>89</sup> Sr, <sup>90</sup> Y, <sup>99m</sup> Tc, <sup>110m</sup> Ag, <sup>111</sup> In, <sup>113m</sup> In, <sup>113</sup> Sn, <sup>123</sup> I, <sup>131</sup> I (capsule), <sup>134</sup> Cs, <sup>137</sup> Cs/ <sup>137m</sup> Ba, <sup>133</sup> Ba, <sup>139</sup> Ce, <sup>141</sup> Ce, <sup>144</sup> Ce/ <sup>144</sup> Pr, <sup>152</sup> Eu, <sup>154</sup> Eu, <sup>155</sup> Eu, <sup>160</sup> Tb, <sup>169</sup> Yb, <sup>188</sup> Re, <sup>192</sup> Ir (solution), <sup>199</sup> Au, <sup>203</sup> Hg, <sup>201</sup> Tl, <sup>203</sup> Pb, <sup>237</sup> Np/ <sup>235</sup> Pa and <sup>243</sup> Am/ <sup>238</sup> Np	
2 – 5%, depending on radionuclide	<sup>7</sup> Be, <sup>18</sup> F, <sup>67</sup> Ga, <sup>75</sup> Se, <sup>85</sup> Kr (gas ampoule), <sup>95</sup> Nb, <sup>99</sup> Mo/ <sup>99m</sup> Tc, <sup>109</sup> Cd, <sup>125</sup> I, <sup>125</sup> I (strand of 10 seeds, Air Kerma Rate only), <sup>125</sup> I (single seed, Air Kerma Rate only), <sup>133</sup> Xe (gas ampoule), <sup>192</sup> Ir (0.3mm diameter wire, 10mm long, Air Kerma Rate and activity), <sup>192</sup> Ir (0.3mm diameter wire, 10-100mm long, Air Kerma Rate and activity), <sup>192</sup> Ir (0.6mm diameter single pin, Air Kerma Rate and activity), <sup>192</sup> Ir (0.6mm diameter hairpin, Air Kerma Rate and activity), <sup>197</sup> Hg and <sup>226</sup> Ra(et seq)			



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Radioactivity Metrology Group measurement services are variously supported by these procedures: <b>N102:</b> Correlation Counting for the Determination of Deadtime or After-Pulse Rate, <b>N103:</b> Cleaning Glassware, <b>N116:</b> Preparation of Radioactive Sources, <b>N124:</b> Weighing for Source Preparation, <b>N130:</b> Preparation of Solutions and Carriers Used in Preparation of Sources of Radioactivity, <b>N131:</b> Calibration of Digital Voltmeters used in the Measurement of Ionisation Chamber Currents, <b>N132:</b> Calibration of Capacitors used in the Measurement of Ionisation Chamber Currents, <b>N138:</b> Operation of Sodium Iodide Counters <b>RMG000:</b> Basic References Supporting Work Within the Radioactivity Metrology Group, <b>RMG002:</b> Additional Requirements for Writing Radioactivity Metrology Group Procedures, <b>RMG302:</b> Production of Thin Films, <b>RMG400:</b> The Production Of <sup>90</sup> Y, <b>RMG401:</b> The Preparation of <sup>56</sup> Mn Solutions for the Neutron Metrology Group, <b>RMG403:</b> The Production of <sup>139</sup> Ce, <b>RMG404:</b> Chemical Separation of Actinoids, <b>RMG405:</b> Electrodeposition of Lanthanoids and Actinoids, <b>RMG406:</b> Separation of Radium from Daughter Radionuclides, <b>RMG407:</b> The Separation of <sup>239</sup> Np from <sup>243</sup> Am, <b>RMG900:</b> Construction and use of Shewhart Control Charts, <b>RMG903:</b> Project Management in RMG, <b>RMG904:</b> Calculating The Significant Figures to State Values Given on Certificates of Measurement <b>RNT001:</b> Ionising Radiation NMS Programme - Radioactivity And Neutron Team Office Manual				<b>Teddington</b>
MASS				
Specific values	Nominal value (g)	(mg)	The stated best measurement capability relates to measurements made on standards that are constructed in accordance with the principles contained in OIML Recommendation III for weights of Class E1.  Intermediate values of weights can be calibrated to an uncertainty equal to the greater of the uncertainties associated with the next higher and lower nominal values in the table.	
	50 000	2.5		
	20 000	1.0		
	10 000	0.4		
	5 000	0.2		
	3 000	0.2		
	2 000	0.07		
	1 000	0.03		
	500	0.015		
	300	0.01		
	200	0.007		
	100	0.004		
	50	0.003		
	30	0.003		
	20	0.0015		
	10	0.001		
	5	0.0006		
	3	0.0006		
	2	0.0003		
	1 to 0.001	0.0002		



