## **Schedule of Accreditation**

issued by

## **United Kingdom Accreditation Service**

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



0478

**TW11 0LW** 

Accredited to ISO/IEC 17025:2017

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

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Calibration performed by the Organisation at the locations specified below

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

### **Laboratory locations:**

Location details		Activity	Location code
Address National Physical Laboratory Hampton Road Teddington Middlesex TW11 0LW	Local contact Mr Tahir Maqba, Customer Services Manager Tel: +44 (0)20 8943 6796 Fax: +44 (0)20 8614 0482 Email: tahir.maqba@npl.co.uk	Calibration  Chemical Mass Density and Optical Volume Pressure Dimensional Radiological Electromagnetic Fibre optics Time and Frequency Flow Ultrasonics Force Underwater Acoustics Humidity	Teddington
Address Wraysbury Reservoir Coppermill Road Wraysbury Middlesex TW19 5NW	Local contact Mr J Ablitt Tel: +44 (0)20 8943 6695 Email: justin.ablitt@npl.co.uk	Calibration  Underwater Acoustics	Wraysbury

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

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

Assessment Manager: JG2 Page 1 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

Calibration performed by the Organisation at the locations specified

### CALIBRATION AND MEASUREMENT CAPABILITY (CMC)

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
DC VOLTAGE Service Reference ED01			Direct comparison against Josephson Junction array.	
Standard cells, not thermostated	1.018 V nominal	0.090 μV/V	Measured in a thermostated air enclosure at 20 °C.	
Standard cells in a thermostated enclosure	1.018 V nominal	0.090 µV/V		
Electronic reference standards	1.0 V 1.018 V 10 V	0.14 μV/V 0.14 μV/V 0.020 μV/V	Supplementary data can be supplied showing detailed behaviour of standard cells or electronic devices.	
DC RESISTANCE			Using build up technique referred to quantum Hall	
Service Reference ED02	0.1 mΩ 1 mΩ 10 mΩ 100 mΩ 1 Ω 10 Ω 25 Ω 100 Ω 1 kΩ 10 kΩ 10 kΩ 10 MΩ	2.5 μΩ/Ω 0.85 μΩ/Ω 0.80 μΩ/Ω 0.18 μΩ/Ω 0.060 μΩ/Ω 0.050 μΩ/Ω 0.050 μΩ/Ω 0.050 μΩ/Ω 0.050 μΩ/Ω 0.060 μΩ/Ω 0.080 μΩ/Ω 0.080 μΩ/Ω 0.12 μΩ/Ω 0.20 μΩ/Ω	resistor. 4 terminal resistors at temperatures between 17 °C and 25 °C and at or less than 1 mW power dissipation  2-terminal resistors at temperatures between 17 °C and 25 °C and at or less than	Teddington
	100 ΜΩ	0.40 μΩ/Ω	1 mW power dissipation. Values >10 k $\Omega$ are not measured in oil.	
	1 GΩ	1.6 μΩ/Ω	Measured in a 2-terminal configuration, in air, at 20 °C or 23 °C.	
Temperature Coefficient	αβ	0.0020 μΩ/Ω K <sup>-1</sup> 0.0010 μΩ/Ω K <sup>-2</sup>	Resistance measurements at 4 temperatures in the range 15 °C to 30 °C. Uncertainty dependent on fit to curve and nominal value of resistor.	
Current Carrying Resistors	100 μΩ to 10 Ω 30 mA to 50 A 20 A to 100 A	0.50 μΩ/Ω to 5.0 μΩ/Ω 5.0 μΩ/Ω to 10 μΩ/Ω	Using ratio techniques.	

Assessment Manager: JG2 Page 2 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

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

Assessment Manager: JG2 Page 3 of 67



Accredited to ISO/IEC 17025:2017

1 kV

9.0

23

33

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Cambration performed by the organization at the recations opening													
	ured Qua nent or G		Range			Expanded Measurement Uncertainty ( <i>k</i> = 2)			Remarks			Location Code	
AC/DC TRA						Build up technique against known AC/DC transfer standard.							
Service Re	ference ED	11											
CMCs for AC/DC Transfer Voltage, at Specific Values, expressed as an Expanded Uncertainty ( $k = 2$ ) [10 <sup>-6</sup> of value]  For intermediate points the uncertainty will be determined using linear interpolation between the adjacent points.													
						Frequency	,						
Voltage	10 Hz	20 Hz to 5 kHz	10 kHz	20 kHz	50 kHz	100 kHz	200 kHz	300 kl	Hz	500 kHz	700 kHz	1 MHz	
1 mV	66	66	66	66	71	85	120	180		260	480	800	
2 mV	66	57	57	57	59	71	99	140		190	330	510	
5 mV	28	28	28	28	33	48	83	120		180	290	460	
10 mV	28	28	28	28	33	46	78	110		170	260	410	
20 mV	28	28	28	28	31	46	78	110		160	250	370	
70 mV	26	26	26	26	31	41	76	110		160	250	370	
100 mV	7.0	7.0	7.0	7.0	9.0	14	24	36	'	58	82	120	
200 mV	7.0	7.0	7.0	7.0	9.0	14	24	36		58	82	120	Tec
300 mV	6.0	6.0	6.0	6.0	7.0	11	20	29		48	68	96	di
500 mV	6.0	6.0	6.0	6.0	7.0	10	16	23		38	54	76	Teddington
1 V	6.0	6.0	6.0	6.0	7.0	7.0	13	17		25	38	51	Ön
2 V	6.0	6.0	6.0	6.0	6.0	7.0	10	12		17	27	38	
3 V	6.0	6.0	6.0	6.0	6.0	7.0	10	12		17	27	38	
4 V	6.0	6.0	6.0	6.0	6.0	6.0	8.0	9.0		13	21	31	
5 V	6.0	6.0	6.0	6.0	6.0	6.0	8.0	9.0		13	21	31	
10 V	6.0	6.0	6.0	6.0	6.0	6.0	8.0	10		15	22	32	
20 V	6.0	6.0	6.0	6.0	6.0	7.0	9.0	11		16	25	34	
30 V	6.0	6.0	6.0	6.0	6.0	7.0	11		l				
50 V	7.0	7.0	7.0	7.0	7.0	10	14						
70 V	7.0	7.0	7.0	7.0	7.0	10	14						
100 V	7.0	7.0	7.0	7.0	7.0	10	14						
200 V	8.0	8.0	8.0	10	13	22		J					
300 V	8.0	8.0	8.0	10	13	22							
500 V	11	9.0	10	15	24	42							
600 V	11	9.0	10	19	29	52							
700 V	11	9.0	10	19	29	52							
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Assessment Manager: JG2 Page 4 of 67

62



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

	ured Qu nent or (			Expanded Range Measurement Remarks Uncertainty (k = 2)					Range				Location Code	
AC/DC TRANSFER CURRENT    Build up technique against known AC/DC transfer standard.    Service Reference ED11    CMCs for AC/DC Transfer Current, at Specific Values, expressed as an Expanded Uncertainty (k = 2) [10-6 of value]														
									ed Uncertai ation betwee					
							Frequenc	у						
Current	10 Hz	20 Hz	40 Hz	100 Hz	400 Hz	1 kHz	2 kHz	5 kHz	10 kHz	20 kHz	50 kHz	70 kHz	100 kHz	
1 mA	31	30	30	30	30	30	30	30	30	31	31	33	35	
2 mA	17	17	16	16	16	16	16	16	17	18	19	22	25	
3 mA	12	12	12	12	12	12	12	12	13	14	16	19	22	
5 mA	11	10	10	10	10	10	10	10	12	13	15	19	22	
10 mA	11	10	10	10	10	10	10	10	12	13	15	19	22	
20 mA	11	10	10	10	10	10	10	10	12	13	15	19	22	Teddington
30 mA	11	10	10	10	10	10	10	10	12	13	15	19	22	ding
50 mA	11	10	10	10	10	10	10	10	12	13	15	19	22	yton
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	

Assessment Manager: JG2 Page 5 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expan Measure Uncertaint	ement	Remarks	Location Code
AC VOLTAGE RATIO  Service Reference ED13  Inductive Voltage Dividers		Voltage ratio un		Using AC bridge and build up techniques.	
Voltage ratio		respect to inp (x 10 In-phase	out voltage <sup>[-8</sup> ] <i>Quadrature</i>		
	LF System  40 Hz 60 Hz 80 Hz 100 Hz 120 Hz 200 Hz 300 Hz 400 Hz 800 Hz 1000 Hz 1300 Hz 1592 Hz 2000 Hz 3000 Hz 4000 Hz 4000 Hz 5000 Hz	16 16 12 9.3 7.1 6.1 6.1 6.1 6.1 6.1 6.1 6.1 6.1 6.1 6	17 17 14 11 8.4 7.7 6.9 6.9 6.9 6.9 6.9 6.9 6.9 6.9 6.9	Normal operating range: Minimum voltage: 1 V Maximum voltage: 0.1 x f(Hz) from 40 Hz to 80 Hz; 0.15 x f(Hz) from 100 Hz to 200 Hz; 30 V otherwise.	Teddington
	HF System  5 kHz 8 kHz 10 kHz 20 kHz 30 kHz 40 kHz 50 kHz 100 kHz	21 30 38 72 120 180 280 630 990 1500	21 30 38 75 120 190 300 650 1000 1600	Normal operating range: Minimum voltage: 1 V Maximum voltage: 30 V	

Assessment Manager: JG2 Page 6 of 67



Accredited to ISO/IEC 17025:2017

## Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
AC POWER Service Reference ED06			Using phantom load terchniques.	
Sinusoidal waveforms	40 Hz to 400 Hz: Current 2 mA to 130 A Voltage 1 V to 1000 V	40 μW/VA	20 °C and 23 °C at unity power factor	
		25 μW/VA	20 °C and 23 °C at zero power factor	
			Uncertainties increase at other power factors	
Current Response of Wattmeters	2 mA to 20 A	30 μW/VA	20 °C and 23 °C	
Voltage Response of Wattmeters	1 V to 1000 V	25 μW/VA	20 °C and 23 °C	
Auxiliary DC Voltage	DC, 1 V to 10 V	5.0 μV/V	20 °C and 23 °C	
AC REACTIVE VOLT-AMPERES	50 Hz to 400 Hz:			
Sinusoidal waveforms	Current 2 mA to 130 A Voltage 1 V to 1000 V	40 μW/VA	20 °C and 23 °C at zero power factor	Ted
	Tollage . T to 1000 !	25 μW/VA	20 °C and 23 °C at unity power factor	Teddington
			Uncertainties increase at other power factors	ton
CALIBRATION OF EN 61000 Service Reference ED17	I HARMONIC AND FLICKER A 	I NALYSERS 		
Sinusoidal waveforms				
Current accuracy	100 mA to 20 A, <i>50 Hz</i>	40 μA/A		
Current frequency response	100 mA to 20 A 50 Hz to 2 kHz	150 µA/A		
Voltage accuracy	1 V to 1000 V, <i>50 Hz</i>	30 μV/V		
Power measurements	Ranges as in AC Power above	45 x 10 <sup>-6</sup> of full-scale	At unity power factor	
Non-sinusoidal waveforms				
Harmonic measurements for current waveforms	Peak values 1A to 10 A 50 Hz fundamental; harmonics up to 2 kHz	200 μA/A	Steady-state, burst fluctuating or smoothly fluctuating harmonics	

Assessment Manager: JG2 Page 7 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge			Remarks	Location Code
CALIBRATION OF EN 61000 HARMONIC AN (continued)	 D FLICKER ANALYSERS			
Flicker (Pst)	0.95 Pst to 1.05 Pst Square or sine wave modulated, 230 V 50 Hz sine wave	0.30 % of Pst reading		
	0.95 Pst to 2.05 Pst Complex waveforms, 230 V 50 Hz sine wave	0.20 % of Pst reading		
CAPACITANCE and DISSIPATION				
FACTOR Service Reference ED04			Using Coaxial bridge techniques. Capacitance and dissipation factor measurements are normally carried out between 20 °C and 23 °C but may exceptionally be carried out at any temperature between 18 °C and 25 °C.	Те
Fused-silica dielectric capacitors	1 pF 10 pF 100 pF	C D 0.90 μF/F 7.0 x 10 <sup>-6</sup> 0.70 μF/F 6.0 x 10 <sup>-6</sup> 0.90 μF/F 7.0 x 10 <sup>-6</sup>	Measurements are normally made at 1 kHz or 1.592 kHz. Other frequencies between 20 Hz and 100 kHz may be used but the uncertainty will be increased in a complex	Teddington
Other types of capacitor	1 pF 10 pF to 1 nF	4.0 μF/F   1.0 x 10 <sup>-5</sup> 3.0 μF/F   7.0 x 10 <sup>-6</sup>	manner that varies with frequency and capacitance.	
Four-terminal pair capacitors	1 pF to 1 nF 10 nF to 100 nF 1 μF 10 μF 100 μF 1 mF	100 μF/F		
General Radio Type 1417	1 μF to 10 mF	0.10 % to   0.0010 to   0.50 %	100 Hz, 120 Hz and 1 kHz	
	100 mF to 1 F	0.30 % to	100 Hz and 120 Hz	

