NATIONAL PHYSICAL LABORATORY
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Test Report

UKAS TESTING
0002

MCERTS
THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

OXIDES OF NITROGEN (AS NO_2) AND CARBON MONOXIDE COMPLIANCE TESTING AT SOUTH HOOK LNG TERMINAL ON BEHALF OF INTERTEK LIMITED

Permit Number:	**XP3538LD**
Operator Name:	**South Hook LNG (on behalf of Intertek Limited)**
Installation Name:	**South Hook LNG Terminal**
Dates of Monitoring Visit:	**2nd - 4th March 2021**
Contract Reference:	**E08040221**
Client Contact:	**Adrian Walsh**
Client Organisation:	**Intertek Limited**
Address:	**Unit 14 - Waterston Trading Estate Main Road, Waterston Milford Haven SA73 3SL**
Monitoring Organisation:	**National Physical Laboratory**
Address:	**Hampton Road Teddington Middlesex TW11 0LW**
Date of Report:	**26th March 2021**
Report Author	**Lorenzo Bonsignore**

Reference: XP3538LD/INTERTEK/SHLNG/MAR2021/SCV/PPC/Q1/V1

Report Approver:	Kevin Blakley	NPL Authorised Signatory
MCERTS Registration:	MM-03-317	Name: Mr R Robinson (for NPLML)
Level & TEs Held:	Level 2, TE1, TE2, TE3 & TE4	Signature: pp K C Blakley
Signature:	K C Blakley	

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1.1 Monitoring Objectives

NPL were awarded a contract by Intertek Limited to carry out emissions compliance testing at South Hook LNG plant near Milford Haven, Pembrokeshire. The scope of work includes carrying out emissions monitoring on the SCV flue stacks phases one and two.
There are a total of fifteen SCV units on the South Hook site that require monitoring, eight on phase one and seven on phase two. Ten units were measured for oxides of nitrogen and carbon monoxide.

In addition, oxygen measurements were taken to allow a correction to reference conditions. Water vapour and flow measurements were also taken to determine the moisture content and velocity of the flue gas.

NPL carried out the monitoring visit between the 2nd and 4th March 2021. The report documents the results obtained.

1.2.1 SCV A (Phase One) Monitoring Results

Client: Intertek
Site: South Hook LNG
Emission Point: SCV A (Phase One)

Field	Units	Oxides of Nitrogen (as NO_2)	Carbon Monoxide	Oxygen	Moisture
Emission Limit Value	**mg/m^3, Reference Conditions**	107	N/A	N/A	N/A
Periodic Monitoring Result	**Reference Conditions**	57.9	119	10.0	1.4
Uncertainty (95% Confidence Level)	**Reference Conditions**	10.6	23.0	0.7	N/A
	Units	mg/m^3	mg/m^3	%Vol/Vol	%Vol/Vol
Average Stack Flow	**m^3/s at Reference Conditions**	7.5			
Reference Conditions		273K, 101.3 kPa, 3% Oxygen on a dry gas basis			
Date	**dd/mm/yyyy**	02/03/2021			
Sample Period	**From hh:mm**	12:00			
	To hh:mm	13:00			
Monitoring Method		BS EN 14792:2017	BS EN 15058:2017	BS EN 14789:2017	BS EN 14790:2017
Accreditation		UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS
Process Status	**Load (Tonnes/Hour)**	145			
Burner Demand	**Burner Demand (%)**	40.4			

1.2.2 SCV C (Phase One) Monitoring Results

Client: Intertek
Site: South Hook LNG
Emission Point: SCV C (Phase One)

Field	Units	Oxides of Nitrogen (as NO_2)	Carbon Monoxide	Oxygen	Moisture
Emission Limit Value	**mg/m^3, Reference Conditions**	107	N/A	N/A	N/A
Periodic Monitoring Result	**Reference Conditions**	56.9	213	11.3	1.5
Uncertainty (95% Confidence Level)	**Reference Conditions**	11.8	36.7	0.7	N/A
	Units	mg/m^3	mg/m^3	%Vol/Vol	%Vol/Vol
Average Stack Flow	**m^3/s at Reference Conditions**	6.3			
Reference Conditions		273K, 101.3 kPa, 3% Oxygen on a dry gas basis			
Date	**dd/mm/yyyy**	02/03/2021			
Sample Period	**From hh:mm**	13:40			
	To hh:mm	14:40			
Monitoring Method		BS EN 14792:2017	BS EN 15058:2017	BS EN 14789:2017	BS EN 14790:2017
Accreditation		UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS
Process Status	**Load (Tonnes/Hour)**	120			
Process Status	**Burner Demand (%)**	31.3			