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Measured Quantity Instrument or Gauge	Range	Best Measurement Capability Expressed as an Expanded Uncertainty ( <i>k</i> =2)	Remarks	Location Code
PRIMARY REFERENCE GAS MIXTURES (PRGM) AND CALIBRATED GAS MIXTURES (CGM)				Teddington
PRIMARY REFERENCE GAS MIXTURES (PRGM) Preparation of synthetic gas mixtures by gravimetry in accordance with ISO 6142:2001; verification by analysis.				
CALIBRATED GAS MIXTURES (CGM) Certification of synthetic gas mixtures by analysis.				
The laboratory also has ISO Guide 34 accreditation for production and certification of Primary Reference Gas Mixtures. Accredited certified reference material producer number 4002.				
Gas mixtures can be prepared and calibrated from pure materials to nmol/mol levels. Some examples are listed below. Gas mixtures include those listed in the BIPM CMC tables: <a href="http://kcdb.bipm.org/appendixc/QM/GB/QM_GB_4.pdf">http://kcdb.bipm.org/appendixc/QM/GB/QM_GB_4.pdf</a>				
SYNTHETIC NATURAL GAS MIXTURES	Amount fraction %mol/mol	Amount fraction %mol/mol	PRGM and CGM	
Nitrogen	0.02 to 25.2	0.18% relative + 0.00038		
Carbon dioxide	0.04 to 25.0	0.20% relative + 0.00045		
Methane	57.0 to 99.9	0.018% relative + 0.002		
Ethane	0.008 to 14.0	0.28% relative + 0.00008		
Propane	0.008 to 8.0	0.30% relative + 0.00008		
<i>i</i> -Butane	0.004 to 1.7	0.40% relative + 0.00004		
<i>n</i> -Butane	0.004 to 1.7	0.40% relative + 0.00004		
<i>neo</i> -Pentane	0.0005 to 0.5	0.80% relative + 0.000015		
<i>i</i> -Pentane	0.0025 to 0.6	0.40% relative + 0.00003		
<i>n</i> -Pentane	0.0025 to 0.6	0.40% relative + 0.00003		
<i>n</i> -Hexane	0.0008 to 0.5	0.40% relative + 0.000018		
Helium	0.004 to 0.5	0.95% relative + 0.00005		
	Amount fraction µmol/m	Amount fraction µmol/m		
Benzene	5 to 500	1.2% relative + 0.045		
Toluene	5 to 250	1.5% relative + 0.05		
Cyclohexane	10 to 400	1.3% relative + 0.12		
Methylcyclohexane	10 to 400	1.3% relative + 0.12		
<i>n</i> -Heptane	10 to 500	1.3% relative + 0.12		
<i>n</i> -Octane	5 to 150	1.5% relative + 0.08		
<i>n</i> -Nonane	1 to 100	1.5% relative + 0.017		
<i>n</i> -Decane	1 to 20	1.5% relative + 0.018		
SYNTHETIC FUEL GAS MIXTURES	Amount fraction %mol/mol	Amount fraction %mol/mol	PRGM and CGM	
Nitrogen	0.5 to 70	0.30 % relative + 0.0035		
Carbon monoxide	0.3 to 8	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	0.50 % relative + 0.0025		
Helium	5 to 10	0.40 % relative + 0.03		
Methane	12 to 85	0.15 % relative + 0.042		
Ethane	0.3 to 24	0.40 % relative + 0.0009		
Ethene	0.2 to 11	0.40 % relative + 0.0009		
Ethyne	0.2 to 0.3	0.40 % relative + 0.0012		
Propane	0.15 to 18	0.40 % relative + 0.0006		
Propene	0.15 to 4	0.49 % relative + 0.0005		