Assessment Manager: JG2 Page 8 of 67



Accredited to ISO/IEC 17025:2017

## Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

#### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge		Range		Expanded Measurement Uncertainty ( <i>k</i> = 2)				Location Code
SELF-INDUCTA Service Referer	_					Using AC bridge tec	hniques.	
	Expande	ed uncertainty in μ	H/H at 95% c	onfidence level (k = 2	2) for the frequ	uencies shown		
Nominal	-	1	100 Hz		1.592 kH	7	1	
value	20 Hz	50 Hz	400 Hz	1 kHz	2 kHz	5 kHz	10 kHz	
4 11			00000	4000	4000	0500	0500	
1 μΗ			20000	1000	1000	2500	3500	
2 μΗ			10000	1000	1000	2200	3000	
3 μH			6100	1000	1000	2200	2600	
5 μH	2500	2500	3500	600	600	1100	1500	
10 μH	3500	2500	2000	310	350	620	930	
20 μΗ	1800	1300	1000	150	160	320	460	
30 μH	1200	840	670	110	120	190	260	
50 μH	700	500	400	100	100	160	200	
100 μΗ	300	200	150	75	80	120	150	
200 μΗ	250	180	100	75	85	110	150	
300 μΗ	250	180	100	85	85	120	150	
500 H	220	160	100	80	80	100	150	
1 mH	180	150	95	70	75	100	150	
2 mH 3 mH	180 180	150 150	100 100	75 85	80 85	110 120	150 150	
5 mH	180	160	100	80	80	110	150	Teddington
10 mH	180	150	100	70	70	100	130	<u>d</u>
20 mH	180	150	100	75	75	110	130	gn
30 mH	180	150	100	85	85	110	150	<u></u>
50 mH	200	160	100	80	80	160	200	_ =
100 mH	190	150	85	70	70	140	200	
200 mH	230	200	90	75	75	200	300	
400 mH	240	200	90	75	75	200	380	
500 mH	240	210	90	80	80	200	400	
1 H	140	110	85	70	70	200	400	
2 H	140	110	85	70	70			
5 H	140	110	85	80	85			
10 H	140	110	85	80	85			
MUTUAL INDU Service Referer		At 1 kHz: 100 μH 1 mH 5 mH 10 mH		150 μH/H 100 μH/H 80 μH/H 70 μH/H 70 μH/H		Measurements can at frequencies of 20 but the uncertainties increased.	Hz and 50 Hz	

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.

Assessment Manager: JG2 Page 9 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
MAGNETIC QUANTITIES Service Reference MT41				
DC MAGNETIC FIELD STRENG	I TH AND MAGNETIC FLUX DEI	NSITY		
	0.8 mA/m (1 nT) to 16 A/m (20 μT)	0.15 % + 0.4 mA/m (0.5 nT)	Using fluxgate magnetometer.	
	16 A/m (20 μT) to 72 A/m (90 μT)	0.0030 %	Using ptoton resonace magnetometer.	
	72 A/m (90 μT) to 280 A/m (350 μT)	0.050 %	Resonance method.	
	280 A/m (350 μT) to 40 kA/m (50 mT)	0.20 %	Using Hall effect gaussmeter.	
	40 kA/m (50 mT) to 10.5 MA/m (13 T)	0.0015 %	Using NMR gaussmeter.	
AC MAGNETIC FIELD STRENG	I TH AND MAGNETIC FLUX DEI I	NSITY	Comparison against reference coils.	
	8 mA/m (10 nT) to 17.5 kA/m (22 mT) 10 Hz to 60 Hz	0.25 %		Teddington
	8 mA/m (10 nT) to 80 A/m (100 μT) 60 Hz to 20 kHz	0.25 %		ton
	8 mA/m (10 nT) to 40 A/m (50 μT) 20 kHz to 50 kHz	0.40 %		
	8 mA/m (10 nT) to 15.9 A/m (20 μT) 50 kHz to 120 kHz	0.70 %		
MAGNETIC FIELD STRENGTH	TO CURRENT RATIO			
Standard solenoids and Helmholtz coils	1 A/m/A to 20 000 A/m/A DC 12 Hz to 60 Hz 60 Hz to 20 kHz	0.015 % 0.050 % 0.25 %	Using reference magnetometer and residual field cancellation technique.	

Assessment Manager: JG2 Page 10 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

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MAGNETIC QUANTITIES (continued)				
TURN AREA (effective area)			Using standard solenoid or Helmholtz coils.	
Search coils	0.0029 m <sup>2</sup> to 17 m <sup>2</sup> 12 Hz to 60 Hz	0.090 %		
	0.0001 m <sup>2</sup> to 200 m <sup>2</sup> 60 Hz to 20 kHz 20 kHz to 50 kHz 50 kHz to 120 kHz	0.25 % 0.40 % 0.70 %		
NORMAL DC MAGNETIZATION	I CURVES AND HYSTERESIS I	I _OOPS		
Ring specimens	H = 0.1 kA/m to 10 kA/m B = 0.05 T to 2.5 T	0.30 % 0.30 %	In accordance with EN 60404 Part 4: 1997 and IEC 60404 Part 4:2008.	
Bar or rod specimens	H = 0.1 kA/m to 200 kA/m B = 0.05 T to 2.5 T	0.30 % 0.30 %	In accordance with EN 60404 Part 4: 1997 and IEC 60404 Part 4:2008.	
DC DEMAGNETIZATION CURV	I E FOR HARD MAGNETIC MAT	I ERIALS		Ted
Remanence	B <sub>r</sub> = 0.02 T to 2 T	0.30 %		Teddington
Coercivity	H <sub>CB</sub> = 0.03 to 1.2 MA/m H <sub>CJ</sub> = 0.03 to 1.6 MA/m	0.40 % 0.40 %	In accordance with BS EN 60404 Part 5: 2007 and IEC 60404 Part 5: 2007.	on
Maximum energy product	$(B.H)_{max} = 1 \text{ to } 400 \text{ kJ/m}^3$	0.50 %		
DC RELATIVE MAGNETIC PER	I MEABILITY, μ <sub>r</sub>			
For low magnetic Permeability materials	$(\mu_r - 1) = 0.001 \text{ to } 1.5$ $(\mu_r - 1) = 0.0002 \text{ to } 0.001$	0.20 % 2.2 %	In accordance with BS EN 60404 Part 15: 2012	
Permeability measuring instruments and indicators	$(\mu_r - 1) = 0.001$ to 1.5	0.20 %	The uncertainty may be increased depending on the characteristics of the device being calibrated	

Assessment Manager: JG2 Page 11 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
SPECIFIC TOTAL POWER LOSS  0. Ai J J J J Soft magnetic materials in ring form only  SPECIFIC APPARENT POWER  Ai J J J J J J J J J J J J J	0.06 Am² to 1000 Am²  0.02 W/kg to 400 W/kg  0.15 50 Hz to 2000 Hz  = 0.1 T to 1.3 T  0.15 T to 1.5 T  = 1.5 T to 1.7 T  = 1.7 T to 1.8 T  = 1.8 T to 1.9 T  0.02 W/kg to 120 W/kg  0.04 Hz to 1000 Hz  = 1 mT to 100 mT  0.06 VA/kg to 450 VA/kg  0.15 O Hz to 2000 Hz  = 0.1 T to 1.3 T  0.15 T to 1.5 T  = 1.5 T to 1.7 T  = 1.7 T to 1.8 T  = 1.8 T to 1.9 T	0.40 % 0.40 % 0.55 % 0.75 % 1.0 %  0.60 % 0.70 % 1.3 % 2.7 % 5.0 %	Using detection coil and integrating fluxmeter.  For strips: f >400 Hz IEC 60404-2 BS EN 60404-2 f = 400 Hz to 1 kHz IEC 60404-10 BS EN 10252  For sheets: IEC 60404-3 BS EN 10280  For oriented and non-oriented materials	Teddington

Assessment Manager: JG2 Page 12 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
MAGNETIC QUANTITIES (continued)				
APPARENT POWER	0.06 VA/kg to 400 VA/kg		Method of	
Soft magnetic materials in ring form only	50 Hz to 100 kHz J = 1 mT to 100 mT	1.1 %	measurement:  For strips: IEC 60404 Part	
AC PERMEABILITY (rms or peal	values)		2:2008 BS EN 60404-2: 1998	
Oriented and non-oriented materials	$\mu_r$ = 500 to 200 000 At 50 Hz and 60 Hz B = 0.5 T to 2.2 T H = 0.5 kA/m to 10 kA/m	0.45 %	For sheets: IEC 60404 Part 3:2010 BS EN 10280: 2001	
AC MAGNETIC FIELD STRENG	l TH (rms or peak values) I		Method of measurement (for strips) in accordance with	
Oriented and non-oriented materials	At 50 Hz and 60 Hz H = 0.5 kA/m to 10 kA/m	0.45 %	IEC 60404 Part 2: 2008, BS EN 60404 Part 2:1998 and (for sheets), IEC 60404 Part 3:2010 BS EN 10280: 2001.	
AC CONDUCTIVITY Service Reference MT41			0.2510 25 2.4 10250. 2001.	Те
AC conductivity reference materials	2 MS/m to 60 MS/m (3.45 % <sub>IACS</sub> to 103 % <sub>IACS</sub> ) 60 kHz, 20°C	0.70 %	Calibration of sets of reference materials produced by NPL.	Teddington
AC conductivity instruments	2 MS/m to 60 MS/m (3.45 % <sub>IACS</sub> to 103 % <sub>IACS</sub> ) 60 kHz, 20°C	0.70 %	Using materials of known conductivity.	
DC RESISTIVITY AND CONDUCTIVITY Service Reference MT41				
Resistivity: Soft magnetic sheet materials	1.4 x 10 <sup>-7</sup> $\Omega$ ·m to 7.0 x 10 <sup>-7</sup> $\Omega$ ·m Temperature 20 °C Test Current ≥ 0.5 A	0.20 %	Four point resistivity measurement of electrical steel strip samples in accordance with IEC 60404-13.	
Resistivity: Soft magnetic sheet materials	1.4 x 10 <sup>-7</sup> $\Omega$ ·m to 7.0 x 10 <sup>-7</sup> $\Omega$ ·m Temperature -40 °C to +200 °C Test Current ≥ 0.5 A	0.25 %	Four point resistivity measurement of electrical steel strip samples.	
Electrical conductivity: Metallic bars of length >200 mm	0.58 MS/m to 65 MS/m (1.0 % <sub>IACS</sub> to 112 % <sub>IACS</sub> ) <i>Temperature 20 °C</i>	0.20 %	Resistivity determined from resistance, cross-sectional area and knife edge separation.	

