



Measurement of Emissions to Atmosphere.

Prepared for: TWMA, Peterhead

Project number: TWM001

Report number: 2025_769

Version number: V01

Test dates: 3 December 2025



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Contract Title: Measurement of Emissions to Atmosphere from a Caterpillar 3512 Engine

Site: TWMA GROUP LIMITED
Peterhead
AB42 3JF

Plant Monitored: Caterpillar 3512 Engine

Sampling Team: REDACTED MM 03 159
MCERTS Level II (TE1, TE2, TE3 & TE4)

Site Contact: REDACTED

Test Date: 03 December 2025

Approved by: sign: REDACTED print: REDACTED

date: 23 December 2025

MCerts Reg No: MM 03 159
MCERTS Level 2 (TE1, TE3, TE4)



0432

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1. EXECUTIVE SUMMARY

1. Site Name & Address	TWMA GROUP LIMITED Peterhead AB42 3JF
2. Process Description	Diesel Engine
3. Permit Number	PPC/A/1017288
4. Sampling Contractor	TÜV SÜD Ltd
5. Test Date	03 December 2025
6. Analytical Laboratories	RPS (UKAS no. 0605)
7. Date Report Issued	23 December 2025
8. Plant Operating Conditions	Normal operation
9. Special Conditions	None

Objective:

TÜV SÜD National Engineering Laboratory was commissioned to carry out emission measurements (see Work Scope below) at TWMA Peterhead. The measurements are required as a condition of the operator's Permit.

The 3512 engine drives the Rotomill process (treatment of drill cuttings from offshore operations).

Work Scope					
Release Points:		Caterpillar 3512 Engine			
Determinands Requested	Sampled? Yes / No	Sampling Method	Deviation from Standard Method? Yes / No	NEL Accreditation	Analytical Laboratory Accreditation
Particulates	Yes	BS EN 13284	No	UKAS	UKAS
Oxides of Nitrogen (as NO ₂)	Yes	BS EN 14792	No	UKAS	N/A
Carbon Monoxide	Yes	BS EN 15058	No	UKAS	N/A
Sulphur Dioxide	Yes	PD CEN/TS 17021:2017	No	UKAS	N/A
Oxygen	Yes	BS EN 14789	No	UKAS	N/A
Volatile Organic Compounds	Yes	BS EN 12619	No	UKAS	N/A

1. EXECUTIVE SUMMARY (cont'd)

Results								
Release Point:	Caterpillar 3512 Engine				Ref. Conditions:		101.3kPa, 273K, dry gas, 15% Oxygen	
Determinand	Run No.	Date	Start Time hh:mm	Finish Time hh:mm	Concentration Measurement mg/m ³	Emission Limit Value mg/m ³	Uncertainty ± mg/m ³	Mass Emission Rate kg/hr
Particulates	1	03-Dec-25	15:20	16:20	3.78	50	1.05	0.008
Oxides of Nitrogen (as NO ₂)	1	03-Dec-25	15:14	16:25	1156	200	21	2.52
Sulphur Dioxide	1				1.2	66	1.5	0.003
Carbon Monoxide	1				185.8	150	2.8	0.41
Oxygen	1				13.1%	-	0.4%	-
Volatile Organic Compounds	1	03-Dec-25	15:11	16:21	17.6	20	0.94	0.038

2. Emission Monitoring Procedures and Instrumentation

2.1 Particulates

Standard	BS EN 13284-1:2017	NEL Work Instruction	WI/EM/962
Technique	Gravimetric	Accreditation	UKAS & MCERTS
Reporting Limit for a flue gas sample of approximately 1 m³ is:			0.5 mgm ⁻³

Principle: A metered volume of flue gas is extracted through a preweighed quartz filter isokinetically. The collected particulate and associated probe and filter holder rinses are then submitted to a sub-contracted UKAS accredited gravimetric laboratory for analysis.

2.2 Oxides of Nitrogen (NO + NO₂) expressed as NO_x

Standard	BS EN 14792:2017	NEL Work Instruction	WI/EM/1273
Technique	Chemiluminescence	Accreditation	UKAS & MCERTS
Reporting Limit for a flue gas sample is:			2.0 mgm ⁻³

Principle: A flue gas sample is extracted via a heated sample transport and conditioning system. The dried sample is passed to a chemiluminescence analyser which measures the light produced during the oxidation of NO to NO₂. Any NO₂ in the initial sample is first reduced to NO prior to analysis. The analyser therefore measures total NO + NO₂ as NO_x. The instrument output is typically logged at one minute intervals.

2.3 Sulphur Dioxide (SO₂)

Standard	CEN/TS 17021	NEL Work Instruction	WI/EM/0058
Technique	Non-Dispersive Infrared	Accreditation	UKAS & MCERTS
Reporting Limit for a flue gas sample is:			0.5 mgm ⁻³

Principle: A flue gas sample is extracted via a heated sample transport and conditioning system. The dried sample is passed to a measuring cell in which the absorbance of infrared radiation is recorded. The instrument output is typically logged at one minute intervals.

2.4 Carbon Monoxide (CO)

Standard	BS EN 15058:2017	NEL Work Instruction	WI/EM/1273
Technique	Non-Dispersive Infrared	Accreditation	UKAS & MCERTS
Reporting Limit for a flue gas sample is:			1.0 mgm ⁻³

Principle: A flue gas sample is extracted via a heated sample transport and conditioning system. The dried sample is passed to a measuring cell in which the absorbance of infrared radiation is recorded. The instrument output is typically logged at one minute intervals.

2.5 Oxygen (O₂)

Standard	BS EN 14789:2017	NEL Work Instruction	WI/EM/1273
Technique	Zirconia Cell	Accreditation	UKAS & MCERTS
Reporting Limit for a flue gas sample is:			0.5 %

Principle: A flue gas sample is extracted via a heated sample transport and conditioning system. The dried sample is passed to a zirconium oxide cell heated to approximately 650°C. The movement of oxygen ions across the zirconium oxide produces a voltage between the two electrodes which is proportional to the oxygen concentration. The instrument output is typically logged at one minute intervals.