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PRIMARY REFERENCE GAS MIXTURES (PRGM) AND CALIBRATED GAS MIXTURES (CGM) (Cont.)					
SYNTHETIC FUEL GAS MIXTURES (Cont)	Amount fraction $\mu\text{mol/m}$	Amount fraction $\mu\text{mol/m}$			
i-Butane	0.15 to 0.3	0.60 % relative + 0.0003			
n-Butane	0.15 to 1.5	0.47 % relative + 0.0005			
1-Butene	0.1 to 0.6	0.52 % relative + 0.00048			
i-Butene	0.1 to 0.6	0.52 % relative + 0.00048			
1,3-Butadiene	0.1 to 0.35	0.72 % relative + 0.00028			
i-Pentane	0.05 to 0.12	0.85 % relative + 0.00018			
n-Pentane	0.05 to 0.12	0.85 % relative + 0.00018			
SULPUR ODORANT GAS MIXTURES	Amount fraction $\mu\text{mol/mol}$	Amount fraction $\mu\text{mol/mol}$			
Hydrogen sulphide	0.4 to 5,000	<u>PRGM</u> 1.0% relative + 0.005 (All components)	Matrix gas: Methane or nitrogen		
Carbonyl sulphide	0.4 to 5,000				
Carbon disulphide	0.4 to 200	<u>CGM</u> 1.2% relative + 0.005 (All components)	CGM		
Dimethyl sulphide	0.4 to 200				
Ethyl methyl sulphide	0.4 to 200				
Diethyl sulphide	0.4 to 200				
Methyl mercaptan [Methanethiol]	0.4 to 200				
Ethyl mercaptan [Ethanethiol]	0.4 to 200				
<i>i</i> -propyl mercaptan [2-propanethiol]	0.4 to 200				
<i>n</i> -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				
BINARY GAS MIXTURES	Amount fraction				
Nitric oxide in nitrogen	100 nmol/mol to 1 $\mu\text{mol/mol}$			1.0 % relative	
Sulphur dioxide in synthetic air or nitrogen	100 nmol/mol to 1 $\mu\text{mol/mol}$			2.0 % relative	
Nitric oxide in nitrogen	200 nmol/mol to 2 $\mu\text{mol/mol}$			3.0 % relative	
Nitrogen dioxide in nitrogen	200 nmol/mol to 2 $\mu\text{mol/mol}$	3.0 % relative			
OZONE PHOTOMETERS					
Ozone in synthetic Air	0 nmol/mol to 100 nmol/mol 100 nmol/mol to 1 $\mu\text{mol/mol}$	3.0 nmol/mol 3.0 % relative			