Assessment Manager: JG2 Page 13 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
DC RESISTIVITY AND CONDUCTIVITY (continued)				
Electrical conductivity: Metallic bars, sheet, wires, reference materials	0.58 MS/m to 65 MS/m (1.0 % <sub>IACS</sub> to 112 % <sub>IACS</sub> ) <i>Temperature -40 °C to</i> +200 °C	0.25 %	Resistivity determined from resistance, cross-sectional area and knife edge separation. Also includes similar methodology using the Van der Pauw technique.	
POWER FLUX DENSITY CW SIGNALS Service Reference EF01				
	0.11 nW/cm <sup>2</sup> to 170 mW/cm <sup>2</sup> 10 Hz to 10 kHz	0.68 dB	TEM Cells The maximum frequency and power flux density level is determined by the size of the probe.	
	0.11 nW/cm <sup>2</sup> to 265 mW/cm <sup>2</sup> 10 kHz to 300 MHz	0.68 dB	Anechoic Chambers The Listed Field levels are	
			derived from the lowest unsaturated maximum power in each range. The achievable level may be up to 20 % greater than the stated limit.	
	0.03 nW/cm² to 38 mW/cm² 240 MHz to 270 MHz	0.65 dB	All probes and small active dipoles	
	0.03 nW/cm <sup>2</sup> to 65 mW/cm <sup>2</sup> 270 MHz to 350 MHz	0.65 dB	All probes and small active dipoles	
	0.03 nW/cm <sup>2</sup> to 87 mW/cm <sup>2</sup> 350 MHz to 500 MHz	0.65 dB	All probes and small active dipoles	
	0.03 nW/cm <sup>2</sup> to 37 mW/cm <sup>2</sup> 450 MHz to 550 MHz	0.62 dB	All probes and small active dipoles	
	0.03 nW/cm² to 72 mW/cm² 550 MHz to 750 MHz	0.62 dB	All probes and small active dipoles	
	0.03 nW/cm <sup>2</sup> to 72 mW/cm <sup>2</sup> 750 MHz to 950 MHz	0.62 dB	All probes and small active dipoles	

Assessment Manager: JG2 Page 14 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
POWER FLUX DENSITY (continued)	0.03 nW/cm² to 38 mW/cm² 950 MHz to 1200 MHz	0.62 dB	All probes and small active dipoles	
	0.03 nW/cm <sup>2</sup> to 138 mW/cm <sup>2</sup> 1100 MHz to 1250 MHz	0.47 dB	All probes and small active dipoles	
	0.03 nW/cm² to 170 mW/cm² 1250 MHz to 1700 MHz	0.47 dB	All probes and small active dipoles	
	0.03 nW/cm <sup>2</sup> to 227 mW/cm <sup>2</sup> 1700 MHz to 2600 MHz	0.47 dB	All probes and small active dipoles	
	0.7 nW/cm <sup>2</sup> to 569 mW/cm <sup>2</sup> 2.45 GHz to 2.7 GHz	0.40 dB	All probes and small active dipoles	
	0.7 nW/cm <sup>2</sup> to 921 mW/cm <sup>2</sup> 2.7 GHz to 8.2 GHz	0.40 dB	All probes and small active dipoles	
	0.7 nW/cm² to 694 mW/cm² 8.2 GHz to 18 GHz	0.40 dB	All probes and small active dipoles	
	1.7 μW/cm² to 92 mW/cm² 18 GHz to 40 GHz	0.35 dB	All probes and small active dipoles	
	0.11 μW/cm² to 10 mW/cm² 40 GHz to 48 GHz	0.35 dB	All probes and small active dipoles	
	0.12 μW/cm² to 0.1 mW/cm² 48 GHz to 50 GHz	0.35 dB	All probes and small active dipoles	
	0.2 μW/cm² to 0.52 mW/cm² 50 GHz to 75 GHz	0.42 dB	All probes and small active dipoles	

Assessment Manager: JG2 Page 15 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 16 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 17 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
0.03 mA/m to 1.5 A/m 350 MHz to 500 MHz	0.65 dB	All probes and small active dipoles	
0.03 mA/m to 1.0 A/m 450 MHz to 550 MHz	0.62 dB	All probes and small active dipoles	
0.03 mA/m to 1.4 A/m 550 MHz to 750 MHz	0.62 dB	All probes and small active dipoles	
0.03 mA/m to 1.4 A/m 750 MHz to 950 MHz	0.62 dB	All probes and small active dipoles	
0.03 mA/m to 1.0 A/m 950 MHz to 1200 MHz	0.62 dB	All probes and small active dipoles	
0.03 mA/m to 1.9 A/m 1100 MHz to 1250 MHz	0.47 dB	All probes and small active dipoles	
0.03 mA/m to 2.1 A/m 1250 MHz to 1700 MHz	0.47 dB	All probes and small active dipoles	
0.03 mA/m to 2.4 A/m 1700 MHz to 2600 MHz	0.47 dB	All probes and small active dipoles	
	0.03 mA/m to 1.5 A/m 350 MHz to 500 MHz  0.03 mA/m to 1.0 A/m 450 MHz to 550 MHz  0.03 mA/m to 1.4 A/m 550 MHz to 750 MHz  0.03 mA/m to 1.4 A/m 750 MHz to 950 MHz  0.03 mA/m to 1.0 A/m 950 MHz to 1200 MHz  0.03 mA/m to 1.9 A/m 1100 MHz to 1250 MHz  0.03 mA/m to 2.1 A/m 1250 MHz to 1700 MHz	Range       Measurement Uncertainty (k = 2)         0.03 mA/m to 1.5 A/m 350 MHz to 500 MHz       0.65 dB         0.03 mA/m to 1.0 A/m 450 MHz to 550 MHz       0.62 dB         0.03 mA/m to 1.4 A/m 550 MHz to 750 MHz       0.62 dB         0.03 mA/m to 1.4 A/m 750 MHz to 950 MHz       0.62 dB         0.03 mA/m to 1.0 A/m 950 MHz to 1200 MHz       0.62 dB         0.03 mA/m to 1.9 A/m 1100 MHz to 1250 MHz       0.47 dB         0.03 mA/m to 2.1 A/m 1250 MHz to 1700 MHz       0.47 dB         0.03 mA/m to 2.4 A/m       0.47 dB	Range         Measurement Uncertainty (k = 2)         Remarks           0.03 mA/m to 1.5 A/m 350 MHz to 500 MHz         0.65 dB         All probes and small active dipoles           0.03 mA/m to 1.0 A/m 450 MHz to 550 MHz         0.62 dB         All probes and small active dipoles           0.03 mA/m to 1.4 A/m 550 MHz to 750 MHz         0.62 dB         All probes and small active dipoles           0.03 mA/m to 1.4 A/m 750 MHz to 950 MHz         0.62 dB         All probes and small active dipoles           0.03 mA/m to 1.0 A/m 950 MHz to 1200 MHz         0.62 dB         All probes and small active dipoles           0.03 mA/m to 1.9 A/m 1100 MHz to 1250 MHz         0.47 dB         All probes and small active dipoles           0.03 mA/m to 2.1 A/m 1250 MHz to 1700 MHz         0.47 dB         All probes and small active dipoles           0.03 mA/m to 2.4 A/m 1700 MHz to 2600 MHz         0.47 dB         All probes and small active dipoles

Assessment Manager: JG2 Page 18 of 67



Accredited to ISO/IEC 17025:2017

## Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
POWER FLUX DENSITY PULSE SIGNALS Service Reference EF01	The field levels shown below are derived from the lowest unsaturated maximum power in each range. The achievable level may be up to 20 % greater than the stated limit.		Pulse repetition frequency 200 Hz to 20 kHz. Pulse width 3 $\mu$ s to 100 $\mu$ s for $f_c$ between 240 MHz and 2.6 GHz. Pulse width 1 $\mu$ s to 100 $\mu$ s for $f_c$ between 2.45 GHz and 18 GHz.	
Power Flux Density and free space equivalent Magnetic Flux Density			Temperature 23 °C ± 2 °C	
	97 μW/cm² to 38 mW/cm² 240 MHz to 270 MHz	0.65 dB	Coaxial systems	
	97 μW/cm² to 65 mW/cm² 270 MHz to 350 MHz	0.65 dB		
	97 μW/cm² to 87 mW/cm² 350 MHz to 500 MHz	0.65 dB		
	97 μW/cm² to 37 mW/cm² 450 MHz to 550 MHz	0.63 dB		
	97 μW/cm² to 72 mW/cm² 550 MHz to 750 MHz	0.63 dB		Teddi
	97 μW/cm² to 72 mW/cm² 750 MHz to 950 MHz	0.63 dB		Teddiongton
	97 μW/cm² to 47 mW/cm² 950 MHz to 1200 MHz	0.63 dB		_
	97 μW/cm² to 138 mW/cm² 1100 MHz to 1250 MHz	0.49 dB		
	97 μW/cm² to 170 mW/cm² 1250 MHz to 1700 MHz	0.49 dB		
	97 μW/cm² to 227 mW/cm² 1700 MHz to 2600 MHz	0.49 dB		
	0.6 mW/cm² to 5100 mW/cm² 2.45 GHz to 2.7 GHz	0.42 dB	Waveguide systems	
	0.6 mW /cm² to 3450 mW/cm² 2.7 GHz to 8.2 GHz	0.42 dB		
	0.5 mW /cm² to 5900 mW/cm² 8.2 GHz to 18 GHz	0.42 dB		

Assessment Manager: JG2 Page 19 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 20 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 21 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 22 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 23 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 24 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
ANTENNA COMPLEX REFLECTION COEFFICIENT	0 to 0.5, real and imaginary parts, higher reflections with increased uncertainty.		The uncertainties for complex reflection coefficient apply to both real and imaginary parts. All measurements are performed at 23 °C	
Waveguide feed	2.6 GHz to 3.95 GHz 3.3 GHz to 4.9 GHz 3.95 GHz to 5.85 GHz 5.4 GHz to 8.2 GHz 7.05 GHz to 10 GHz 8.2 GHz to 12.4 GHz 10 GHz to 15 GHz 12.4 GHz to 18 GHz 18 GHz to 26.5 GHz 26.5 GHz to 40 GHz 33 GHz to 50 GHz 40 GHz to 60 GHz 50 GHz to 75 GHz 75 GHz to 110 GHz	0.0080 0.0080 0.0080 0.0080 0.0080 0.0080 0.0080 0.0080 0.0080 0.0080 0.013 0.015 0.015	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 24 Waveguide No 25 Waveguide No 27	
7 mm coaxial feed	1 GHz to 1.5 GHz 1.5 GHz to 18 GHz 1 GHz to 8.2 GHz 8.2 GHz to 18 GHz	0.015 0.011 0.013 0.018	$50~\Omega$ Type N connectors $50~\Omega$ Type N connectors $50~\Omega$ GPC-7 connectors $50~\Omega$ GPC-7 connectors	Тес
3.5 mm coaxial feed	1 GHz to 8.2 GHz 8.2 GHz to 18 GHz 18 GHz to 26.5 GHz	0.010 0.020 0.029	$50~\Omega$ GPC-3.5 connectors $50~\Omega$ GPC-3.5 connectors $50~\Omega$ GPC-3.5 connectors	Teddington
2.92 mm coaxial feed	1 GHz to 26.5 GHz 26.5 GHz to 40 GHz	0.028 0.043	50 $\Omega$ 2.92 mm connectors 50 $\Omega$ 2.92 mm connectors	
2.4 mm coaxial feed	1 GHz to 26.5 GHz 26.5 GHz to 40 GHz 40 GHz to 50 GHz	0.021 0.041 0.056	$50~\Omega$ 2.4 mm connectors $50~\Omega$ 2.4 mm connectors $50~\Omega$ 2.4 mm connectors	
			Devices fitted with coaxial connectors other than those listed above may be calibrated but the uncertainties may be increased.	
ANTENNA FACTOR Service Reference: EF06	-30 dB/m to +80 dB/m		Calibrations to meet the requirements of ARP 958, ANSI C63.5 (2006 & 2017), CISPR 16-1-6.	
Linear dipole	20 MHz to 500 MHz 500 MHz to 1000 MHz	0.35 dB 0.50 dB	Defined height, tuned element	
Linear dipole	20 MHz to 40 MHz 40 MHz to 1000 MHz	0.70 dB 0.50 dB	Free-space, tuned element	

Assessment Manager: JG2 Page 25 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 26 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
ATTENUATION Service Reference EG03  Coaxial Line	0 dB to 100 dB		Comparison with inductive voltage divider using down-conversion techniques.  50 Ω 14 mm Coaxial Line	
			(GR-900 connector) up to 8 GHz.  50 Ω 7 mm Coaxial Line:  Standard N-Type connector up to 12.4 GHz; Precision N-type 3.5mm, 2.92 mm, 2.4 mm and GPC-7 connectors to 18 GHz.	
	0.5 MHz to 18 GHz	(0.00060 dB per 10 dB) + 0.00060 dB		
	100 dB to 120 dB 0.5 MHz to 100 MHz	0.00080 dB per 10 dB		
	120 dB to 130 dB 0.5 MHz to 100 MHz	(0.0010 dB per 10 dB) + 0.010 dB	NOTE	
			The uncertainties for attenuation apply to the measurement of a device that is well matched to the ideal characteristic impedance of the transmission line system. The quoted uncertainty will be increased for other devices to account for mismatch and repeatability, when these contributions exceed those which have been allowed for in this Schedule.	Teddington