1.2.3 SCV D (Phase One) Monitoring Results

Client: Intertek
Site: South Hook LNG
Emission Point: SCV D (Phase One)

Field	Units	Oxides of Nitrogen (as NO_2)	Carbon Monoxide	Oxygen	Moisture
Emission Limit Value	**mg/m^3, Reference Conditions**	107	N/A	N/A	N/A
Periodic Monitoring Result	**Reference Conditions**	52.9	267	10.2	1.7
Uncertainty (95% Confidence Level)	**Reference Conditions**	10.3	39.0	0.7	N/A
	Units	mg/m^3	mg/m^3	%Vol/Vol	%Vol/Vol
Average Stack Flow	**m^3/s at Reference Conditions**	7.8			
Reference Conditions		273K, 101.3 kPa, 3% Oxygen on a dry gas basis			
Date	**dd/mm/yyyy**	02/03/2021			
Sample Period	**From hh:mm**	15:15			
	To hh:mm	16:15			
Monitoring Method		BS EN 14792:2017	BS EN 15058:2017	BS EN 14789:2017	BS EN 14790:2017
Accreditation		UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS
Process Status	**Load (Tonnes/Hour)**	150			
Process Status	**Burner Demand (%)**	34.1			

1.2.4 SCV E (Phase One) Monitoring Results

Client: Intertek
Site: South Hook LNG
Emission Point: SCV E (Phase One)

Field	Units	Oxides of Nitrogen (as NO_2)	Carbon Monoxide	Oxygen	Moisture
Emission Limit Value	**mg/m^3, Reference Conditions**	107	N/A	N/A	N/A
Periodic Monitoring Result	**Reference Conditions**	70.1	315	14.0	1.0
Uncertainty (95% Confidence Level)	**Reference Conditions**	18.1	67.6	0.7	N/A
	Units	mg/m^3	mg/m^3	%Vol/Vol	%Vol/Vol
Average Stack Flow	**m^3/s at Reference Conditions**	4.5			
Reference Conditions		273K, 101.3 kPa, 3% Oxygen on a dry gas basis			
Date	**dd/mm/yyyy**	03/03/2021			
Sample Period	**From hh:mm**	16:00			
	To hh:mm	17:00			
Monitoring Method		BS EN 14792:2017	BS EN 15058:2017	BS EN 14789:2017	BS EN 14790:2017
Accreditation		UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS
Process Status	**Load (Tonnes/Hour)**	80			
Process Status	**Burner Demand (%)**	38			

1.2.5 SCV F (Phase One) Monitoring Results

Client: Intertek
Site: South Hook LNG
Emission Point: SCV F (Phase One)

Field	Units	Oxides of Nitrogen (as NO_2)	Carbon Monoxide	Oxygen	Moisture
Emission Limit Value	**mg/m^3, Reference Conditions**	107	N/A	N/A	N/A
Periodic Monitoring Result	**Reference Conditions**	72.5	251	13.1	1.2
Uncertainty (95% Confidence Level)	**Reference Conditions**	16.4	49.6	0.7	N/A
	Units	mg/m^3	mg/m^3	%Vol/Vol	%Vol/Vol
Average Stack Flow	**m^3/s at Reference Conditions**	4.8			
Reference Conditions		273K, 101.3 kPa, 3% Oxygen on a dry gas basis			
Date	**dd/mm/yyyy**	03/03/2021			
Sample Period	**From hh:mm**	14:05			
	To hh:mm	15:05			
Monitoring Method		BS EN 14792:2017	BS EN 15058:2017	BS EN 14789:2017	BS EN 14790:2017
Accreditation		UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS
Process Status	**Load (Tonnes/Hour)**	90			
Process Status	**Burner Demand (%)**	32			

1.2.6 SCV G (Phase One) Monitoring Results

Client: Intertek
Site: South Hook LNG
Emission Point: SCV G (Phase One)