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ACOUSTICS			All tests are carried out at temperatures specified in procedures and in the relevant standards	<b>Teddington</b>
Sound pressure level of pistonphones and sound calibrators	70 dB to 130 dB (SPL) 31.5 Hz to 16 kHz	Examples at 124 dB, 250 Hz	Using measurement microphones according to IEC 61094-1:1992 and IEC 61094-4:1995	
Periodic testing to IEC 60942:2003		Microphone type LS1P 0.04 dB WS1P 0.06 dB LS2P 0.04 dB WS2P 0.05 dB WS3P 0.06 dB	Insert voltage technique using standard microphone for microphone types: LS1, WS1, LS2, WS2  Voltage ratio technique for microphone type WS3	
Free-field sensitivity of microphones	31.5 Hz – 5 kHz 6.3 kHz – 10 kHz 12.5 kHz	0.2 dB 0.3 dB 0.4 dB	Free field sensitivity measured by substitution using a standard microphone in a duct and free-field room	
Free field sensitivity of microphone systems	31.5 Hz – 5 kHz 6.3 kHz – 10 kHz 12.5 kHz	0.2 dB 0.3 dB 0.5 dB		
Pressure sensitivity level of a laboratory standard microphone			As per IEC 61094-2:1992	
Type LS1 including type WS1 converted to LS1 configuration using an adaptor specified by the manufacturer	63 Hz to 2.5 kHz 3.15 kHz to 4 kHz 5 kHz to 8 kHz 10 kHz	0.03 dB 0.04 dB 0.05 dB 0.10 dB		
Type LS2 including type WS2 converted to LS2 configuration using an adaptor specified by the manufacturer	63 Hz to 5 kHz 6.3 kHz 8 kHz 10 kHz 12.5 kHz 16 kHz 20 kHz	0.03 dB 0.04 dB 0.05 dB 0.06 dB 0.08 dB 0.09 dB 0.18 dB		



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Measured Quantity Instrument or Gauge	Range	Best Measurement Capability Expressed as an Expanded Uncertainty ( $k=2$ )	Remarks	Location Code
ACOUSTICS (continued)				<b>Teddington</b>
Pressure sensitivity level of laboratory standard or working standard microphone, type LS2 or WS2 respectively	63 Hz to 5 kHz 6.3 kHz 8 kHz 10 kHz 12.5 kHz	0.07 dB 0.08 dB 0.09 dB 0.10 dB 0.11 dB	Simultaneous calibration using a reference microphone	
System sound pressure level response of:				
Reference coupler	125 Hz to 8 kHz	0.2 dB	Comparison using a standard microphone	
Artificial ear	125 Hz to 8 kHz	0.2 dB	Comparison using a standard microphone	
Output of reference earphones for checking output of air conduction system				
Reference coupler Artificial ear	125 Hz to 8 kHz 125 Hz to 8 kHz		Application of known voltage to earphone	
Force response of mechanical coupler system	250 Hz to 4 kHz	0.3 dB	Response to application of known force	
Output of reference bone vibrators for checking output of bone conduction system	250 Hz to 4 kHz		Application of known voltage to bone vibrator	



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<b>ULTRASONICS</b>				
Reference hydrophone sensitivity	1 MHz to 8 MHz 9 MHz to 12 MHz 13 MHz to 16 MHz 17 MHz to 20 MHz 21 MHz to 30 MHz 31 MHz to 40 MHz	6% 7% 8% 11% 12% 15%	Free field sensitivity determined through substitution using a secondary hydrophone in a non- linearly distorted sound field	Teddington
End of cable hydrophone receive sensitivity	25 Hz to 400 Hz	0.5 dB	By comparison to a microphone using an air-pistonphone	
Free field sensitivity of reference measuring hydrophones/projectors	1 kHz to 2 kHz 2 kHz to 500 kHz	0.7 dB 0.5 dB	Using three-transducer spherical wave reciprocity method in a laboratory tank	
Free field sensitivity of reference measuring hydrophones	1 kHz to 2 kHz 2 kHz to 1 MHz	0.9 dB 0.7 dB	By comparison with NPL reference hydrophone in a laboratory tank	
Directional response of transducers and hydrophones	1 kHz to 1 MHz	0.21 dB	Normalised response versus angle. XY, XZ and YZ responses available. Performed in a laboratory tank	
<b>UNDERWATER ACOUSTICS</b>				
Projector sensitivity	250 Hz to 350 kHz From noise limit to 210 dB re 1 µPa/V at 1 m	0.9 dB	Using calibrated hydrophone method in an open-water test facility	Blue shaded area
Hydrophone sensitivity	250 Hz to 350 kHz From -250 to -100 dB re. 1 V/µPa	0.9 dB	Using calibrated projector method in an open-water test facility	
Complex admittance  conductance susceptance capacitance	250 Hz to 350 kHz	(2% + 10) µS (2% + 10) µS (2% + 20) µS	For underwater electro acoustic transducers only. Undertaken in open-water test facility.	