Assessment Manager: JG2 Page 27 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 28 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
COMPLEX REFLECTION COEFFICIENT (in support of Attenuation and Power calibrations)			Using VNA techniques	
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 10 kHz to 18 GHz 10 kHz to 18 GHz	0.0040 0.0040 0.0040 0.0040 0.0040 0.0040 0.0040 0.0040 0.0040 0.0040 0.0040 0.0040 0.0040 0.0040 0.0040	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 25 Waveguide No 27  50 Ω APC-7 or Type N Connectors.  50 Ω 3.5 mm connectors. Measurements may be made up to 33 GHz however the uncertainties may be increased.	Teddington
	Frequency range as for Magnitude	sin <sup>-1</sup> (magnitude uncertainty)° magnitude	If the magnitude is less than its uncertainty, then the phase uncertainty is 180°	

Assessment Manager: JG2 Page 29 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
TIME AND FREQUENCY Service Reference TT02 Characterisation of GPS discip Time offset Time offset Frequency	plined oscillators and frequency sta From UTC (NPL) From UTC 5 MHz and 10 MHz	ndards  1.5 ns 6.3 ns  7.5 x 10 <sup>-15</sup> Minimum measurement period 24 hours.	Calibration of frequency standards with a 1 pulse per second output can also be undertaken.	Teddington
Time delay (coaxial cables)	0 ns to 300 ns	1.0 ns	For cable characterisation in support of GPSDO calibration.	
Service Reference TT04 Remote characterisation of GF Time offset Time offset Time offset Frequency	PS disciplined oscillators and frequest Weekly values relative to UTC (NPL)  Weekly values relative to estimated UTC  Post-processed values relative to corrected UTC data  5 MHz and 10 MHz	ency standards  20 ns  40 ns  5 ns  1.0 x 10 <sup>-13</sup> Minimum measurement period 24 hours.	The capability relates to a remote common-view service where NPL-supplied software gathers data and returns it to NPL for processing. The user is supplied with instructions for the setting up of the equipment and the antenna.  Calibration of frequency standards with a 1 pps output can also be undertaken.	Customers' sites

Assessment Manager: JG2 Page 30 of 67



Accredited to ISO/IEC 17025:2017

## Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

	ıred Qu nent or	uantity Gauge Range				ı		cpand asurer tainty	nent	)		Re	emark	s		Location Code		
			Primary Impedance Measurement System (PIMMS)															
			Service Reference EG02															
NOTES																		
For the linear voltage reflection and transmission coefficient measurands (i.e. complex-valued <i>S</i> -parameters) described in this section of the Schedule, the uncertainty is shown as an interval of values, where a selected value within the interval represents an expanded uncertainty at a level of confidence of approximately 95%. Furthermore, a selected value within the interval will represent the uncertainty applied equally and simultaneously to <i>both</i> the Real and Imaginary parts of the <i>S</i> -parameter. The uncertainty value therefore defines a circular region of uncertainty, in the appropriate complex <i>S</i> -parameter plane, centred on the measured, quoted, mean value with radius equal to the stated expanded uncertainty. The corresponding <i>k</i> value will not be less than 2.5.																		
For Voltage interval is pr is dependen $0 \le  VTC  \le$	esented a t on the r	applicab	le for a	II  VRĆ	in the ra	inge 0 ≤	[VRC]	≤ 1. Fo	r Voltag	je Trans	missior	Coeffic	cients (\	/TCs), tl	he state	d uncer	tainty	
Voltage Re	flection (	Coefficie	ent Mac	nitude	(IVRCI)	in 50 C	) coaxia	al syste	ms Me	easuren	nents m	nav be i	made u	sina oth	ner 50 (	O coaxia	al	
connector t											1101110 11	iay bo	nado a	onig ou	101 00 1	- COUNT	<u>.</u>	
Connector			1	ı	ı		ı	F	requen	cy (GH	z)	ı	ı	•		,		
Туре	VRC	0.01	0.02	0.04	0.045	0.05	0.07	0.09	0.1	0.2	0.3	0.5	1.0	1 to 7.5	7.5 to 8.5	8.5 to 18	18 to 26.5	
7-16	0 to 0.5				0.002	0.002	0.002	0.002	0.002	0.002	0.0015	0.0015	0.001	0.001	0.5		20.5	
7-16	0.5 to 0.7				0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.002	0.002	0.002	0.002				Te
7-16	0.7				0.003	0.003	0.003	0.003	0.003	0.003	0.0025	0.0025	0.0025	0.0025				ddi
7-16	0.9				0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.003	0.003	0.003	0.003				Teddington
7-16	1.0				0.004	0.004	0.004	0.004	0.004	0.004	0.0035	0.0035	0.0035	0.0035				Ö
GR900	0 to 0.5				0.002	0.002	0.002	0.002	0.002	0.002	0.0015	0.0015	0.001	0.001	0.001			
GR900	0.5 to 0.7				0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.002	0.002	0.002	0.002	0.002			
GR900	0.8				0.003	0.003	0.003	0.003	0.003	0.003	0.0025	0.0025	0.0025	0.0025	0.0025			
GR900	0.9				0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.003	0.003	0.003	0.003	0.003			
GR900	1.0				0.004	0.004	0.004	0.004	0.004	0.004	0.0035	0.0035	0.0035	0.0035	0.0035		:	
GPC-7	0 to 0.6	0.0055	0.0045	0.004	0.004	0.004	0.004	0.0035	0.0035	0.0035	0.003	0.003	0.0025	0.0025	0.0025	0.0025		
GPC-7	0.6 to 0.8	0.0055	0.005	0.0045	0.0045	0.0045	0.0045	0.004	0.004	0.004	0.0035	0.0035	0.003	0.003	0.003	0.003	:	
GPC-7	0.9	0.006	0.0055	0.005	0.005	0.005	0.005	0.0045	0.0045	0.0045	0.004	0.004	0.004	0.0035	0.0035	0.0035		
GPC-7	1.0	0.0065	0.0055	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.0045	0.0045	0.0045	0.004	0.004	0.004		
Type-N	0 to 0.6	0.0055	0.0045	0.004	0.004	0.004	0.004	0.0035	0.0035	0.0035	0.003	0.003	0.0025	0.0025	0.0025	0.0025		
Type-N	0.6 to 0.8	0.0055	0.005	0.0045	0.0045	0.0045	0.0045	0.004	0.004	0.004	0.0035	0.0035	0.003	0.003	0.003	0.003		
Type-N	0.9	0.006	0.0055	0.005	0.005	0.005	0.005	0.0045	0.0045	0.0045	0.004	0.004	0.004	0.0035	0.0035	0.0035		
Type-N	1.0	0.0065	0.0055	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.0045	0.0045	0.0045	0.004	0.004	0.004		
3.5 mm	0 to 0.8				0.01	0.0095	0.009	0.0085	0.008	0.007	0.007	0.0065	0.006	0.005	0.005	0.005	0.005	
3.5 mm	0.8 to 1.0				0.01	0.01	0.0095	0.009	0.0085	0.0075	0.0075	0.007	0.0065	0.0055	0.0055	0.0055	0.0055	

Assessment Manager: JG2 Page 31 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quant Instrument or Gau		R	dange	Expanded Measurement Uncertainty ( <i>k</i> =		Re	emarks	Location Code
	Primary Impedance Measurement System (PIMMS) (continued)							
	Vol	tage Reflec	tion Coefficient Mag	gnitude ( VRC ) in wavegu	ide systems			
Marra arrida aiza				Frequency (GHz)				
Waveguide size	5.4	to 8.2	8.2 to 12.4	12.4 to 18	18 to	26.5	26.5 to 40	
R70	0.	001						
R100			0.001	0.0045	4			
R140 R220				0.0015	0.0	015		
R320					0.0	1013	0.003	
11020	Volta	ne Transmis	sion Coefficient Ma	ignitude ( VTC ) in 50 Ω co	navial system	ne	0.000	
			and corresponding		Janiai System			
Connector Type	е		ertion loss (dB)	Frequency		Minimum	uncertainty (VTC)	
7-16			1 (0 dB)	10 MHz to 7.5			0.00040	
7-16			0.316 (10 dB)	10 MHz to 7.5			0.00035	
7-16 7-16		0	0.1 (20 dB) .0316 (30 dB)	10 MHz to 7.5 10 MHz to 7.5			0.00020 0.00010	
7-16			0.01 (40 dB)	10 MHz 100 I			0.00010	
7-16			0.01 (40 dB)	100 MHz to 7.5			0.00005	
7-16			00316 (50 dB)	10 MHz to 100	MHz		0.00010	
7-16		0.	00316 (50 dB)	100 MHz to 7.5	5 GHz		0.00004	
			1 (O ID)	45.441.4.0.5	011		0.00040	l de
14 mm		<b> </b>	1 (0 dB)	45 MHz to 8.5			0.00040	Teddington
14 mm 14 mm			0.316 (10 dB) 0.1 (20 dB)	45 MHz to 8.5 45 MHz to 8.5			0.00035 0.00020	5
14 mm		0	.0316 (30 dB)	45 MHz to 8.5			0.00020	gtc
14 mm			0.01 (40 dB)	45 MHz 100 I			0.00010	ă
14 mm			0.01 (40 dB)	100 MHz to 8.5			0.00005	
14 mm			00316 (50 dB)	45 MHz to 100	MHz		0.00010	
14 mm		0.	00316 (50 dB)	100 MHz to 8.5	5 GHz		0.00004	
Type-N			1 (0 dB)	10 MHz to 18	GHz		0.00040	
Type-N		(	0.316 (10 dB)	10 MHz to 18			0.00035	
Type-N			0.1 (20 dB)	10 MHz to 18	GHz		0.00020	
Type-N			.0316 (30 dB)	10 MHz to 18			0.00010	
Type-N			0.01 (40 dB)	10 MHz to 100			0.00010	
Type-N			0.01 (40 dB)	100 MHz to 18			0.00005	
Type-N Type-N			00316 (50 dB) 00316 (50 dB)	10 MHz to 100 100 MHz to 18			0.00010 0.00004	
туре-іч		0.	00316 (50 dB)	TOO WITH TO TO	GHZ		0.00004	
3.5 mm			1 (0 dB)	45 MHz to 26.5	5 GHz		0.0010	
3.5 mm			0.316 (10 dB)	45 MHz to 26.5			0.00040	
3.5 mm			0.1 (20 dB)	45 MHz to 100			0.00025	
3.5 mm			0.1 (20 dB)	100 MHz to 26.			0.00020	
3.5 mm			.0316 (30 dB) .0316 (30 dB)	45 MHz to 100			0.00015	
3.5 mm 3.5 mm			0.01 (40 dB)	100 MHz to 26. 45 MHz to 100			0.00010 0.00006	
3.5 mm			0.01 (40 dB) 0.01 (40 dB)	100 MHz to 26.			0.00005	
3.5 mm			00316 (50 dB)	45 MHz to 100			0.00010	
3.5 mm			00316 (50 dB)	100 MHz to 26.			0.00004	

Assessment Manager: JG2 Page 32 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
	Primary Impedance Measurer	ment System (PIMMS) (continued)	)	-
Vo	oltage Transmission Coefficient M	lagnitude ( VTC ) in waveguide sy	stems	
Waveguide size	VTC  and corresponding insertion loss (dB)	Frequency	Minimum uncertainty (VTC)	-
R100 R100 R100 R100 R100 R100 R100 R140 R14	1 (0 dB) 0.316 (10 dB) 0.1 (20 dB) 0.0316 (30 dB) 0.01 (40 dB) 0.00316 (50 dB)  1 (0 dB) 0.316 (10 dB) 0.316 (30 dB) 0.01 (40 dB) 0.0316 (30 dB) 0.01 (40 dB) 0.00316 (50 dB)  1 (0 dB) 0.316 (10 dB) 0.316 (10 dB) 0.1 (20 dB) 0.0316 (50 dB)  1 (0 dB) 0.0316 (50 dB) 0.01 (40 dB) 0.0316 (50 dB) 0.01 (40 dB) 0.00316 (50 dB) 0.01 (40 dB) 0.00316 (50 dB) 0.01 (40 dB) 0.00316 (30 dB) 0.1 (20 dB) 0.316 (10 dB) 0.1 (20 dB) 0.016 (30 dB)	8.2 GHz to 12.4 GHz 12.4 GHz to 18 GHz 12.6 GHz to 18 GHz 18 GHz to 26.5 GHz 26.5 GHz to 40 GHz	0.0010 0.00040 0.00020 0.00010 0.00006 0.00004  0.0025 0.00075 0.00030 0.00010 0.00006 0.00075 0.00030 0.00010 0.00006 0.00004	Teddington
R320 R320	0.01 (40 dB) 0.00316 (50 dB)	26.5 GHz to 40 GHz 26.5 GHz to 40 GHz	0.00006 0.00004	
Mechanically-derived characteristic impedance of the following coaxial lines:	40.0 0 4 50.0 0	0.000.0	Paradan managari (**	
7-16 14 mm Type-N Type-N or GPC-7 Type-N Type-N 3.5 mm 2.92 mm 2.4 mm	49.8 Ω to $50.2$ Ω $49.8$ Ω to $50.2$ Ω $27.7$ Ω to $28.3$ Ω $49.6$ Ω to $50.4$ Ω $74.4$ Ω to $75.6$ Ω $99.2$ Ω to $100.8$ Ω $49.2$ Ω to $50.8$ Ω $48.9$ Ω to $50.9$ Ω $48.9$ Ω to $51.4$ Ω	0.009 Ω 0.010 Ω 0.018 Ω 0.016 Ω 0.031 Ω 0.078 Ω 0.038 Ω 0.048 Ω 0.063 Ω	Based on measurements of the diameters of airline conductors, these and associated uncertainties will also be reported. These measurements are made using air gauging techniques.	