Field	Units	Oxides of Nitrogen (as NO_2)	Carbon Monoxide	Oxygen	Moisture
Emission Limit Value	**mg/m^3, Reference Conditions**	107	N/A	N/A	N/A
Periodic Monitoring Result	**Reference Conditions**	49.3	694	10.9	1.4
Uncertainty (95% Confidence Level)	**Reference Conditions**	10.5	96.9	0.7	N/A
	Units	mg/m^3	mg/m^3	%Vol/Vol	%Vol/Vol
Average Stack Flow	**m^3/s at Reference Conditions**	7.1			
Reference Conditions		273K, 101.3 kPa, 3% Oxygen on a dry gas basis			
Date	**dd/mm/yyyy**	03/03/2021			
Sample Period	**From hh:mm**	12:15			
	To hh:mm	13:15			
Monitoring Method		BS EN 14792:2017	BS EN 15058:2017	BS EN 14789:2017	BS EN 14790:2017
Accreditation		UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS
Process Status	**Load (Tonnes/Hour)**	130			
Process Status	**Burner Demand (%)**	40			

1.2.7 SCV H (Phase One) Monitoring Results

Client: Intertek
Site: South Hook LNG
Emission Point: SCV H (Phase One)

Field	Units	Oxides of Nitrogen (as NO_2)	Carbon Monoxide	Oxygen	Moisture
Emission Limit Value	**mg/m^3, Reference Conditions**	107	N/A	N/A	N/A
Periodic Monitoring Result	**Reference Conditions**	49.5	162	10.1	1.5
Uncertainty (95% Confidence Level)	**Reference Conditions**	9.8	26.5	0.7	N/A
	Units	mg/m^3	mg/m^3	%Vol/Vol	%Vol/Vol
Average Stack Flow	**m^3/s at Reference Conditions**	8.0			
Reference Conditions		273K, 101.3 kPa, 3% Oxygen on a dry gas basis			
Date	**dd/mm/yyyy**	03/03/2021			
Sample Period	**From hh:mm**	10:00			
	To hh:mm	11:00			
Monitoring Method		BS EN 14792:2017	BS EN 15058:2017	BS EN 14789:2017	BS EN 14790:2017
Accreditation		UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS
Process Status	**Load (Tonnes/Hour)**	150			
Process Status	**Burner Demand (%)**	48			

1.2.8 SCV A (Phase Two) Monitoring Results

Client: Intertek
Site: South Hook LNG
Emission Point: SCV A (Phase Two)

Field	Units	Oxides of Nitrogen (as NO_2)	Carbon Monoxide	Oxygen	Moisture
Emission Limit Value	**mg/m^3, Reference Conditions**	107	N/A	N/A	N/A
Periodic Monitoring Result	**Reference Conditions**	50.5	268	10.4	1.4
Uncertainty (95% Confidence Level)	**Reference Conditions**	10.2	38.9	0.7	N/A
	Units	mg/m^3	mg/m^3	%Vol/Vol	%Vol/Vol
Average Stack Flow	**m^3/s at Reference Conditions**	7.7			
Reference Conditions		273K, 101.3 kPa, 3% Oxygen on a dry gas basis			
Date	**dd/mm/yyyy**	04/03/2021			
Sample Period	**From hh:mm**	10:00			
	To hh:mm	11:00			
Monitoring Method		BS EN 14792:2017	BS EN 15058:2017	BS EN 14789:2017	BS EN 14790:2017
Accreditation		UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS
Process Status	**Load (Tonnes/Hour)**	140			
Process Status	**Burner Demand (%)**	44			

1.2.9 SCV D (Phase Two) Monitoring Results

Client: Intertek
Site: South Hook LNG
Emission Point: SCV D (Phase Two)

Field	Units	Oxides of Nitrogen (as NO_2)	Carbon Monoxide	Oxygen	Moisture
Emission Limit Value	**mg/m^3, Reference Conditions**	107	N/A	N/A	N/A
Periodic Monitoring Result	**Reference Conditions**	52.6	439	10.5	1.3
Uncertainty (95% Confidence Level)	**Reference Conditions**	10.5	60.5	0.7	N/A
	Units	mg/m^3	mg/m^3	%Vol/Vol	%Vol/Vol
Average Stack Flow	**m^3/s at Reference Conditions**	5.9			
Reference Conditions		273K, 101.3 kPa, 3% Oxygen on a dry gas basis			
Date	**dd/mm/yyyy**	04/03/2021			
Sample Period	**From hh:mm**	12:00			
	To hh:mm	13:00			
Monitoring Method		BS EN 14792:2017	BS EN 15058:2017	BS EN 14789:2017	BS EN 14790:2017
Accreditation		UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS
Process Status	**Load (Tonnes/Hour)**	110			
Process Status	**Burner Demand (%)**	40			

1.2.10 SCV E (Phase Two) Monitoring Results

Client: Intertek
Site: South Hook LNG
Emission Point: SCV E (Phase Two)