2.6 Total Gaseous/Volatile Organic Compounds (VOC)

Standard	BS EN 12619:2013	NEL Work Instruction	WI/EM/965
Technique	Flame Ionisation Detector	Accreditation	UKAS & MCERTS
Reporting Limit for a flue gas sample is:			0.5 mgm ⁻³

Principle: A flue gas sample is extracted hot and wet via a heated sample line and optional heated pre-filter. The sample temperature is maintained at 180°C throughout the sample system. The detector, which is housed in an oven also at 180°C, consists of two charged plates which allow current to pass in the presence of carbonyl ions produced by the vapourisation of volatile carbon compounds. In general, the detector responds linearly to the carbon content of the sample. The instrument output is typically logged at one minute intervals.

3. Deviations from Standards

None

Annexes - Test Results and Derived Data

Annex 01 - Total Particulate Sampling Data and Result

Stack/Process Ref:	Diesel Engine
--------------------	---------------

Sampling Data									
---------------	--	--	--	--	--	--	--	--	--

Date	03-Dec-25
Start Time	15:20
End Time	16:20
Sampling Time	01:00

Pitot ID	4439
Calibration Constant (K_{pt})	0.854
Meter ID No	4258
Meter Calibration Factor	1.007
Av. dH (kPa)	0.25

Nozzle Diameter [d] mm	7.9
Leak Check Before OK? (Y/N)	Y
Leak Check After OK? (Y/N)	Y
Duct Area, m ²	0.091
Barometric Pressure, kPa	99.3
Duct Pressure, kPa	0.10
Reference Oxygen, %	15
Measured Oxygen, %	13.1
Reference Moisture, %	0
Measured Moisture, %	5.5

Moisture Weights, g		
	Initial	Final
Impinger 1	802.7	829.5
Impinger 2	772.4	780.1
Impinger 3	645.6	650.1
Impinger 4	1014.0	1020.4
Total		45.4
Volume of H ₂ O @ STP, m ³	0.056	

[illegible]

Total	Average			Average	Average	Average	Average	Max (20°C)	Tot Volume
60	5.75	25.88	7.5	310	-	-	10.8	9	1.028

Results Summary

Initial Gas Meter Reading	1.827	m ³
Final Gas Meter Reading	2.855	m ³
Sampled Vol. (Dry at Meter)	1.028	m ³
Sampled Vol. (Dry, STP)	0.972	m ³
Sampled Vol (@ Ref. O ₂)	1.289	m ³
Gas meter average Temperature	10.8	°C
Velocity (Duct)	11.59	ms ⁻¹
Duct gas flowrate at sample point	1.05	m ³ s ⁻¹
Duct gas flowrate (Dry, STP, O ₂ corrected)	0.61	m ³ s ⁻¹

	Result ¹	Blank ¹	Units
Filter ID	TWM001/02	TWM001/01	
Particulate mass	4.17	<0.04	mg
Rinse ID	TWM001/02	TWM001/01	
Particulate mass	0.70	<0.5	mg
Total mass	4.87	0.54	mg
Particulate Concentration	3.78	0.42	mgm ⁻³
Particulate Emission Rate	0.008	N/A	kg hr ⁻¹

Wet, STP

(1) Figures in bold were reported below the limit of detection for the analysis. Detection limit quoted for calculation.

blank < 20% ELV?	Yes
------------------	-----

Out of stack or in-stack filter?	In
----------------------------------	----

% Isokinetic	109.6
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Particulate analysis (in italics) was carried out by RPS Ltd
UKAS Accredited Testing Laboratory Number 0605.

Annex 02 - VOC Sampling Data and Results

Stack/Process Ref:	Diesel Engine 3512
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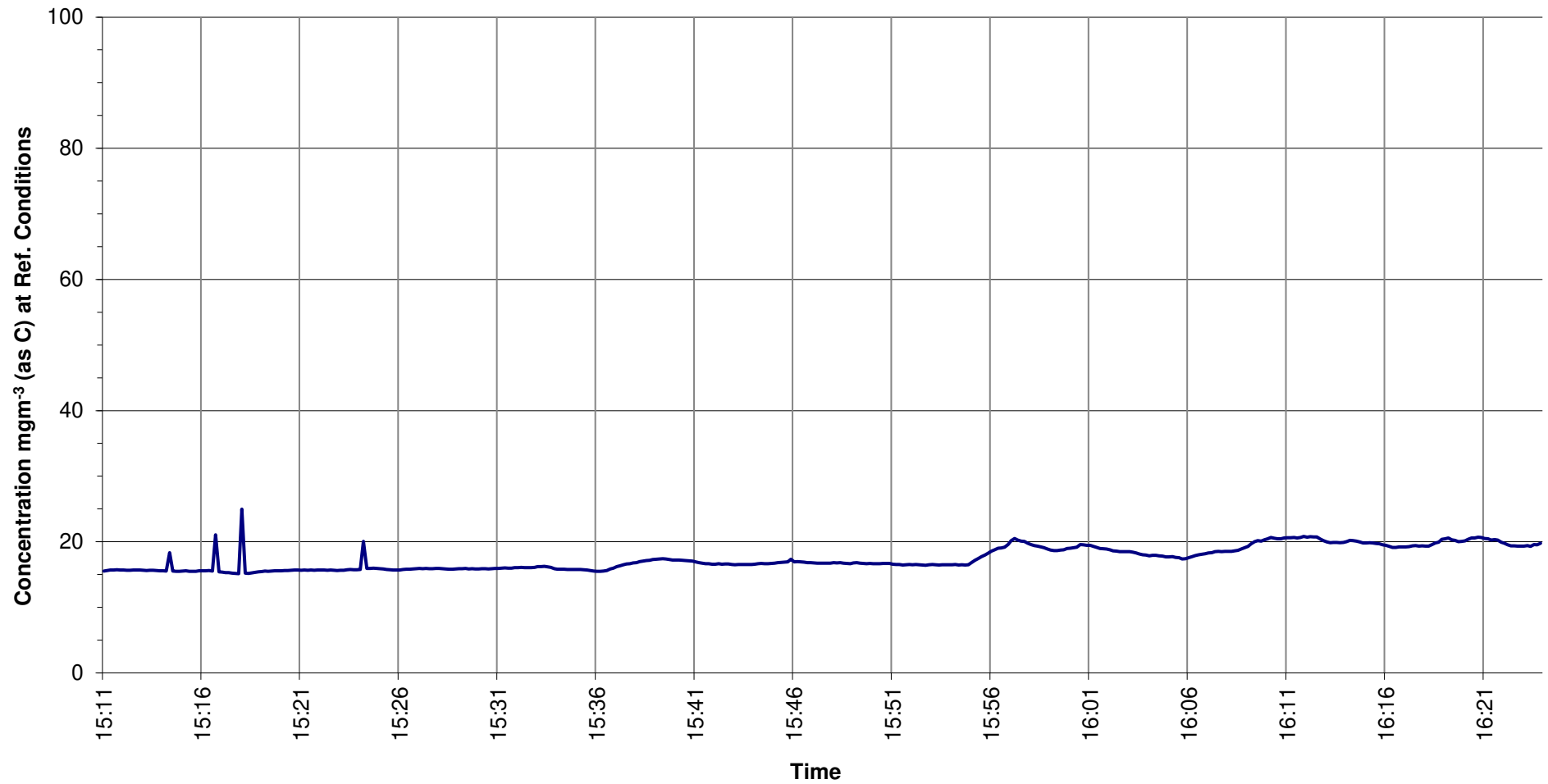
	Start	ppm as propane	mg/m ³ C, Dry, STP, 15% O ₂
DATE	TIME	VOC	VOC
3-Dec-25	15:11	11.2	15.8
3-Dec-25	15:21	11.3	15.9
3-Dec-25	15:31	11.6	16.3
3-Dec-25	15:41	11.9	16.7
3-Dec-25	15:51	12.8	18.0
3-Dec-25	16:01	13.3	18.7
3-Dec-25	16:11	14.2	20.0
3-Dec-25	16:21	14.0	19.7