Assessment Manager: JG2 Page 33 of 67



Accredited to ISO/IEC 17025:2017

## **Schedule of Accreditation** issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 34 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
LENGTH			All linear calibrations may be given in inch units	
Gauge blocks: millimetre Service Reference: LD01	As BS EN ISO 3650:1999 0.5 mm to 25 mm 25 mm to 50 mm 50 mm to 75 mm 75 mm to 100 mm	Q[19, 0.21 <i>L</i> ] nm, <i>L</i> in mm 20 nm 20 nm to 22 nm 22 nm to 25 nm 25 nm to 29 nm	Measurement of central length by interferometry for gauges of length <i>L</i> (in mm, or inch). Measured twice, wrung to a platen by each of the two measuring faces in turn, and the mean of these two measurements stated on the certificate.	
	0.5 mm to 100 mm	32 nm	Measurement of flatness of measuring faces by interferometry	
	0.5 mm to 100 mm	50 nm	Measurement of variation in length by interferometry	
Gauge blocks: inch Service Reference: LD01	As BS 4311:2007 0.01 inch to 0.4 inch 0.4 in to 1 inch 2 inch 3 inch 4 inch	Q[0.75, 0.21 $L$ ] $\mu$ inch, $L$ in inch 0.76 $\mu$ inch 0.76 $\mu$ inch to 0.78 $\mu$ inch 0.86 $\mu$ inch 0.98 $\mu$ inch 1.13 $\mu$ inch		Тес
	0.01 inch to 4 inch	1.26 μ inch	Measurement of flatness of measuring faces by interferometry	Teddington
	0.01 inch to 4 inch	1.97 μ inch	Measurement of variation in length by interferometry	
Gauge blocks: millimetre Service Reference: LD01	As BS EN ISO 3650:1999 0.5 mm to 10 mm 10 mm to 25 mm 25 mm to 50 mm 50 mm to 75 mm 75 mm to 100 mm	Q[32 ,0.76 <i>L</i> ] nm, <i>L</i> in mm 32 nm to 33 nm 33 nm to 37 nm 37 nm to 50 nm 50 nm to 66 nm 66 nm to 83 nm	Measurement of central length by mechanical comparison with gauge block of similar size, for gauges of length <i>L</i> (in mm)	
	0.5 mm to 100 mm	40nm	Measurement of variation in length by mechanical comparison	
Gauge blocks: inch Service Reference: LD01	As BS 4311:2007 0.01 inch to 0.4 inch 0.4 inch to 1 inch 2 inch 3 inch 4 inch	Q[1.26, 0.76 $L$ ] $\mu$ inch, $L$ in inch 1.26 $\mu$ inch to 1.30 $\mu$ inch 1.30 $\mu$ inch to 1.47 $\mu$ inch 1.97 $\mu$ inch 2.60 $\mu$ inch 3.29 $\mu$ inch		
	0.01 inch to 4 inch	1.57 μ inch	Measurement of variation in length by mechanical comparison	

Assessment Manager: JG2 Page 35 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 36 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

# **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
LENGTH (continued)  Gauge blocks and length bars Thermal expansion coefficient at 20 °C Service Reference: LD03	Expansion coefficient 9 × 10 <sup>-6</sup> K <sup>-1</sup> to 13 × 10 <sup>-6</sup> K <sup>-1</sup>	(0.004 + 11/ <i>L</i> + 0.000 007 <i>L</i> ) × 10 <sup>-6</sup> K <sup>-1</sup> , <i>L</i> in mm	The uncertainty applies to the measurement of the linear coefficient of thermal expansion, at 20 °C, of long series gauge blocks and length bars above 100 mm, up to 1200 mm (4 inch to 48 inch) which comply with the following standards:  Reference and calibration grades of BS 1790:1961 (inch). Reference and calibration grades of BS 5317:1976 (millimetre). Grades K, 0 of ISO 3650:1998.	
Step gauges Service Reference: LD04	210 mm to 1020 mm	(100 + 0.23 <i>L</i> ) nm, <i>L</i> in mm	Grades IX, 6 of 100 3000.1000.	
Thread measuring cylinders Service Reference: LD07	0.05 mm to 5 mm diameter	(0.080 + 0.0010 <i>D</i> ) μm <i>D</i> : diameter in mm	As BS 3777:1964 BS 5590:1978 and specials	Tedd
External cylinder Plain plug gauges (parallel) reference cylinders and rollers Service Reference: LD07	0.1 mm to 100 mm diameter 100 mm to 150 mm diameter	(0.070 + 0.0011 <i>D</i> ) μm, <i>D</i> in mm (0.050 + 0.0014 <i>D</i> ) μm, <i>D</i> in mm		Teddington
Plain setting rings (parallel) Service Reference: LD07	3 mm to 250 mm diameter	(0.070 + 0.0005 <i>D</i> ) μm, <i>D</i> in mm	As BS 4064:1966 and BS 4065:1966 Grade AA, and equivalent quality setting rings	
Stage micrometers and graticules Service Reference: LR04	0 mm to 50 mm 50 mm to 100 mm 100 mm to 150 mm	0.20 μm 0.30 μm 0.40 μm	equivalent quality setting rings	
Linewidth standards Service Reference: LR03	0.5 μm to 10 μm 10 μm to 50 μm	0.050 µm 0.10 µm		
Reference stage graticules for image analysers Service Reference: LR07	Grid sizes 0 to 400 µm × 400 µm Spot sizes 3 µm to 48 µm	0.10 μm 0.10 μm		
Reference master screw plug and ring gauges to API specification 7 Service Reference: LD06	0 inch to 9 inch diameter Stand off	0.00034 inch		

Assessment Manager: JG2 Page 37 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 38 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
ANGLE Service Reference: LD08				
Indexing tables	From 0° to 360°	0.040 seconds of arc		
Precision polygons	4 sides to 12 sides, excluding 7 and 11 sides	0.11 seconds of arc		
Combination angle gauges	0° to 45°	0.30 seconds of arc	As MOY/SCMI/18 and MOY/SCMI/45	
Autocollimators Visual and photoelectric	0 minutes of arc to 10 minutes of arc	0.060 seconds of arc		
FORM				
Roundness reference standards	5 mm to 100 mm diameter	0.0050 μm		
Reference Sphere Diameter Service Reference: LD07	10 mm to 50 mm diameter	0.11 μm		
Back vertex focal length or power of a lens. Service Reference: LR02	± 0.01 <i>D</i> to ± 25 <i>D</i>	0.0010 <i>D</i> to 0.010 <i>D D</i> : dioptre	Phase shifting interferometer and length measuring interferometer traceable to dimensional standards used to measure vertex of the back surface of a lens to the corresponding focus.	Teddington
Radius of curvature and sphericity of optical quality surfaces. Service Reference: LR02	4 mm to 1000 mm radius of curvature.	0.0020 mm, 26 nm for sphericity	Test items are calibrated for radius of curvature and departure from spherical form using a phase shifting interferometer in conjunction with a commercial laser length measuring interferometer.	
Power of small angle prisms. Service Reference: LR02	0 to 20 prism dioptres (0° to 12° deviation).	0.010 prism dioptres.	Measurements of small angle prisms are carried out using a phase shifting interferometer, auxiliary mirrors, a clinometer and calibration test pieces when necessary.	
Optical flatness Service Reference: LR01	5 mm to 33 mm 33 mm to 100 mm 100 mm to 150 mm	14 nm 17 nm 20 nm	Flatness of optical quality surfaces using a phase shifting interferometer housing a reference flat traceable to a liquid surface.	

Assessment Manager: JG2 Page 39 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
OTHER MEASURING INSTRUMENTS, EQUIPMENT AND MACHINES				
Laser frequency (Vacuum wavelength) Service Reference: LL03	Nominal wavelengths 500 nm to 2 μm	1 part in 10 <sup>13</sup>		
Laser interferometer systems	0 m to 45 m			
Service Reference: LL01	Compensated	Q[0.08, 0.2 <i>L</i> ] μm, <i>L</i> in m	Heim with a town a bound at ODOO	
Service Reference: LL02	Uncompensated	Q[0.08, 0.12 <i>L</i> ] μm, <i>L</i> in m	Using the tape bench at OPSS	
Laser interferometer systems	0 m to 10.8 m			
Service Reference: LL01	Compensated	Q[0.08, 0.14 L] μm, L in m	Llaina tha 100 malasan mail	-
Service Reference: LL02	Uncompensated	Q[0.08, 0.088 L] µm, L in m	Using the 10.8 m laser rail	eddi
Extensometer calibration rigs Service Reference MF06	Displacements 0 mm to 300 mm	For the First two minutes 31 + (3.1 x R) nm For the second two minutes 51 + (3.1 x R) nm where R is the extension in mm	As BS EN ISO 9513:2012 and ASTM E83-23	Teddington
INFRA-RED				
Wavenumber, v for QA checks on mid-IR spectrophotometers Service Reference: OT21	Nominal Values: 3060.0 cm <sup>-1</sup> 2849.5 cm <sup>-1</sup> 1942.9 cm <sup>-1</sup> 1601.2 cm <sup>-1</sup> 1583.0 cm <sup>-1</sup> 1154.5 cm <sup>-1</sup> 1028.3 cm <sup>-1</sup> 906.60 cm <sup>-1</sup>	0.30 cm <sup>-1</sup>	Calibrated Artefact: Matt polystyrene film nominally 0.04 mm thick. Each film is individually calibrated at all eight selected transmittance minima. Films are measured in an FTIR spectrophotometer	

Assessment Manager: JG2 Page 40 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
PHOTOMETRY  Luminous intensity (tungsten lamps) Service Reference: OT15  Illuminance (tungsten lamps and illuminance meters) Service Reference: OT15  Luminance (tungsten sources and luminance meters) Service Reference: OT16  Correlated colour temperature (tungsten lamps and colour	1 cd to 100 cd 100 cd to 1000 cd 1000 cd to 10000 cd 0.1 lux to 5000 lux 500 lux to 50000 lux 5000 lux to 20000 lux 20000 lux to 50000 lux (1 to 100) cd m <sup>-2</sup> (100 to 10000) cd m <sup>-2</sup> (1000 to 45000) cd m <sup>-2</sup> (45000 to 450000) cd m <sup>-2</sup>	0.70 % 0.60 % 0.70 % 0.90 % 0.80 % 0.90 % 1.0 % 1.3 % 1.2 % 1.3 % 1.4 %	The actual measurement uncertainty quoted on certificates depends critically on the lamp repeatability or the meter performance. The CMC relates to that which can be achieved using specially designed transfer standards and, in the case of sources, assumes that the correlated colour temperature or spectral power distribution is known. For illuminance/luminance meters, the calibration only applies for a tungsten source at a correlated colour temperature of 2856 K.	Teddington
temperature meters) Service Reference: OT15  Spectral responsivity of laser power meters Service Reference: OT25  Spectral responsivity Service Reference: OT24	100 pW to 1 mW 350 nm to 1600 nm 200 nm to 210 nm 211 nm to 239 nm 240 nm >240 nm to 315 nm 316 nm to 404 nm 405 nm to 919 nm 920 nm to 1000 nm 1001 nm to 1400 nm 1401 nm to 1800 nm	0.040 %  3.2% 1.0% 0.7% 0.5% 0.3% 0.1% 0.3% 0.3% 0.3% 0.3% to 0.4%*	At laser wavelength or peak wavelength of bandpass filter.  *Where the uncertainty is stated as a range, linear interpolation may be used to find the measurement uncertainty at intermediate values, as per the CIPM-MRA-G-13 document, section 2.3 (Calibration and measurement capabilities in the context of the CIPM MRA),	