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<b>FORCE</b>  Proving devices, load cells and other force-measuring devices in compression and tension modes	<i>50 N Machine</i> 1.5 N to 50 N  <i>500 N Machine</i> 25 N to 500 N  <i>2.5 kN Machine</i> 25 N to 2.5 kN  <i>20 kN Machine</i> 0.5 kN to 20 kN  <i>120 kN Machine</i> 2.5 kN to 120 kN  <i>1.2 MN Machine</i> 10 kN to 1.2 MN  <i>5 MN Machine</i> 100 kN to 5 MN	0.002%  0.002%  0.001%  0.001%  0.001%  0.001%  0.05%	The uncertainty figures show the best accuracy of application of the calibration force and do not take into account the characteristics of the device being calibrated.  The calibration procedure used may be either in accordance with BS EN ISO 376:2004, ASTM E74- 06, ISO 376:2004, BS 8422:2003 standard and supplementary calibrations A, B, E, L & R, NPL Procedure Document QPMAM/B/070 or as agreed by UKAS.  Forces can be applied incrementally and decrementally thus permitting the determination of hysteresis errors.  In the place of the Newton, calibrations may be requested in the following units: ton-force (tonf), pound-force (lbf) or kilogram-force (kgf).	<b>Teddington</b>
Strain Cylinders	200 kN to 2 MN		Strain cylinders compared with a reference strain cylinder in a 3 MN compression machine in accordance with BS EN 12390- 4:2000.	
<b>Voltage Ratio</b>  Calibration of AC and DC voltage ratio meters used with strain gauge force transducers	0.01 mV/V to 0.05 mV/V 0.05 mV/V to 1.0 mV/V 1.0 mV/V to 2.5 mV/V 2.5 mV/V to 10 mV/V	0.010% 0.005% 0.007% 0.005%	Ratio meters are compared to a reference resistance network using a precision digital voltmeter to measure the voltage ratios generated	



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<b>PRESSURE</b>				<b>Teddington</b>
<u>Gas Pressure (absolute)</u>				
Determination of effective area of deadweight testers	3.5 kPa to 16 kPa 16 kPa to 700 kPa 700 kPa to 7 MPa	0.0023% 0.0021% 0.0025% + 0.25 ppm/MPa		
Calibration of pressure indicating instruments	75 kPa to 110 kPa	5 Pa		
<u>Gas Pressure (gauge)</u>				
Determination of effective area of deadweight testers	3.5 kPa to 16 kPa 16 kPa to 700 kPa 700 kPa to 7 MPa	0.0023% 0.0021% 0.0025% + 0.25 ppm/MPa		
<u>Oil Pressure (gauge)</u>				
Determination of effective area of deadweight testers	500 kPa to 200 MPa 200 MPa to 500 MPa	0.0031% + 0.24 ppm/MPa 0.0038% + 0.24 ppm/MPa		
<b>FIBRE OPTICS</b>			Measurements carried out at $23 \pm 2^\circ\text{C}$ , unless stated otherwise	
Mode field diameter	3.5 $\mu\text{m}$ to 13 $\mu\text{m}$	0.6%	Single-mode fibre from 1250 nm to 1625 nm. Far field scan method Petermann II definition	
Mode field noncircularity	0% to 1%	0.1%		
Effective area	30 $\mu\text{m}^2$ to 90 $\mu\text{m}^2$	2.0%	Far field scan method. Hankel transform	
Dispersion in single-mode optical fibre			Fibre length: 2-50 km	
Dispersion	up to $1.32 \times 10^{-5} \text{ ps.nm}^{-1}$	1.5% added in quadrature with $0.01 \text{ ps.nm}^{-1}.\text{km}^{-1}$	Laser based system	
Zero dispersion wavelength	1250 to 1650 nm	0.1 nm	Laser based system	
Dispersion slope at zero dispersion wavelength	-100 to 100 $\text{ps.nm}^{-1}.\text{km}^{-1}$	1.5%	Laser based systems	