	VOC
Average Concentration	17.6

Measured Volumetric Flow, Dry 15% O ₂	0.61	m ³ s ⁻¹
--	------	--------------------------------

Mass Emission Rate kg/hr, Dry, STP	0.0385
------------------------------------	--------

Annex 02 - VOC Gas Analysis
Stack/Process Ref: Diesel Engine 3512
Date: 3 Dec 2025



Annex 03 - Combustion Gas Sampling Data and Results

Stack/Process Ref:	Diesel Engine 3512
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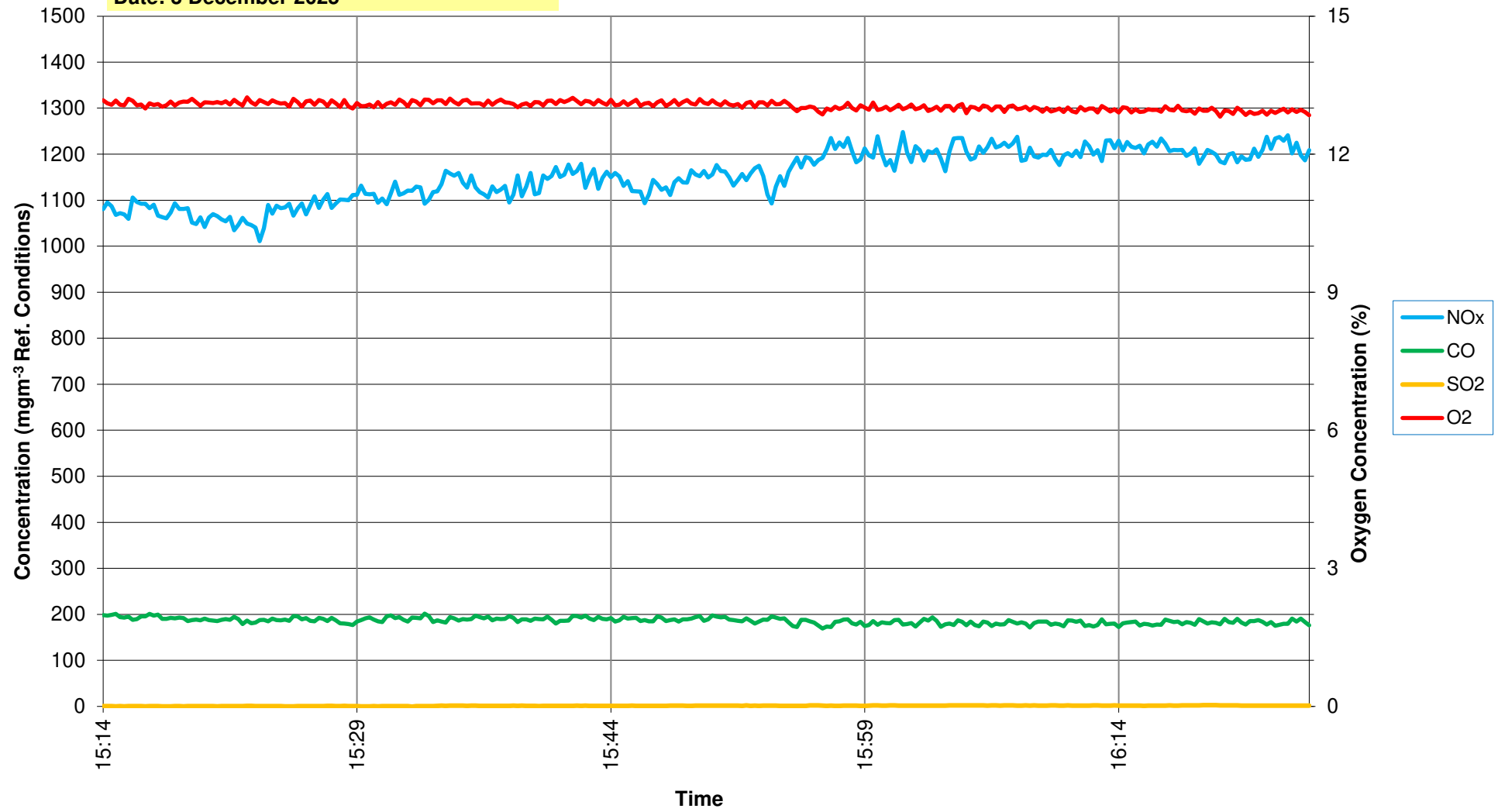
	Start	ppm	ppm	ppm	%	-	mg/m ³ Dry, STP 15% O ₂		
DATE	TIME	NO	CO	SO ₂	O ₂	-	NOx	CO	SO ₂
3-Dec-25	15:14	688	199	0.2	13.1	-	1075	189.5	0.4
3-Dec-25	15:29	724	200	0.4	13.1	-	1132	190.1	0.9
3-Dec-25	15:44	745	197	0.6	13.1	-	1158	186.8	1.3
3-Dec-25	15:59	784	193	0.8	13.0	-	1206	180.8	1.8
3-Dec-25	16:14	791	196	0.8	12.9	-	1209	181.9	1.8