Assessment Manager: JG2 Page 41 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service

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

## **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
COLORIMETRY AND SPECT REGULAR TRANSMITTANCE				
Service Reference: OT22	1			
Regular transmittance	0.001 <i>T</i> % to 100 <i>T</i> %	Absolute uncertainty for <i>T</i> %		

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

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

Assessment Manager: JG2 Page 42 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 43 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

# **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 44 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

# **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

## Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
TEMPERATURE				
Standard resistance thermometers, fixed point calibrations Service Reference: PM02	-196 °C to +0.01 °C -189.3442 °C -38.8344 °C 0.01 °C 0 °C to 29.7646 °C 0 °C to 156.5985 °C 231.928 °C 419.527 °C 0 °C to 419.527 °C 419.527 °C to 660.323 °C 660.323 °C to 961.78 °C	0.0017 °C to 0.00016 °C 0.00050 °C 0.00035 °C 0.00011°C 0.00016 °C to 0.00030 °C 0.00030 °C to 0.00070 °C 0.00070 °C 0.00090 °C 0.0010 °C 0.0010 °C to 0.0025°C 0.0020 °C 0.0020 °C 0.0040 °C	Comparison at LN <sub>2</sub> . Calibrations at measurement current.  For HTSPRTs	
Resistance thermometers, calibration by comparison Service Reference: PM04	-196 °C -100 °C to -80 °C -80 °C to 0 °C 0 °C to 30 °C 30 °C to 100 °C	0.0050 °C 0.010 °C 0.0060 °C 0.0030 °C 0.0050 °C	Comparison at LN <sub>2</sub> and in acetone. Oil and water baths.	
Resistance thermometers, by dry block calibration Service Reference: PM04	50 °C to 150 °C 150 °C to 420 °C	0.040 °C 0.040 °C to 0.10 °C		Teddington
Temperature indicators with resistance sensor Service Reference: PM04	-196 °C to +420 °C	As for sensor		gton
Fixed Point Cells Service Reference: PK01				
Triple point of Argon	-189.3442 °C	0.00050 °C	Cell compared with NPL	
Triple point of Mercury	-38.8344 °C	0.00020 °C	reference cell during several realisations of the fixed point	
Melting point of Gallium	29.7646 °C	0.00020 °C	temperature using Standard Platinum Resistance	
Freezing point of Indium	156.5985 °C	0.00070 °C	Thermometers	
Freezing point of Tin	231.928 °C	0.00060 °C		
Freezing point of Zinc	419.527 °C	0.00090 °C		
Freezing point of Aluminium	660.323 °C	0.0025 °C		
Freezing point of Silver	961.78 °C	0.0040 °C		

Assessment Manager: JG2 Page 45 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
TEMPERATURE (continued)				
Fixed Point Cells (continued) Service Reference: PK01				
Water triple point cells	0.01 °C	0.000070 °C	By comparison with 2 cells from	
		0.000058 °C	NPL reference batch By comparison with 5 cells from NPL reference batch	
Thermocouples Service Reference: PM03				
Noble metal type Pt-Rh	420 °C	0.13 °C	ITS-90 fixed points	
	962 °C, 1085 °C 1324 °C 1492 °C	0.21 °C 0.53 °C 0.72 °C	Secondary fixed point Co-C Secondary fixed point Pd-C derived from ITS-90	
	0 °C to 1100°C 1100 °C to 1330 °C 1330 °C to 1500 °C	0.30 °C 0.30 °C to 0.55 °C 0.55 °C to 0.72 °C	Polynomial interpolation with improved homogeneity	
	1064.18 °C	0.57 °C	Wire Bridge Method Au	
	1554.8 °C	0.85 °C	Pd	
	0 °C to 1100 °C with 1100 °C to 1600 °C	1.0 °C 1.0 °C to 1.5 °C	Interpolation based upon Au and Pd wire bridge measurements	
Pt-Rh (type B only)			Wire bridge method	
	1768.2 °C	1.1 °C 0.30 °C	Pt Paged upon 7n and Ag fived	
	400 °C to 1100 °C 1100 °C to 1800 °C	0.30 °C to 1.2 °C	Based upon Zn and Ag fixed points and Pt wire bridge	
Thermocouples noble metal type Pt-Pd				
	420 °C 962 °C. 1085 °C	0.10 °C 0.070 °C	ITS-90 fixed points	
	1324 °C 1492 °C	0.53 °C 0.72 °C	Secondary fixed point Co-C Secondary fixed point Pd-C derived from ITS-90	
	0 °C to 1100 °C 1100 °C to 1330 °C 1100 °C to 1500 °C	0.20 °C 0.20 °C to 0.55 °C 0.20 °C to 0.72 °C	Interpolation	

Assessment Manager: JG2 Page 46 of 67



Accredited to ISO/IEC 17025:2017

# **Schedule of Accreditation** issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

# **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
TEMPERATURE (continued)				
Thermocouples, Noble metal type Au-Pt	420 °C, 660 °C, 962 °C	0.050 °C		
	0 °C to 1000 °C	0.050 °C	Where Zn and Ag fixed points used.	
Thermocouples, base metal types	-196 °C -80 °C to 0 °C 0 °C to 50 °C 50 °C to 100 °C	0.50 °C 0.10 °C 0.050 °C 0.10 °C	Comparison with LN <sub>2</sub> and in oil and water baths	
Thermocouples, by dry block calibration	50 °C to 700 °C	0.75 °C	Calibration via comparison to the integrated reference PRT of a dry block calibrator	
Temperature indicators with thermocouple sensor Service Reference: PM04	-196 °C to +100 °C	As for sensor	·	
Compensating and extension cables Service Reference: PM03	-25 °C to +100 °C	As for base metals thermocouples	By comparison.	Te
Thermocouple fixed point cells				Teddington
Service Reference: PK01 Cu fixed point cell (freeze)	1084 °C	0.031 °C	Certification of fixed point cells by measurement (with Pt/Pd	ton
Co-C fixed point cell (melt) Pd-C fixed point cell (melt)	1324 °C 1492 °C	0.44 °C 0.65 °C	thermocouples) against NPL National Standard fixed point cells	
Disappearing filament pyrometers Service Reference: PM06	700 °C to 800 °C 800 °C to 1700 °C 1700 °C to 2800 °C	5.0 °C to 2.0 °C 2.0 °C 2.0 °C to 8.0 °C		
Infrared Thermometers Service Reference: PM06	-40 °C to +50 °C 15 °C to 45 °C 50 °C to 260 °C 260 °C to 600 °C 600 °C to 1000 °C	0.10 °C 0.050 °C 0.10 °C 0.20 °C 0.30 °C	Including tympanic thermometers	
	1000 °C to 3000 °C	0.050 % of Celsius temperature	For temperatures above 1324 °C Eutectic Fixed Point can be used	
Blackbody Sources Service Reference: PM06	-40 °C to +260 °C 260 °C to 600 °C 600 °C to 1000 °C 962 °C, 1064 °C, 1085 °C 1000 °C to 3000 °C	0.20 °C 0.24 °C 0.30 °C 0.060 °C 0.050 % of Celsius temperature		

Assessment Manager: JG2 Page 47 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 48 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 49 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
NEUTRON FLUENCE (contin	ued)			
Thermal neutron fluence Service Reference: RN01	Energy: thermal Isotropic field Fluence rates: (10 <sup>4</sup> to 3 x 10 <sup>7</sup> ) cm <sup>-2</sup> .s <sup>-1</sup>	1.0 % for Westcott fluence	Fast neutrons moderated in graphite pile. Isotropic thermal neutron fields in a small 150 cm³ cavity. Fluence standard - gold foil activation.	
Fast neutron fluence Service Reference: RN02	Energy: 70 keV to 17 MeV Accelerator based Monoenergetic fields Fluence rates: (1 to 1500) cm <sup>-2</sup> .s <sup>-1</sup> at 1 m from target	4.0 %	Neutrons are produced using beams of protons or deuterons from a 3.5 MV Van de Graaff accelerator. Fluences measured using precision long counter. Service conforms to ISO 8529 Parts 1 to 3.	
Fast neutron fluence Service Reference: RN04	Energy: broad range Sources: <sup>241</sup> Am-Be, <sup>252</sup> Cf, <sup>241</sup> Am-B, <sup>241</sup> Am-Li, <sup>241</sup> Am-F Fluence rates: (1 to 400) cm <sup>-2</sup> .s <sup>-1</sup>	1.3 %	Fields are produced using radionuclide neutron sources of known emission rate and anisotropy. Actual fluence rate depends on particular source Service conforms to	_
NEUTDON DOOF FOUNDALE	at 1 m from source		ISO 8529 Parts 1 to 3.	Teddington
NEUTRON DOSE EQUIVALE				ngto
Thermal neutron dose equivalents Service Reference: RN01,	Energy: thermal Neutron beam Dose equivalent rates: 40 µSv h <sup>-1</sup> to 2.0 mSv h <sup>-1</sup>	5.0 %	Fluences are converted to ambient dose equivalent or personal dose equivalent using accepted conversion coefficients from ICRU 57 or	3
Fast neutron dose equivalents Service Reference: RN02	Energy: 70 keV to 17 MeV Accelerator based monoenergetic fields Dose equivalent rates: 0.2 µSv h <sup>-1</sup> to 2.0 mSv h <sup>-1</sup>	4.0 %	ICRU 95. For broad energy range neutron fields from sources the uncertainties in the neutron dose equivalent values reflect uncertainties in the source spectra rather than the	
Fast neutron dose equivalents Service Reference: RN04	Energy: broad range Radionuclide sources Dose equivalent rates:		conversion coefficients, which are assumed to be exact. Service conforms to: ISO 8529 Parts 1 to 3.	
	<sup>241</sup> Am-Be: (1 to 400) μSv.h <sup>-1</sup> at 1m from the source	8.1 %		
	252Cf: 2 μSv.h <sup>-1</sup> to 3 mSv.h <sup>-1</sup>		Actual dose equivalent rate depends on particular source.	
	at 1m from the source	2.4 %		

Assessment Manager: JG2 Page 50 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
NEUTRON DOSE EQUIVALE	NT (continued)			
Fast neutron dose equivalents Service Reference: RN04	241Am-B: 5 μSv h <sup>-1</sup> 1m from the source	8.5%		
	241Am-F: 1.6 μSv h <sup>-1</sup> 1m from the source	9.0%		
	241Am-Li: 1.8 μSv h <sup>-1</sup> 1m from the source	9.0%		Ted
Protection level dosemeters Air kerma rate				Teddington
X-rays Service Reference: RD02	ISO 4037 narrow spectrum (generating potential 8 keV to 250 keV) 350 μGy h <sup>-1</sup> to 100 mGyh <sup>-1</sup>	1.6 %	Calibration of protection level ionisation chamber with volumes ranging from 35 cm³ to 10 litres connected to a suitable secondary standard electrometer.	УП
γ-radiation Service Reference: RD02	<sup>60</sup> Co 1 μGyh <sup>-1</sup> to 0.1 Gyh <sup>-1</sup> <sup>137</sup> Cs 1 μGyh <sup>-1</sup> to 0.6 Gyh <sup>-1</sup>	1.7 % 1.7 %		
	<sup>241</sup> Am 8 μGyh <sup>-1</sup> to 0.3 mGyh <sup>-1</sup>	1.7 %		

Assessment Manager: JG2 Page 51 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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

Assessment Manager: JG2 Page 52 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