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FIBRE OPTICS (cont'd)			Measurements carried out at $23 \pm 2^\circ\text{C}$ , unless stated otherwise	Teddington
Optical length	0.1 km to 15 km measured in the wavelength range 1270 nm to 1650 nm.	$(0.04 + 1.75 \times 10^{-5} L)$	Single-mode optical fibre, pulsed time of flight technique.  $L$ is optical length in metres	
	15 km to 105 km measured at wavelengths of 1310 nm, 1550 nm & 1625 nm	$(0.1 + 1.75 \times 10^{-5} L)$		
Fibre attenuation coefficient uniformity	0.17 to 0.43 db/km	0.006 dB/km	Single-mode optical fibre (length 4 km to 14 km). Measured using an optical time domain reflectometer (OTDR), 1300 and 1550 nm wavelength windows	
Spectral attenuation of single mode fibre	0.1 dB to 35 dB	0.02 dB	Cut-back technique Wavelength range 1200 - 1650 nm Measurements carried out over the temperature range $18^\circ\text{C}$ to $23^\circ\text{C}$ .	
Spectral attenuation of multimode fibre	0.1 dB to 35 dB	0.02 dB	Cut-back technique Wavelength range 800 - 900 nm 1250 - 1350 nm Measurements carried out over the temperature range $18^\circ\text{C}$ to $23^\circ\text{C}$ .	
Cut-off wavelength of optical fibre and cable	800 - 1600 nm	2 nm	Transmitted power technique Measurements carried out over the temperature range $18^\circ\text{C}$ to $23^\circ\text{C}$ .	
<u>Fibre optic test equipment</u>			Measurements carried out at $20 \pm 2^\circ\text{C}$ , unless otherwise stated	
Absolute responsivity of fibre optic power meters with FC/PC connectors	<i>Power level: -10 to 23 dBm</i>  850 nm $\pm$ 30 nm 1300 nm $\pm$ 25 nm	0.9% 0.7%	Minimum customer meter resolution 2% of stated power levels Multimode fibre	
	980 nm $\pm$ 10 nm 1300 nm $\pm$ 25 nm 1500 nm $\pm$ 30 nm 1550 nm $\pm$ 20 nm 1620 nm $\pm$ 20 nm	0.9% 0.7% 0.8% 0.7% 0.7%	Single mode fibre	
Absolute responsivity of fibre optic power meters with SC/PC connectors	<i>Power level: -10 to 23 dBm</i>  850 nm $\pm$ 30 nm 980 nm $\pm$ 10 nm 1300 nm $\pm$ 25 nm	1.5% 1.5% 1.0%	Minimum customer meter resolution 2% of stated power levels Multimode fibre Single mode fibre Single mode and multi mode fibre	