					O ₂ (%)	-	NOx (mg/m ³)	CO (mg/m ³)	SO ₂ (mg/m ³)
Average Concentration					13.1	-	1156	185.8	1.2

Measured Volumetric Flow, Dry 15% O ₂	0.61	m ³ s ⁻¹
--	------	--------------------------------

			NOx	CO	SO ₂
Mass Emission Rate kg hr ⁻¹ , Dry, STP, O ₂ corrected			2.52	0.41	0.003

Annex 03 - Combustion Gas Analysis
Process Ref: Engine 3512
Diesel
Date: 3 December 2025



Annex 04 - On-site Instrument Calibrations

Gas Analyser Zero & Span Pre/Post - site Calibration Data					Drift, %
Determinand	Cylinder Reference	Instrument Range (ppm)	Pre-test Zero	Post-test Zero	
Carbon Monoxide	24/0621/06	200	0.0	0.2	0.10
VOCs	H/C free air	100	0.01	0.2	0.19
Oxides of Nitrogen	24/0621/06	50	0.1	0.2	0.20
Sulphur Dioxide	24/0621/06	200	0.2	0.5	0.15
Oxygen	24/0621/06	25.00 %	0.01	0.04	0.12

Instrument Calibration

Determinand	Cylinder Reference & concentration (ppm)	Actual Span Pre-test (ppm)	Actual Span Post-test (ppm)	Drift, %
Carbon Monoxide	24/0621/05 & 101.6	101.4	99.7	-0.85
VOCs	25/1023/01 & 89.2	89.2	87.6	-1.60
Oxides of Nitrogen *	24/0621/02 & 103.7	103.6	102.9	-1.40
Sulphur Dioxide*	24/0621/03 & 50.1	50.9	49.5	-0.70
Oxygen	Ambient Air	20.90 %	20.84 %	-0.24

Appendix 1

Supporting Information & Uncertainty Calculations

Appendix 1 - Supporting Information

Personnel

Team Leader		MCERTS Level	Technical Endorsement	Expiry Date
REDACTED	MCERTS ref: MM 03 159	Level II	TE1 / TE2 / TE3 / TE4	Dec-27
Report Author				
REDACTED	MCERTS ref: MM 03 372	Level II	TE1 / TE3 / TE4	Jan-29

Equipment

Equipment Used	Description	NOT Number
Pitot-static tube	S-type	4439
Method 5 Train	DGM, etc.	4258
PG350	Combustion Gas analyser	6003
Barometer	Pressure Measurement	4498
Sick Maihak	VOC Analyser	4492

The Total Uncertainty of Measurement for BS EN 13284-1

1. Introduction

The total uncertainty of measurement for particulate method, BS EN 13284-1, hinges on a few key areas which are a combination of uncertainty values. Therefore all values must be in a common unit before combining, in this case percentages %. The two main key areas where the uncertainty will play an integral part of the test is in calculating the particulate concentration and the Iso-kinetic ratio. The aim of this report is to provide an uncertainty value that can be used easily when reporting and to prove our execution conforms with the standard (i.e. within the general stated uncertainty associated with the method, in this case 10%).

All of our instruments are calibrated to be within the standard set out by the method in use (e.g. Dry gas meter uncertainty in BS EN 13284-1 low particulate to be under 2%). This means our worse case scenario of uncertainty will be to use these maximum limits. All of our data and assumptions are supported by our NATCAL calibration system, which is made up of internal calibrations by trained staff using UKAS accredited reference equipment or external UKAS calibration laboratories.

As for our weighing uncertainty, this figure is taken from the subcontracted UKAS accredited laboratory's analysis test certificate.

2. Iso-kinetic ratio calculation

Simply this is the ratio between the Actual Meter Volume (Mstd) and the theoretical volume, which should have been sampled according to the stack velocity (Vs), time (t) and nozzle area (An). It should be noted that the error in moisture collection in comparison to its role in the end result is estimated to be negligible and therefore not taken into account.

$$\text{Actual Meter Uncertainty } V_{(Mstd)} = \sqrt{\left(\frac{2}{\sqrt{3}}\right)^2 + \left(\frac{1}{\sqrt{3}}\right)^2 + \left(\frac{1}{\sqrt{3}}\right)^2 + \left(\frac{1}{\sqrt{3}}\right)^2}$$

*Dry Gas
meter*

*Meter
Temperature
Thermocouple +
Thermosensor*

*Meter
Pressure*

Value is divided by square root of three in order to give standard uncertainty, as the measured values are tolerances (+/-) percentages, therefore have rectangular/uniform distribution.-Type B evaluation NPL Guide.

Standard Uncertainty (s.u) = **1.53%**

To 95% confidence(where k=2) = **3.06%**

A spreadsheet for uncertainty calculation using a set of our most recent calibration data (for one set of sampling equipment) is available as an example/verification of how we achieve the standard uncertainty per specific test. However for this total uncertainty, as explained, the worst case shall be displayed, e.g. Pitot coefficient 1% in method - 0.007% in spreadsheet. Also as uncertainty can change with scale of measurement, typical values will be used, such as 10mm/H2O for pitot pressure drop (manometer) or 1 metre for average stack size, etc.