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Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
RADIOACTIVITY METROLOGY  RR20 – Standards of Radioactivity (activity per unit mass, Bq g¹): Solutions and spiked substrates of α-particle, β-particle, X-ray and γ-ray emitting radionuclides measured by secondary techniques. Service Reference: RR20-ICGS	4 kBq g <sup>-1</sup> to 15 GBq g <sup>-1</sup> , depending on radionuclide	0.30 %	Procedures directly supporting this work are:  RMS005 – Standards of Radioactivity Solutions RMT006 - Measurement of a Gamma Spectrometry Sample RMT007 - Analysis of a Gamma Spectrometry Sample RMT031 - Activity Assay Using Ionisation Chambers  Results for gamma emitters may be certificated as gammas s-1 g-1 by multiplication of the measured activity per unit mass by published emission	
RR20 - Standards of Radioactivity (activity per unit mass, Bq g¹): Solutions of α-particle, β-particle and X-ray emitting radionuclides measured by secondary liquid scintillation techniques Service Reference: RR20-LSC	10 Bq g <sup>-1</sup> to 500 kBq g <sup>-1</sup>	0.20 %	probabilities.  Procedures directly supporting this work are:  RMS005 - Standards of Radioactivity Solutions RMT009 - Secondary Standardisation of Radionuclides using CIEMAT/NIST Technique RMT010 - Standardisation of Radionuclides by Alpha LSC RMT012 - Dilution check by liquid scintillation counting  RMT054 - Secondary standardisation of beta-emitting radionuclides by the TDCR	Teddington
RR20- Standards of Radioactivity (activity per unit mass, Bq g¹ or γ emission rate per unit mass, s¹ g¹): Solutions of Environmental level standards of radioactivity Service Reference: RR20-BATCH	0.001 Bq g <sup>-1</sup> to 100 kBq g <sup>-1</sup> , 0.01 s <sup>-1</sup> g <sup>-1</sup> to 1000 s <sup>-1</sup> g <sup>-1</sup> depending on radionuclide	0.30 %	technique  Procedures directly supporting this work are:  RMS005 – Standards of radioactivity Solutions RMS020 – Production of Customer Certificates and Dispatch Requests RMS007 - Production of the NPL Mixed Radionuclide Solution RMT012 - Dilution check by liquid scintillation counting	

Assessment Manager: JG2 Page 53 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

# **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
RADIOACTIVITY METROLOGY (continued)  RR20- Solid substrates (air filters) directly spiked with solutions produced by the above techniques (activity, Bq or γ emission rate, s-1) Service Reference RR20-SPIKE	10 Bq to 500 kBq, 0.01 s <sup>-1</sup> to 1000 s <sup>-1</sup> depending on radionuclide	0.60 %	Procedures directly supporting this work are: RSP013 – Preparation of radioactive sources RMS018 – Preparation of radioactive air filters RMT006 - Measurement of a Gamma Spectrometry Sample RMT007 - Analysis of a Gamma Spectrometry Sample	
RR/0203 - Instrument Calibration (response to activity concentration, Bq m³): Customer supplied radioactivity-in-air monitors (other than radon) Service Reference RR02	40 kBq m <sup>-3</sup> to 30 GBq m <sup>-3</sup>	4.0 %	Procedures directly supporting this work are:  RMT003 - Calibration of Tritium-In-Air Monitors	Teddington
RR/0301 – Wide Area Reference Source Calibration (surface particle emission rate, particles s-1): Customer supplied radioactive surface contamination sources Service Reference RR03	10 particles s <sup>-1</sup> to 10000 particles s <sup>-1</sup>	For Alpha emitters: 0.42 %  For Beta emitters with β <sub>max</sub> : > 500 keV: 0.58 % 100 keV to 500 keV: 0.78 %	Procedures directly supporting this work are:  RMS008 - RR0300 Calibration Service RMT004 - Measurement of a Wide Area Reference Source by the Primary Large Area Proportional Counter RQC004 - Quality Checks of the Large Area Proportional Counter RSP008 - Setting of the Alpha and Beta Counting Thresholds	

Assessment Manager: JG2 Page 54 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
RADIOACTIVITY METROLOGY (continued)  RR/0701 - Artefact calibration (activity content, Bq or Activity per unit mass, Bq g <sup>-1</sup> ): ): Gelatine capsules ( <sup>131</sup> I only), brachytherapy wires ( <sup>192</sup> Ir only), brachytherapy seeds ( <sup>125</sup> I only) or solutions of β- particle, X-ray and γ-ray emitting radionuclides measured by secondary techniques. Service Reference: RR07	400 Bq to 15 GBq, 400 Bq g <sup>-1</sup> to 15 GBq g <sup>-1</sup> , depending on radionuclide	0.32%	Procedures directly supporting this work are:  RMT031 - Activity Assay using lonisation Chambers RMS001 - Calibration of Customer Supplied Sources (Gamma Emitters) RMS002 - Calibration of Customer Supplied Sources (Beta Emitters) RMT006 - Measurement of a Gamma Spectrometry Sample RMT007 - Analysis of a Gamma Spectrometry Sample	Teddington

Assessment Manager: JG2 Page 55 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
MASS Service Reference: MM01 Specific values	Nominal value (g)  50 000 20 000 10 000 5 000 3 000 2 000 1 000 500 300 200 100 50 30 20 10 5 3 2 1 to 0.001 0.0005 to 0.00005	(mg)  3.0  1.3  0.57  0.28  0.16  0.10  0.046  0.024  0.015  0.010  0.0060  0.0035  0.0025  0.0020  0.0015  0.0020  0.0015  0.00090  0.00090  0.00090  0.00040  0.00040  0.00040	The stated uncertainties relate to measurements made on standards that are constructed in accordance with the principles contained in OIML Recommendation III for weights of Class E1.  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.	Teddington
DENSITY Service Reference: MM03  Density of solid materials  VOLUME	Artefacts, 1000 kg/m³ to 9000 kg/m³  1 g to 100 g 100 g to 1 kg 1 kg to 20 kg  Artefacts >9000 kg/m³ 1 g to 100 g 100 g to 1 kg 1 kg to 20 kg	(4.0 to 0.50) kg/m³ (0.50 to 0.25) kg/m³ (3.0 to 1.0) kg/m³ (4.0 to 1.0) kg/m³ 1.0 kg/m³ (5.0 to 2.0) kg/m³	Using the following apparatus:  100 g hydrostatic weighing apparatus 1 kg hydrostatic weighing apparatus 20 kg hydrostatic weighing apparatus	
Service Reference: MM03  Volume of solid materials	0.1 cm <sup>3</sup> to 2500 cm <sup>3</sup>	0.00006 cm <sup>3</sup> to 0.25 cm <sup>3</sup>	Artefact density > 1000 kg/m <sup>3</sup>	

Assessment Manager: JG2 Page 56 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

# **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
NPL Primary Reference Mater Preparation of synthetic gas management of Synthetic Synthetic Synthetic Synthetic Natural Gas mixtures may be produced Synthetic Natural Gas Mixtures  Nitrogen Carbon dioxide	rials (NPL PRMs) nixtures by gravimetry in accorda FURES (NPL CGMs) nixtures by analysis.  7034:2016 accreditation for proc material producer number 4002 ad-schedule/4002/ReferenceMa d and/or calibrated as listed belo d and/or calibrated for other amo Amount fraction %mol/mol  0.02 to 25.2  0.04 to 25.0	w or in the BIPM <u>CMC</u> tables:  ount fractions and/or other combinati  Amount fraction %mol/mol  0.18 % relative + 0.00038  0.20 % relative + 0.00045	n by analysis. aterials (NPL PRMs).	
Methane Ethane Propane i-Butane n-Butane n-Pentane n-Pentane n-Hexane Helium Oxygen  Benzene Toluene Cyclohexane Methylcyclohexane n-Heptane n-Octane n-Nonane n-Decane	55.0 to 99.9 0.008 to 18 0.008 to 8.0 0.004 to 1.7 0.004 to 1.7 0.0005 to 0.5 0.0025 to 0.6 0.0025 to 0.6 0.0025 to 1.0  Amount fraction µmol/mol  5 to 500 5 to 250 10 to 400 10 to 400 10 to 500 5 to 10 10 to 200 1 to 10 10 to 120 1 to 20	0.018 % relative + 0.0020 0.28 % relative + 0.000080 0.30 % relative + 0.000080 0.40 % relative + 0.000040 0.40 % relative + 0.000040 0.80 % relative + 0.000015 0.40 % relative + 0.000030 0.40 % relative + 0.000030 0.40 % relative + 0.000050 1.0% relative + 0.000050 1.0% relative  Amount fraction μmol/mol  1.1 % relative + 0.030 1.1 % relative + 0.040 1.3 % relative + 0.040 1.3 % relative + 0.040 1.6 % relative + 0.048 1.6 % relative + 0.048		Teddington

Assessment Manager: JG2 Page 57 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty (k = 2)	Remarks	Location Code
NPL PRIMARY REFERENCE (continued)  SYNTHETIC FUEL GAS MIXTURES  Nitrogen Carbon monoxide Carbon dioxide Oxygen Hydrogen Helium Methane Ethane Ethene Ethene Ethyne Propane Propene i-Butane n-Butane 1-Butene i-Butene t-2-Butene c-2-Butene 1,3-Butadiene i-Pentane n-Pentane	Amount fraction %mol/mol  0.1 to 95 0.1 to 11 0.3 to 8 0.2 to 2.5 1 to 70 1 to 85 0.3 to 35 0.1 to 20 0.025 to 2 0.1 to 18 0.04 to 10 0.1 to 4 0.1 to 6 0.015 to 1.55 0.018 to 1.2 0.015 to 0.85 0.01 to 3 0.05 to 0.8 0.05 to 0.8	Amount fraction %mol/mol  0.30 % relative + 0.0020 0.48 % relative + 0.0016 0.48 % relative + 0.0016 0.78 % relative + 0.0025 0.38 % relative + 0.0025 0.40 % relative + 0.0025 0.33 % relative + 0.0015 0.35 % relative + 0.0010 0.35 % relative + 0.00010 0.35 % relative + 0.00020 0.40 % relative + 0.00025 0.40 % relative + 0.00025 0.40 % relative + 0.00025 0.40 % relative + 0.00020 0.45 % relative + 0.00025 0.45 % relative + 0.00020 0.50 % relative + 0.00020 0.50 % relative + 0.00013 0.45 % relative + 0.00013 0.45 % relative + 0.00015 0.45 % relative + 0.00020 0.45 % relative + 0.00015 0.45 % relative + 0.00020	S (NPL CGMs)  NPL PRMs and NPL CGMs	Teddington
SULPHUR ODORANT GAS MIXTURES  Hydrogen sulphide Carbonyl sulphide Carbon disulphide Dimethyl sulphide Ethyl methyl sulphide Diethyl sulphide Diethyl sulphide Methyl mercaptan [Methanethiol] Ethyl mercaptan [Ethanethiol] i-propyl mercaptan [2-propanethiol] n-propyl mercaptan [1-propanethiol] Tert-butyl mercaptan [2-methyl-2-propanethiol] Tetrahydrothiophene [THT]	Amount fraction μmol/mol  0.4 to 5,000 0.4 to 5,000 0.4 to 200	Amount fraction µmol/mol  NPL PRM 1.0 % relative + 0.0050 (All components)  NPL CGM 1.2 % relative + 0.0050 (All components)	Matrix gas: Methane or nitrogen	

Assessment Manager: JG2 Page 58 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
NPL PRIMARY REFERENCE (continued)  OZONE PHOTOMETERS Service Reference: QE85-0000  Ozone in synthetic Air	MATERIALS (NPL PRMs) AND  (0 to 0.1) x 10 <sup>-6</sup> mol/mol (0.1 to 1) x 10 <sup>-6</sup> mol/mol (1 to 10) x 10 <sup>-6</sup> mol/mol (10 to 50) x 10 <sup>-6</sup> mol/mol	NPL CALIBRATED GAS MIXTURE:  3.0 nmol/mol 3.0 % 3.2% 3.5%	Calibrated using ozone standard reference photometer and for ozone amount fractions in excess of 1 part per million, an external ozone generator according to NPL in-house procedure QPDQM/B/516.	Teddington