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<u>Fibre optic test equipment</u> (cont'd)			Measurements carried out at 23 ± 2° C, unless stated otherwise	<b>Teddington</b>
Absolute responsivity of fibre optic power meters with SC/PC connectors (cont'd)	Power level: -10 to 23 dBm		Minimum customer meter resolution 2% of stated power levels	
	1500 nm ± 30 nm	1.0%	Single mode fibre	
	1550 nm ± 20 nm	1.0%		
	1620 nm ± 20 nm	1.0%		
Absolute responsivity of fibre optic power meters with FC/APC or SC/APC connectors	<i>Power level: -10 to 23 dBm</i>		Minimum customer meter resolution 2% of stated power levels	
	1500 nm ± 30 nm	1.6%	Single mode fibre	
	1550 nm ± 20 nm	1.6%		
	1620 nm ± 20 nm	1.6%		
Linearity in fibre optic power meters with FC/PC, SC/PC, FC/APC and SC/APC connectors - Comparison technique	+20 dBm to +10.01 dBm +10 dBm to -90 dBm	0.7% 0.3%	Wavelength range: 830 nm to 1620 nm Single mode and multi mode fibre	
Linearity in fibre optic power meters with FC/PC, SC/PC, FC/APC and SC/APC connectors - Superposition technique	+15 dBm to -90 dBm	0.05%	Wavelength range: 1275 nm to 1640 nm Single mode fibre	
Effective centre wavelength of fibre optic light source with spectral line width <5 nm	800 nm to 1700 nm	0.3 nm	FC/PC connectorised fibre output	
Effective centre wavelength of fibre optic light source with spectral line width in the range 5 nm to 50 nm	800 nm to 1700 nm	1.2 nm	FC/PC connectorised fibre output	
Spectral line width (FWHM) of sources	0.07 to 50 nm	0.10 nm	800 nm to 1700 nm	
Output power stability of fibre optic light sources	10 dBm to -50 dBm	0.004 dB	Wavelength range 800 nm to 1700 nm	
Wavelength accuracy of a wavelength meter	1286 nm to 1355 nm 1480 nm to 1650 nm	0.13 pm	Calibration by reference to a frequency locked standard Measurements performed at 23±2° C	



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Issue No:048 Issue date: 23 December 2009

Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Best Measurement Capability Expressed as an Expanded Uncertainty ( $k=2$ )	Remarks	Location Code
<u>Fibre optic test equipment</u> (cont'd)  Wavelength scale accuracy of an optical spectrum analyser  PARTICLE COUNTERS  <u>Airborne particle number concentration</u>  Calibration factor for condensation particle counters	600 nm to 1700 nm           Concentration range 1000 cm <sup>-3</sup> to 100,000 cm <sup>-3</sup>	10.5 pm           ±7%	Accuracy is typically limited by the instrument under test Measurements performed at 23±2°C           Comparison with an aerosol electrometer	Teddington



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Measured Quantity Instrument or Gauge	Range	Best Measurement Capability Expressed as an Expanded Uncertainty ( $k=2$ )	Remarks	Location Code
<b>INSTRUMENTS FOR AIR QUALITY MONITORING</b>				
Analyser Calibration	NO <sub>x</sub> 200 ppb to 2 ppm SO <sub>2</sub> 150 ppb to 1 ppm O <sub>3</sub> 30 ppb to 1 ppm CO 0.5 ppm to 45 ppm	4%	Two point (zero and span) calibration. An assessment of uncertainty due to analyser repeatability and linearity is also undertaken.	<b>Customers' sites</b>
Determination of on site standard concentration	NO <sub>x</sub> 200 ppb to 2 ppm (NO and NO <sub>2</sub> ) SO <sub>2</sub> 150 ppb to 1 ppm CO 0.5 ppm to 45 ppm	4%		
NO <sub>2</sub> molybdenum converter efficiency test	100 to 250 ppb NO <sub>2</sub>	1.5%	Reaction of NO with O <sub>3</sub>	
Sample system collection efficiency	NO <sub>2</sub> 50 to 150 ppb SO <sub>2</sub> 50 to 150 ppb O <sub>3</sub> 50 to 150 ppb CO 6 to 12 ppm	1.5% absolute 1% absolute 1.5% absolute 1% absolute		
Analyser span noise test	Range as analyser calibration	2 ppb		
Analyser zero noise test	NO <sub>x</sub> , NO, SO <sub>2</sub> , O <sub>3</sub> , CO	1 ppb		
Particulate analyser calibration	0 to 1 mg.m <sup>-3</sup>	1.5%	Using 4 pre-weighed masses	
Particulate analyser flow rate test	1 slm to 10 slm 10 slm to 40 slm	1.5% 2%	Volumetric and mass flow	
END				