We take the uncertainty of our dry molecular weight using a combination of the uncertainties

Stack gas Velocity Uncertainty Vs =

$$= \sqrt{\left(\frac{1}{\sqrt{3}}\right)^2 + \left(\frac{0.5 \times 2.3}{\sqrt{3}}\right)^2 + \left(\frac{0.5 \times 1}{\sqrt{3}}\right)^2 + \left(\frac{0.5 \times 1}{\sqrt{3}}\right)^2 + \left(\frac{0.5 \times 2}{\sqrt{3}}\right)^2 + \left(\frac{1}{\sqrt{3}}\right)^2}$$

*Pitot
Coefficient*

Manometer

*Stack Temperature
Thermocouple +
Thermosensor*

*Molecular
dry
weight*

*Stack
Pressure*

Standard Uncertainty (s.u) = **1.27%**
 To 95% confidence (where k=2) = **2.54%**

*Note: When square root of component uncertainty (velocity heads, stack temp and molecular weight) is placed into this "square root of the sums of the component squares" equation it changes to half 1/2. "NPL Guide, P15"

Time Uncertainty (t) is proven through past test certificates, to be 1 second out in the 1 hour test run therefor +/- 0.5sec.

$$= \frac{0.5}{\sqrt{3}} \times \frac{2.89}{60} \times 100$$

*Typical particulate
run duration (mins)*

Standard Uncertainty (s.u) = **0.48%**
 To 95% confidence (where k=2) = **0.96%**

Nozzle Area Uncertainty (A_n) arises as a function of the accuracy of the UKAS Accredited calipers used to calibrate the nozzles. The diameter resolution/scaling degree goes to 0.01mm which gives an uncertainty of:

$$= \frac{0.005}{\sqrt{3}} \times 2 \times 100 \text{ for } \%$$

*Used twice in
area
conversion*

Standard Uncertainty (s.u) = **0.58%**
 To 95% confidence (where k=2) = **1.15%**

Iso-kinetic ratio =

$$\sqrt{(1.53)^2 + (0.58)^2 + (0.48)^2 + (1.27)^2}$$

<i>Actual Volume Measured</i>	<i>Nozzle Area</i>	<i>Time</i>	<i>Stack Velocity</i>
---------------------------------------	------------------------	-------------	---------------------------

Since these values are measured uncertainties (not type B) they need only to be combined.

Standard Uncertainty (s.u) = **2.13%**
 To 95% confidence(where k=2) = **4.25%**

Particulate Concentration Uncertainty will be the combination of the mass of particulate measured (M), the volume sampled at meter V(mstd), plus any uncertainty related to referencing it to oxygen.

Actual Volume Uncertainty =	1.53 %
Oxygen Referencing Uncertainty =	3.1 %
Laboratory Weighing Standard Uncertainty =	13.4 %

Particulate Concentration Uncertainty =

$$\sqrt{(1.53)^2 + (xx)^2 + (xx)^2}$$

<i>Actual Volume Uncertainty</i>	<i>Weighing Uncertainty</i>	<i>Oxygen Referencing Uncertainty</i>
--	---------------------------------	---

Standard Uncertainty (s.u) = **13.8 %**
 To 95% confidence(where k=2) = **27.7 %**

SO2 Uncertainty Budget Calculation

Calculated in accordance with Annex A, CEN/TS 17021:2017

Performance characteristic	Partial Uncertainty	Value of partial Standard uncertainty (ppm)	
Lack of fit	$u(\text{Corr}_{fit})$	=	0.10
Zero drift	$u(\text{Corr}_{0,dr})$	=	0.01
Span drift	$u(\text{Corr}_{s,dr})$	=	0.01
Repeatability at span level	$u(\text{Corr}_{rep})$	=	0.04
Sensitivity to sample volume flow	$u(\text{Corr}_{s,vf})$	=	0.17
Sensitivity to atmospheric pressure	$u(\text{Corr}_{apress})$	=	0.00
Sensitivity to ambient temperature	$u(\text{Corr}_{temp})$	=	0.00
Sensitivity to electric voltage	$u(\text{Corr}_{volt})$	=	0.10
Interferents	$u(\text{Corr}_{inter})$	=	0.55
Losses & leakage in sampling system	$u(\text{Corr}_{losses})$	=	0.16
Uncertainty of calibration gas	$u(\text{Corr}_{adj})$	=	0.07

$$u(C_{SO2,stack}) = u(C_{SO2,ppm}) = \text{SQRT} \{ u^2(\text{Corr}_{fit}) + u^2(\text{Corr}_{0,dr}) + u^2(\text{Corr}_{s,dr}) + u^2(\text{Corr}_{rep}) + u^2(\text{Corr}_{s,vf}) + u^2(\text{Corr}_{apress}) + u^2(\text{Corr}_{temp}) + u^2(\text{Corr}_{volt}) + u^2(\text{Corr}_{inter}) + u^2(\text{Corr}_{losses}) + u^2(\text{Corr}_{adj}) \}$$

=

±

0.6 ppm

SO2

$$u(C_{SO2,mg/m3}) =$$

±

1.8 mg/m³

SO2

$$U(C_{SO2,mg/m3}) (k=2) =$$

±

3.5 mg/m³

SO2

±

122.27% relative

Concentration in stack	1 ppm SO2
Calibration gas concentration	
Analyser range	0 to 51 ppm

TWM001_PPC-PPC_A1_017288_Dec_2025_MR_V1

Uncert SO2-RTO B

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NOx/NO Uncertainty Budget Calculation

Calculated in accordance with BS EN 14792

Performance characteristic	Partial Uncertainty	Value of partial Standard uncertainty (ppm)	
Lack of fit	$u(\text{Corr}_{fit})$	= 0.25	
Zero drift	$u(\text{Corr}_{0,dr})$	= 0.05	
Span drift	$u(\text{Corr}_{s,dr})$	= 0.19	
Repeatability at span level	$u(\text{Corr}_{rep})$	= 0.04	
Sensitivity to sample volume flow	$u(\text{Corr}_{s,vf})$	= 0.55	
Sensitivity to atmospheric pressure	$u(\text{Corr}_{apress})$	= 0.00	
Sensitivity to ambient temperature	$u(\text{Corr}_{temp})$	= 0.00	
Sensitivity to electric voltage	$u(\text{Corr}_{volt})$	= 0.26	
Interferent: NH3	$u(\text{Corr}_{NH3})$	= 0.43	
Interferent: CO2	$u(\text{Corr}_{CO2})$	= 0.00	
Uncertainty of calibration gas	$u(\text{Corr}_{adj})$	= 0.07	
Converter efficiency	$u(\eta)$	= 0.045	% absolute
Converter efficiency	η	= 0.955	

$$u(C_{NO,stack}) = u(C_{NO,ppm}) = \text{SQRT} \{u^2(\text{Corr}_{fit}) + u^2(\text{Corr}_{0,dr}) + u^2(\text{Corr}_{s,dr}) + u^2(\text{Corr}_{rep}) + u^2(\text{Corr}_{s,vf}) + u^2(\text{Corr}_{apress}) + u^2(\text{Corr}_{temp}) + u^2(\text{Corr}_{volt}) + u^2(\text{Corr}_{NH3}) + u^2(\text{Corr}_{CO2}) + u^2(\text{Corr}_{adj})\}$$