Assessment Manager: JG2 Page 59 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
ULTRASONICS Service Reference: AW07				
End-of-cable loaded sensitivity of a hydrophone	1 MHz to 8 MHz 9 MHz to 12 MHz 13 MHz to 16 MHz 17 MHz to 20 MHz 21 MHz to 30 MHz 31 MHz to 40 MHz	6.0 % 7.0 % 8.0 % 11 % 12 % 15 %	Free field sensitivity determined through substitution using a secondary hydrophone in a non-linearly distorted sound field	
End-of-cable loaded sensitivity of a hydrophone in fine frequency range	0.5MHz to <1MHz 1 MHz to 8 MHz 9 MHz to 12 MHz 13 MHz to 16 MHz 17 MHz to 20 MHz	9.0% 8.0 % 9.0 % 10 % 11 %	Free field sensitivity determined through substitution using a secondary hydrophone in a quasi-linear tone-burst acoustic field. Lowest frequency resolution is 10 kHz.	1
UNDERWATER ACOUSTICS  Calibration of hydrophones and projectors			According to IEC 60565:2006	Teddington
Service Reference: AW10  End of cable hydrophone receive sensitivity	25 Hz to 400 Hz	0.50 dB	By comparison to a microphone using an air-pistonphone	
Free field sensitivity of reference measuring hydrophones/projectors	5kHz to 500 kHz	0.50 dB	Using three-transducer spherical wave reciprocity method in a laboratory tank	
Free field sensitivity of reference measuring hydrophones	5 kHz to 1 MHz	0.70 dB	By comparison with NPL reference hydrophone in a laboratory tank	
Directional response of transducers and hydrophones	5 kHz to 1 MHz	0.21 dB	Normalised response versus angle. XY, XZ and YZ responses available. Performed in a laboratory tank	

Assessment Manager: JG2 Page 60 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
UNDERWATER ACOUSTICS (continued)  Calibration of hydrophones and projectors Service Reference: AW15			According to IEC 60565:2006	
Projector sensitivity	250 Hz to 500 Hz 500 Hz to 1kHz 1 kHz to 350 kHz	1.2 dB 1.0 dB 0.9 dB	Using calibrated hydrophone method in an open-water test facility	Wraysbury
Hydrophone sensitivity	250 Hz to 500 Hz 500 Hz to 1 kHz 1 kHz to 350 kHz	1.2 dB 1.0 dB 0.9 dB	Using calibrated projector method in an open-water test facility	bury
Complex admittance conductance susceptance capacitance	250 Hz to 350 kHz	2.0 % + 10 μS 2.0 % + 10 μS 2.0 % + 20 μS	For underwater electro acoustic transducers only. Undertaken in open-water test facility.	
FORCE				
Proving devices, load cells and other force-measuring devices in compression and tension modes increasing and decreasing forces Service Reference: MF01	1.5 N to 25 N 25 N to 1.2 MN 1.2 MN to 5 MN	0.0020 % 0.0010 % 0.05%	Calibrations can be performed in accordance with, ASTM E74-18, ISO 376:2011, NPL Management Documented In-House Method' QPMAM/M/B/070, BS 8422:2003 standard and	Teddingtor
Proving devices, load cells and other force-measuring devices in compression mode increasing forces only Service Reference: MF01	5 MN to 12 MN 12 MN to 30 MN	0.05 % 0.15 %	supplementary calibrations A, B, E, L and R.	on

Assessment Manager: JG2 Page 61 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

# **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
FORCE (continued) Strain Gauged Column Service Reference: MF03	200 kN to 2 MN Linear dimensions 80 mm to 120 mm 180 mm to 220 mm Flatness 0.00 mm to 1 mm Parallelism 0.00 mm to 1 mm	0.014 mm 0.021 mm 0.0034 mm 0.0034 mm	Calibration of Strain Gauged Columns in accordance with BS EN 12390-4:2019 Annexes A2 and A3. Measurement of Strain ratio, Height, Diameter, Flatness and Parallelism	
Calibration of DC voltage ratio meters used with strain gauge force transducers Service Reference: MF04	0.01 mV/V to 0.05 mV/V 0.05 mV/V to 1.0 mV/V 1.0 mV/V to 2.5 mV/V 2.5 mV/V to 10 mV/V	0.010 % 0.0050 % 0.0070 % 0.0050 %	Ratio meters are compared to a reference resistance network using a precision digital voltmeter to measure the voltage ratios generated.	
PRESSURE  Service Reference: MP03  Gas Pressure (absolute)  Determination of effective area of deadweight testers  Calibration of pressure indicating instruments  Gas Pressure (gauge)  Determination of effective area of deadweight testers  Service reference: MP04  Oil Pressure (gauge)  Determination of effective area of deadweight testers	3.5 kPa to 16 kPa 16 kPa to 700 kPa 700 kPa to 7 MPa 80 kPa to 110 kPa 3.5 kPa to 7 MPa 3.5 kPa to 16 kPa 16 kPa to 700 kPa 700 kPa to 7 MPa 7 MPa to 21 MPa	0.0017 % 0.0015 % Q[ $p \times 0.0019\%$ , $p^2 \times 2.5 \times 10^{-13}$ ] 5.0 Pa 0.0015 % 0.0017 % 0.0015 % Q[ $p \times 0.0025\%$ , $p^2 \times 2.5 \times 10^{-13}$ ] Q[ $p \times 0.0028\%$ , $p^2 \times 1.1 \times 10^{-12}$ ]	Calibration against pressure balance standards	Teddington

Assessment Manager: JG2 Page 62 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
FIBRE OPTICS			Measurements carried out at 23 °C ± 2 °C, unless stated otherwise	
Mode field diameter Service Reference: OT06-1020	3.5 μm to 13 μm 0 % to 1 %	0.62 % 0.10 %	Single-mode fibre from 1250 nm to 1625 nm. Far field scan method Petermann II definition	
Mode field noncircularly Service Reference: OT06-1020				
Effective area Service Reference: OT06-1050	30 μm² to 130 μm²	2.0 %	Far field scan method. Hankel transform	
Dispersion in single-mode optical fibre Service Reference: OT06-1010			Fibre length: 2 km to 50 km	
Dispersion	0 ps.nm <sup>-1</sup> to 1.3 x 10 <sup>-5</sup> ps.nm <sup>-1</sup>	1.5 % added in quadrature with 0.010 ps.nm <sup>-1</sup> .km <sup>-1</sup>	Laser based system	
Zero dispersion wavelength	1250 nm to 1650 nm	0.10 nm	Laser based system	Ted
Dispersion slope at zero dispersion wavelength	-100 to +100 ps.nm <sup>-1</sup> .km <sup>-1</sup>	1.5 %	Laser based systems	Teddington
Optical length Service Reference: OT06-1110	0.1 km to 15 km measured in the wavelength range 1270 nm to 1650 nm.	(0.040 + 1.7 x 10 <sup>-5</sup> L)	Single-mode optical fibre, pulsed time of flight technique.	5
	15 km to 105 km measured at wavelengths of 1310 nm, 1550 nm and 1625 nm	(0.10 + 1.7 x 10 <sup>-5</sup> <i>L</i> )	L is optical length in metres	
Fibre attenuation coefficient uniformity Service Reference: OT06-1100	0.17 dB/km to 0.43 dB/km	0.0060 dB/km	Single-mode optical fibre (length 4 km to 14 km). Measured using an optical time domain reflectometer (OTDR), 1300 nm and 1550 nm wavelength windows	
Spectral attenuation of single mode fibre Service Reference: OT06-1060	0.1 dB to 35 dB	0.021 dB	Cut-back technique Wavelength range 1200 nm to 1650 nm Measurements carried out over the temperature range 18 °C to 23 °C.	

Assessment Manager: JG2 Page 63 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

# **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
FIBRE OPTICS (continued)  Spectral attenuation of multimode fibre Service Reference: OT06-1060	0.1 dB to 35 dB	0.021 dB	Cut-back technique Wavelength range 800 nm to 900 nm 1250 nm to 1350 nm Measurements carried out over the temperature range 18 °C to 23 °C.	
Cut-off wavelength of optical fibre and cable Service Reference: OT06-1070  Fibre optic test equipment Service Reference: OT02-1010	800 nm to 1600 nm	2.0 nm	Transmitted power technique Measurements carried out over the temperature range 18 °C to 23 °C.  Measurements carried out at 20 °C $\pm$ 2 °C, unless otherwise stated.	
Absolute responsivity of fibre optic power meters with FC/PC connectors	Power level: -10 dBm to +23 dBm 850 nm ± 30 nm 1300 nm ± 25 nm 980 nm ± 10 nm 1300 nm ± 25 nm	0.90 % 0.70 % 0.90 % 0.70 %	Minimum customer meter resolution 2 % of stated power levels. Multimode fibre  Single mode fibre	Teddington
Absolute responsivity of fibre optic power meters with SC/PC connectors	1500 nm ± 30 nm 1550 nm ± 20 nm 1620 nm ± 20 nm Power level: -10 dBm to +23 dBm 850 nm ± 30 nm 980 nm ± 10 nm 1300 nm ± 25 nm	0.80 % 0.70 % 0.70 % 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	_
	Power level: -10 dBm to +23 dBm 1500 nm ± 30 nm 1550 nm ± 20 nm 1620 nm ± 20 nm	1.0 % 1.0 % 1.0 %	Minimum customer meter resolution 2 % of stated power levels.  Single mode fibre	
Absolute responsivity of fibre optic power meters with FC/APC or SC/APC connectors	Power level: -10 dBm to +23 dBm 1500 nm ± 30 nm 1550 nm ± 20 nm 1620 nm ± 20 nm	1.6 % 1.6 % 1.6 %	Minimum customer meter resolution 2 % of stated power levels  Single mode fibre	

Assessment Manager: JG2 Page 64 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
Fibre optic test equipment (co	ntinued)			
Linearity in fibre optic power meters with FC/PC, SC/PC, FC/APC and SC/APC connectors - Comparison technique	+20 dBm to +10 dBm +10 dBm to -90 dBm	0.70 % 0.30 %	Wavelength range: 830 nm to 1620 nm Single mode and multi mode fibre	
Linearity in fibre optic power meters with FC/PC, SC/PC, FC/APC and SC/APC connectors - Superposition technique	+15 dBm to -90 dBm	0.050 %	Wavelength range: 1275 nm to 1640 nm Single mode fibre	
Effective centre wavelength of fibre optic light source with spectral line width <5 nm	800 nm to 1700 nm	0.30 nm	FC/PC connectorised fibre output	
Effective centre wavelength of fibre optic light source with spectral line width in the range 5 nm to 50 nm	800 nm to 1700 nm	1.2 nm	FC/PC connectorised fibre output	Teddington
Spectral line width (FWHM) of sources	0.07 nm to 50 nm	0.10 nm	800 nm to 1700 nm	ngton
Output power stability of fibre optic light sources	+10 dBm to -50 dBm	0.0040 dB	Wavelength range 800 nm to 1700 nm	
PARTICLE COUNTERS Service Reference: QE15- 1010				
Airborne particle number concentration				
Calibration factor for condensation particle counters	Particle number concentration range 1000 cm <sup>-3</sup> to 100,000 cm <sup>-3</sup>	5.0 %	Comparison with an aerosol electrometer	
Airborne particle charge concentration:				
Detection efficiency (η) for Faraday Cup Aerosol Electrometers	Charge concentration range 0.15 fC.cm <sup>-3</sup> to 3.00 fC.cm <sup>-3</sup>	3 %	Documented in-house procedure TECHPRO0063.	

Assessment Manager: JG2 Page 65 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

**NPL Management Ltd** 

Issue No: 147 Issue date: 07 November 2025

### Calibration performed by the Organisation at the locations specified

Measured Quantity Instrument or Gauge	Range	Expanded Measurement Uncertainty ( <i>k</i> = 2)	Remarks	Location Code
INSTRUMENTS FOR AIR QU Service Reference: QE85- 0000 Particulate analyser flow rate test	JALITY MONITORING  1 slm to 10 slm 10 slm to 40 slm	1.5 % 1.9 %		Customers' sites
END				

Assessment Manager: JG2 Page 66 of 67



Accredited to ISO/IEC 17025:2017

# Schedule of Accreditation issued by United Kingdom Accreditation Service

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

### **NPL Management Ltd**

Issue No: 147 Issue date: 07 November 2025

Calibration performed by the Organisation at the locations specified

### Appendix - Calibration and Measurement Capabilities

#### Introduction

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

#### Calibration and Measurement Capabilities (CMCs)

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

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

### Expression of CMCs - symbols and units

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

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

Assessment Manager: JG2 Page 67 of 67