CERTIFICATE OF CALIBRATION

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Authorised Signatories: D Hector
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Signed: Date of Issue: 26th July 2017

Certificate Number: 3763

Customer Name and Address:

Scottish Government
Water, Air, Soils and Flooding Division
Environmental Quality Directorate
Scottish Government
Victoria Quay
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Description: Calibration factors for Glasgow City Council's Anderson, Abercromby St, Broomhill, Burgher Street, Byres Road, Dumbarton Road, Nithsdale Road and Waulkmillglen Reservoir air monitoring stations.

Site / Date Test Carried Out	Species	Analyser Serial No.	Zero Response [1]	Uncertainties ppb	Calibration Factor[2]	Uncertainties %	Converter eff. (%)[3]
Anderston 7th December 2016	NO_x	529b-229	0.0	2.5	1.0362	3.5	98.0
	NO		-0.1	2.5	1.0365	3.5	
Burgher Street 8th December 2016	NO_x	CM1105 0006	0.4	2.5	1.0612	3.5	98.5
	NO		0.2	2.5	1.0612	3.5	
Byres Road 6th December 2016	NO_x	M1362 -M575	0.0	2.6	1.1010	3.5	98.3
	NO		-1.0	2.8	1.0993	3.6	
Dumbarton Road 24th March 2017	NO_x	404b-174	-55.0	3.1	0.8630	12.4	105.7
	NO		-58.0	2.6	0.8677	11.3	

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2 providing a level of confidence of approximately 95% The uncertainty evaluation has been carried out in accordance with UKAS requirements.

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Site / Date Test Carried Out	Species	Analyser Serial No.	Zero Response[1]	Uncertainties ppb	Calibration Factor[2]	Uncertainties %	Converter eff. (%)[3]
Waulkmillglen Reservoir 7th December 2016	NO_x	697b-309	2.0	2.5	1.0751	3.5	98.8
	NO		0.0	2.5	1.0607	3.5	
	O_3	M1620-M334	0.0	3	1.0591	3.1	

Site / Date Test Carried Out	Species	Analyser Serial No.	Parameter	Specified Value	Measured Value	Deviation %	Uncertainty %
Dumbarton Road 6th December 2016	TEOM PM_{10}	25458	Main Flow[4]	3.00	2.33	-22.5	2.25
			Aux Flow[4]	13.71			
			Total Flow	16.67	15.53	-6.8	2.25
			k_0[5]	13085	13317	1.8	1.00
Waulkmillglen Reservoir 7th December 2016	TEOM PM_{10}	22763	Main Flow[4]	3.00	3.19	6.5	2.25
			Aux Flow[4]	13.67			
			Total Flow	16.67	16.91	1.4	2.25
			k_0[5]	13426	13862	3.2	1.00
Abercromby Street 6th December 2016	FDMS PM_{10}	26459	Main Flow[4]	3.00	**3.17**	5.6	2.25
			Aux Flow[4]	13.63	**14.07**	3.2	
			Total Flow	16.67	**17.24**	3.4	2.25
			k_0[5]	15641	16226	3.7	1.00
Anderston 7th December 2016	FDMS PM_{10}	21650	Main Flow[4]	3.00	**3.03**	0.8	2.25
			Aux Flow[4]	13.62	**13.52**	-0.7	
			Total Flow	16.67	**16.55**	-0.7	2.25
			k_0[5]	13818	14127	2.2	1.00
Broomhill 6th December 2016	FDMS PM_{10}	26460	Main Flow[4]	3.00	3.06	2.0	2.25
			Aux Flow[4]	13.63			
			Total Flow	13.67	16.41	-1.5	2.25
			k_0[5]	14989	15583	4.0	1.00
Burgher Street 8th December 2016	FDMS PM_{10}	140ab2212 79806	Main Flow[4]	3.00	2.97	-0.9	2.25
			Aux Flow[4]	13.66			
			Total Flow	16.67	16.05	-3.7	2.25
			k_0[5]	16036	16405	2.3	1.00

Site / Date Test Carried Out	Species	Analyser Serial No.	Parameter	Specified Value	Measured Value	Deviation %	Uncertainty %
Byres Road 6th December 2016	FDMS PM_{10}	140ab2603 10602	Main Flow[4]	2.99	3.09	3.5	2.25
			Aux Flow[4]	13.65			
			Total Flow	16.67	16.67	0.0	2.25
			k_0[5]	12912	12999	0.7	1.00
Nithsdale Road 7th December 2016	FDMS PM_{10}	26457	Main Flow[4]	2.99	**3.00**	0.5	2.25
			Aux Flow[4]	13.67	**12.85**	-5.8	2.25
			Total Flow	16.67	**15.85**	-4.9	2.25
			k_0[5]	13822	14479	4.7	1.00

The gaseous ambient analysers listed above have been tested for zero response, calibration factor, linearity and converter efficiency (NO_x analysers only) by documented methods. The factors have been calculated using certified gas standards. The particulate analysers listed above have been tested for sample flow rates and k_0 (where appropriate) by documented methods. Note that the test results are valid on the day of test only, as analyser drift over time cannot be quantified. All results for gaseous species are given in ppb (parts per billion) mole fractions or ppm (parts per million) mole fractions.

[1]The zero response is the zero reading on the data logging system of the analyser when audit zero gas was introduced to the analysers under test.

[2]The calibration factor is the multiplying factor required to scale the reading on the data logging system of the analyser into reported concentration units (ppb for NO, NO_x, SO_2, O_3 and ppm for CO. Where 1 ppm = 1000 ppb). It should be used in conjunction with the zero response. A corrected concentration is calculated using the following equation:

Concentration = F (Output - Zero Response)

Where F = Calibration Factor provided on this certificate
Output = Reading on the data logging system of the analyser
Zero Response = Zero Response provided on this certificate

[3]Converter eff. is the measured efficiency of the NO_2 to NO converter within the oxides of nitrogen analyser under test.

[4]The measured main flow rate (where applicable) is the flow rate through the sensor unit of the TEOM particulate analyser under test. The measured aux flow rate (where applicable) is the flow rate through the bypass tubing of the TEOM particulate analyser under test. The measured total flow rate is the total flow rate through the particulate analyser under test. Units of flow are l.min-1. Where flow rates are highlighted in bold, it indicates that measurements were not made at the analyser sample inlet. These measurements therefore may not accurately reflect analyser performance in normal operation.

[5]The calculated k0 value (TEOM analysers only) is the calculated k0 spring constant based on tests undertaken with filters of known weight. The % deviation indicates the closeness of the calculated result to the manufacturer's specified k0 value.

The calibration results shaded are those that fall out with our scope of accreditation, all other results on this certificate are not UKAS accredited, but have been included for completeness.