$$= \pm 0.8 \text{ ppm NO}$$

$$u(C_{NO,mg/m^3}) = \pm 1.1 \text{ mg/m}^3 \text{ NO}$$

$$U(C_{NO,mg/m^3}) (k=2) = \pm 2.2 \text{ mg/m}^3 \text{ NO} \pm 0.22\% \text{ relative}$$

$$u(C_{NOx,stack}) = u(C_{NO,ppm}) + \text{converter}_{function} = \pm 0.9 \text{ ppm NO}_2$$

$$u(C_{NO2,mg/m^3}) = \pm 1.8 \text{ mg/m}^3 \text{ NO}_2$$

$$U(C_{NO2,mg/m^3}) (k=2) = \pm 3.5 \text{ mg/m}^3 \text{ NO}_2 \pm 0.23\% \text{ relative}$$

To be used as the SRM the overall uncertainty has to be < ±10% of the daily ELV

Concentration in stack 746 ppm NOx
 Calibration gas concentration
 Analyser range 0 to 1000 ppm

ELV = 200 mg/m³
 Overall uncertainty = 1.8 %

CO Uncertainty Budget Calculation

Calculated in accordance with BS EN 15058

Performance characteristic	Partial Uncertainty	Value of partial Standard uncertainty (ppm)	
Lack of fit	$u(\text{Corr}_{fit})$	=	0.13
Zero drift	$u(\text{Corr}_{0,dr})$	=	0.18
Span drift	$u(\text{Corr}_{s,dr})$	=	0.18
Repeatability at span level	$u(\text{Corr}_{rep})$	=	0.05
Sensitivity to sample volume flow	$u(\text{Corr}_{s,vf})$	=	0.59
Sensitivity to atmospheric pressure	$u(\text{Corr}_{apress})$	=	0.00
Sensitivity to ambient temperature	$u(\text{Corr}_{temp})$	=	0.00
Sensitivity to electric voltage	$u(\text{Corr}_{volt})$	=	0.65
Interferent: CH4	$u(\text{Corr}_{NH3})$	=	0.00
Interferent: CO2	$u(\text{Corr}_{CO2})$	=	0.00
Uncertainty of calibration gas	$u(\text{Corr}_{adj})$	=	0.08

$$u(C_{CO,stack}) = u(C_{CO,ppm}) = \text{SQRT} \{ u^2(\text{Corr}_{fit}) + u^2(\text{Corr}_{0,dr}) + u^2(\text{Corr}_{s,dr}) + u^2(\text{Corr}_{rep}) + u^2(\text{Corr}_{s,vf}) + u^2(\text{Corr}_{apress}) + u^2(\text{Corr}_{temp}) + u^2(\text{Corr}_{volt}) + u^2(\text{Corr}_{CH4}) + u^2(\text{Corr}_{CO2}) + u^2(\text{Corr}_{adj}) \}$$

= ± 0.9 ppm CO

$$u(C_{CO,mg/m^3}) = \pm 1.2 \text{ mg/m}^3 \text{ CO}$$

$$U(C_{CO,mg/m^3}) (k=2) = \pm 2.3 \text{ mg/m}^3 \text{ CO} \pm 0.93\% \text{ relative}$$

To be used as the SRM the overall uncertainty has to be < ±6% of the daily ELV

ELV = 150 mg/m³
Overall uncertainty = 1.5 %

Concentration in stack	197 ppm CO
Calibration gas concentration	
Analyser range	0 to 200 ppm

The Total Uncertainty of Measurement for BS EN 12619 - Total VOCs

1. Introduction

The Total Measurement of Uncertainty for Volatile Organic Compounds (VOCs) using direct instrumental analysis giving real time readings according to BS EN 12619. The gas analyser which we use is the *Bernath model 3006* which uses the Flame Ionisation Detection method of VOC detection. This instrument undergoes an annual calibration check which includes measurement of bias, interferences, linearity and response times. All cells are zeroed and re-calibrated on-site before use.

All specifications used in the uncertainty calculations are from the *Bernath instruction manual and manufactures calibration test certificate* with the exception of the propane calibration gas to span. All of our calibration gases have a gold star for quality which means it is within +/- 2% of the stated value.

It should be noted that when on ranges between 10 - 10,000ppm the uncertainty linked with linearity drops from 5% to 1%.

2. Combining Uncertainty Components

$$= \sqrt{\left(\frac{2}{\sqrt{3}}\right)^2 + \left(\frac{1}{\sqrt{3}}\right)^2 + \left(\frac{0.5}{\sqrt{3}}\right)^2 + \left(\frac{2.8}{\sqrt{3}}\right)^2 + \left(\frac{2}{\sqrt{3}}\right)^2 + \left(\frac{2}{\sqrt{3}}\right)^2} = 2.65$$

Calibration
Gas
Linearity
Drift of
zero
Drift of
span
Sample Line
Loss
Interference

Value is divided by square root of three in order to give standard uncertainty, as the measured

Standard Uncertainty (s.u) =	2.65%
To 95% confidence(Where k=2) =	5.30%

O₂ Uncertainty Budget Calculation

Calculated in accordance with BS EN 14789

Performance characteristic	Partial Uncertainty	Value of partial Standard uncertainty (%vol)	
Lack of fit	$u(\text{Corr}_{fit})$	=	0.06
Zero drift	$u(\text{Corr}_{0,dr})$	=	0.04
Span drift	$u(\text{Corr}_{s,dr})$	=	0.02
Repeatability at span level	$u(\text{Corr}_{rep})$	=	0.01
Sensitivity to sample volume flow	$u(\text{Corr}_{s,vf})$	=	0.12
Sensitivity to atmospheric pressure	$u(\text{Corr}_{apress})$	=	0.000
Sensitivity to ambient temperature	$u(\text{Corr}_{temp})$	=	0.000
Sensitivity to electric voltage	$u(\text{Corr}_{volt})$	=	0.03
Interferent: NO	$u(\text{Corr}_{NO})$	=	0.00
Interferent: CO ₂	$u(\text{Corr}_{CO2})$	=	0.00
Uncertainty of calibration gas	$u(\text{Corr}_{adj})$	=	0.14

$$u(C_{O2,stack}) = u(C_{O2,\%vol}) = \text{SQRT} \{u^2(\text{Corr}_{fit}) + u^2(\text{Corr}_{0,dr}) + u^2(\text{Corr}_{s,dr}) + u^2(\text{Corr}_{rep}) + u^2(\text{Corr}_{s,vf}) + u^2(\text{Corr}_{apress}) + u^2(\text{Corr}_{temp}) + u^2(\text{Corr}_{volt}) + u^2(\text{Corr}_{NO}) + u^2(\text{Corr}_{CO2}) + u^2(\text{Corr}_{adj})\}$$

= ± 0.2 %vol O₂

U(C_{O2},%vol) (k=2) = ± 0.4 %vol O₂ ± 3.08% relative

Concentration in stack	13.1 %vol O ₂
Calibration gas concentration	
Analyser range	0 to 21 %vol

Appendix 2

Sub-contracted Laboratory Analysis Certificates

Certificate of Analysis

Report No.: 25-11014-1

Issue No.: 1

Date of Issue 24/12/2025

Customer Details: TUV SUD Ltd, NEL, Scottish Enterprise Tech. Park, East Kilbride, Glasgow, G75 0QF, Scotland

Customer Contact: REDACTED

Customer Order No.: TO FOLLOW

Customer Reference: Not Supplied

Quotation Reference: Q25-07614

Description: 2 liquid samples, 2 solid samples

Date Received: 10/12/2025

Date Started: 10/12/2025

Date Completed: 23/12/2025

Test Methods: Details available on request (refer to SOP code against relevant result/s)

Notes: None

REDACTED

Approved By: REDACTED

This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service.

This certificate shall not be reproduced except in full without the prior written approval of the laboratory.

Observations and interpretations are outside of the scope of UKAS accreditation.

Results reported herein relate only to the items supplied to the laboratory for testing.

Results on an Interim Report are not dry-weight corrected.

Where the laboratory is not responsible for the sampling, results apply to the sample(s) as they were received.

The laboratory shall not be responsible for any information that is supplied by the customer that may affect the validity of results.



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Unit 12, Waters Edge Business Park, Modwen Road, Salford, M5 3EZ. T +44 161 872 2443

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Results Summary

Report No.: 25-11014-1

Customer Reference: Not Supplied

Customer Order No: TO FOLLOW

Customer Sample No	TWM001/01 a (003809)	TWM001/01 b	TWM001/02 a (262092)	TWM001/02 b
RPS Sample No	340009	340010	340011	340012
Sample Matrix	FILTER	SOLUTION	FILTER	SOLUTION
Sampling Date	04/12/2025	04/12/2025	04/12/2025	04/12/2025

Determinand	CAS No	Codes	SOP	RL	Units				
particulates		UM	D9	0.04	mg	< 0.04		4.17	
particulates		UM	D9	0.5	mg		< 0.5		0.7

Deviating Samples

Report No.: 25-11014-1

Customer Reference: Not Supplied

Customer Order No: TO FOLLOW

Our policy on Deviating Samples has been implemented in accordance with UKAS Policy on Deviating Samples (TPS63).
RPS is not responsible for the integrity of samples as received, unless RPS personnel performed the sampling. Samples submitted may be declared to be deviating.
Where applicable the analysis method remains UKAS accredited, however results reported for a deviating sample may be compromised.
Where no sampling date was supplied, samples have been declared to be deviating. If the date can be supplied, results may be reissued if assessed not deviating.
Where the sample container used was unsuitable or broken, the sample is flagged as deviating and re-sampling/re-submission may be required.

RPS No.	Customer No.	Customer ID	Date Sampled	Containers Received	Deviating	Reason for Deviation
340009	TWM001/01 - a		04/12/2025	Container	No	
	(003809)					
340010	TWM001/01 - b		04/12/2025	Container	No	
	TWM001/02 - a					
340011	(262092)		04/12/2025	Container	No	
340012	TWM001/02 - b		04/12/2025	Container	No	

Report No.: 25-11014-1

Key Code	Description
N	Not Accredited Test
U	UKAS Accredited Test - UKAS accreditation is only implied if the report carries the UKAS logo
UF	UKAS Flexible Scope Test
M	MCERTS Accredited Test - MCERTS accreditation is only implied if the report carries the MCERTS logo
O	Marine Management Organisation (MMO) Validated
SN	Subcontracted to approved laboratory not accredited for the test
SU	Subcontracted to approved laboratory UKAS Accredited for the test
SM	Subcontracted to approved laboratory MCERTS/UKAS Accredited for the test
SIN	Subcontracted to internal RPS Group laboratory not accredited for the test
SIU	Subcontracted to internal RPS Group laboratory UKAS Accredited for the test
SIM	Subcontracted to internal RPS Group laboratory MCERTS/UKAS Accredited for the test
I/S (in results)	Insufficient Sample
U/S (in results)	Unsuitable Sample
S/C (in results)	See Comments
ND (in results)	Not Detected
L (in results)	Result is outside normal limits

Please note that all samples will be destroyed 4 WEEKS after the report has been issued.

Note: Sample retention may be subject to agreement with the customer for particular projects

Certificate Notes	Description
Note 1	This test report shall not be reproduced except in full, without written approval of the Laboratory.
Note 2	Unless otherwise stated, results are not corrected for analytical recoveries.
Note 3	Samples were taken by the customer and, unless otherwise stated, sampling locations were not supplied.
Note 4	Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.
Note 5	Unless otherwise stated, method D9 conditioning temperatures are 180°C for pre-weigh and 160°C for re-weigh.
Note 6	The PDF version of the certificate is the definitive copy and the Excel version is uncontrolled and provided for information only.

Note: Where the following information is included in this certificate, it has usually been supplied by the customer: Customer Sample ID, Sample Location, Sampling Date and Sample Air Volumes. The laboratory shall not be responsible for any information that is supplied by the customer that may affect the validity of results.

Report No.: 25-11014-1

Determinand	CAS No	Media	SOP	% Recovery	% Uncertainty
acetaldehyde	75-07-0	tube	A40	98	16.2
benzaldehyde	100-52-7	tube	A40	100	19.4
butyraldehyde	123-72-8	tube	A40	92	11.5
formaldehyde	50-00-0	tube	A40	97	12.8
hexanal	66-25-1	tube	A40	89	11
propionaldehyde	123-38-6	tube	A40	96	12.6
valeraldehyde	110-62-3	tube	A40	93	12.3
ammonia	7664-41-7	sulphuric acid solution	A6	n/a	8.9
chlorine	7782-50-5	sodium hydroxide solution	C27	n/a	15.2
hydrogen bromide	10035-10-6	sulphuric acid solution	C27	n/a	10.9
hydrogen chloride	7647-01-0	deionised water	C27	n/a	7.9
hydrogen chloride	7647-01-0	sulphuric acid solution	C27	n/a	13.3
hydrogen fluoride	7664-3-3	sodium hydroxide solution	C27	n/a	7.9
sulphur dioxide	7446-09-5	hydrogen peroxide solution	C27	n/a	7.7
nitrogen oxide	10102-43-9	potassium permanganate solution	C27	n/a	11.7
particulates	n/a	filter	D9	n/a	12.2
particulates	n/a	wash solution	D9	n/a	14.8
formaldehyde	50-00-0	deionised water	M103	n/a	23.7
2,4- & 2,6-toluene diisocyanate (TDI)	n/a	filter	M119	n/a	8.6
hexamethylene diisocyanate (HDI)	822-06-0	filter	M119	n/a	5.6
methylene diphenyl diisocyanate (MDI)	101-68-8	filter	M119	n/a	11.8
hydrogen sulphide	7783-06-4	zinc acetate solution	M120	n/a	4.2
antimony	7440-36-0	filter	M31	n/a	10.3
arsenic	7440-38-2	filter	M31	n/a	17.1
cadmium	7440-43-9	filter	M31	n/a	12.1
chromium	7440-47-3	filter	M31	n/a	17.1
cobalt	7440-48-4	filter	M31	n/a	13.1
copper	7440-50-8	filter	M31	n/a	14
lead	7439-92-1	filter	M31	n/a	9.8
manganese	7439-96-5	filter	M31	n/a	17.5
nickel	7440-02-0	filter	M31	n/a	14.4
thallium	7440-28-0	filter	M31	n/a	15.3
tin	7440-31-5	filter	M31	n/a	18.5
vanadium	7440-62-2	filter	M31	n/a	12.1
zinc	7440-66-6	filter	M31	n/a	15.2
antimony	7440-36-0	nitric acid wash	M31	n/a	10.3
arsenic	7440-38-2	nitric acid wash	M31	n/a	17.1
cadmium	7440-43-9	nitric acid wash	M31	n/a	12.1
chromium	7440-47-3	nitric acid wash	M31	n/a	17.1
cobalt	7440-48-4	nitric acid wash	M31	n/a	13.1
copper	7440-50-8	nitric acid wash	M31	n/a	14
lead	7439-92-1	nitric acid wash	M31	n/a	9.8
manganese	7439-96-5	nitric acid wash	M31	n/a	17.5
nickel	7440-02-0	nitric acid wash	M31	n/a	14.4
selenium	7782-49-2	nitric acid wash	M31	n/a	15.1
thallium	7440-28-0	nitric acid wash	M31	n/a	15.3
tin	7440-31-5	nitric acid wash	M31	n/a	18.5
vanadium	7440-62-2	nitric acid wash	M31	n/a	12.1
zinc	7440-66-6	nitric acid wash	M31	n/a	15.2
antimony	7440-36-0	nitric/peroxide solution	M31	n/a	5.9
arsenic	7440-38-2	nitric/peroxide solution	M31	n/a	6.8
cadmium	7440-43-9	nitric/peroxide solution	M31	n/a	6.3
chromium	7440-47-3	nitric/peroxide solution	M31	n/a	7.2
cobalt	7440-48-4	nitric/peroxide solution	M31	n/a	5.2
copper	7440-50-8	nitric/peroxide solution	M31	n/a	6.8
lead	7439-92-1	nitric/peroxide solution	M31	n/a	8.6
manganese	7439-96-5	nitric/peroxide solution	M31	n/a	9.6
nickel	7440-02-0	nitric/peroxide solution	M31	n/a	5.5
selenium	7782-49-2	nitric/peroxide solution	M31	n/a	8.7
thallium	7440-28-0	nitric/peroxide solution	M31	n/a	7.7
tin	7440-31-5	nitric/peroxide solution	M31	n/a	5.8
vanadium	7440-62-2	nitric/peroxide solution	M31	n/a	6.7
zinc	7440-66-6	nitric/peroxide solution	M31	n/a	11.9
1,2,4-trimethylbenzene	95-63-6	tube	O8	88	8.1
1,3,5-trimethylbenzene	108-67-8	tube	O8	92	7.7
2-ethyltoluene	611-14-3	tube	O8	91	8.4
3- & 4-ethyltoluene	n/a	tube	O8	91	8.4
benzene	71-43-2	tube	O8	90	13.9
butyl acetate	123-86-4	tube	O8	90	10.3
decane	124-18-5	tube	O8	97	6.7
dichloromethane	75-09-2	tube	O8	88	24
ethyl acetate	141-78-6	tube	O8	n/a	n/a
ethyl benzene	100-41-4	tube	O8	92	9.8
heptane	142-82-5	tube	O8	94	10.5
hexane	110-54-3	tube	O8	n/a	n/a
limonene	138-86-3	tube	O8	93	13
m- & p-xylene	n/a	tube	O8	90	9.3
methyl isobutyl ketone (MIBK)	108-10-1	tube	O8	86	10
methyl tert-butyl ether (MTBE)	1634-04-4	tube	O8	92	15
o-xylene	95-47-6	tube	O8	86	9.9
propylbenzene	103-65-1	tube	O8	92	7.5
tetrachloroethylene	127-18-4	tube	O8	91	9.3
tetrahydrofuran (THF)	109-99-9	tube	O8	87	14.7
toluene	108-88-3	tube	O8	89	10.7
trichloroethylene	79-01-6	tube	O8	91	10.6
m- & p-cresol	n/a	tube	P1	n/a	11
m- & p-xylenol	n/a	tube	P1	n/a	11.9
o-cresol	95-48-7	tube	P1	n/a	10.8
o-xylenol	526-75-0	tube	P1	n/a	12
phenol	108-95-2	tube	P1	n/a	10.4