Field	Units	Oxides of Nitrogen (as NO_2)	Carbon Monoxide	Oxygen	Moisture
Emission Limit Value	**mg/m^3, Reference Conditions**	107	N/A	N/A	N/A
Periodic Monitoring Result	**Reference Conditions**	55.8	224	10.2	1.7
Uncertainty (95% Confidence Level)	**Reference Conditions**	10.5	33.1	0.7	N/A
	Units	mg/m^3	mg/m^3	%Vol/Vol	%Vol/Vol
Average Stack Flow	**m^3/s at Reference Conditions**	8.0			
Reference Conditions		273K, 101.3 kPa, 3% Oxygen on a dry gas basis			
Date	**dd/mm/yyyy**	04/03/2021			
Sample Period	**From hh:mm**	14:02			
	To hh:mm	15:02			
Monitoring Method		BS EN 14792:2017	BS EN 15058:2017	BS EN 14789:2017	BS EN 14790:2017
Accreditation		UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS	UKAS & MCERTS
Process Status	**Load (Tonnes/Hour)**	135			
Process Status	**Burner Demand (%)**	47			

1.3 Operating Information

South Hook LNG Terminal, situated in Pembrokeshire South West Wales, is a regasification plant for natural gas. The LNG is transported in specially designed vessels to Milford Haven where it is then transferred into storage tanks, where it awaits reheating and distribution into the UK National Grid.

A total of fifteen SCVs have been built across two phases. Each one has at least two five inch ports installed, as set out in BS EN 15259. The ports are located approximately thirteen metres from the base of the stack and can be accessed by ladders that lead to a permanent platform. The sampling platform has lighting, toe boards and handrails. There is sufficient parking on the roadway at the base of the stacks for the mobile laboratory and provision of 240v 16A power supply outlets.

Continuous or Batch Process?	Each SCV operates on a batch process. The number of SCVs operating and the load at which they are set depend upon the required site output.				
What part of the batch process was sampled? (If applicable)	The periodic monitoring is carried out once an SCV has been brought online to the operators required load and has stabilised. This loading remains constant through the one hour test.				
What fuel was used during monitoring? (If applicable)	A small amount of LNG is used as fuel to heat a volume of water. This heat exchange warms up the LNG allowing it to be passed out into the National Grid system.				
What feedstock was used during monitoring? (If applicable)	N/A				
What was the load during monitoring?	**Emission Point**	**Load (Ton/hr)**	**Burner Demand (%)**		
	SCV 1A	145	40.4		
	SCV 1C	120	31.3		
	SCV 1D	150	34.1		
	SCV 1E	80	38		
	SCV 1F	90	32		
	SCV 1G	130	40		
	SCV 1H	150	48		
	SCV 2A	140	44		
	SCV 2D	110	40		
	SCV 2E	135	47		
What abatement systems are present? Were they in operation?	Each SCV uses water injection to abate NOx emissions. The system was in operation during the periodic monitoring of each SCV.				
Periodic monitoring results and corresponding CEM values	**Emission Point**	**Substance Monitored**	**CEM Result**	**Periodic Monitoring Result**	**Units**
	SCV 1H	Oxides of Nitrogen	48.7	49.5	mg/Nm^3
	SCV 1H	Oxygen	10.8	10.1	% Vol
	SCV 2A	Oxides of Nitrogen	42.2	50.5	mg/Nm^3
	SCV 2A	Oxygen	10.7	10.4	% Vol

1.4 Monitoring Deviations

Were all substances in the monitoring objectives monitored? If not why?	All substances set out in the objective were monitored.
Were all substances monitored in accordance to the relevant method? If not why?	All substances set out in the monitoring objectives were measured in accordance to the relevant standards.
Were there any other issues relevant to the monitoring results?	Only one port was measured for flow on the SCV 2D as the other was painted over and couldn't be removed

1.5 Conclusions

NPL carried out the emissions monitoring at South Hook LNG over a period of week. Ten SCVs were monitored for the required determinands.

The client is aware of BS EN 15259 and the requirement to carry out homogeneity testing. These tests were carried out on SCVs 1H and 2A, both units passed.

Reference - XP3538LD/INTERTEK/SHLNG/JULY2011/SCV/HOMOGENEITY.

1.6 References

1. STA – Risk Assessment Guide: Industrial-emission monitoring.

2. Environmental Agency - Manual Stack emission monitoring performance standard for Organisations.

3. Environmental Agency – M1 Technical Guidance Note – Sampling requirements for stack emission monitoring.

4. Environmental Agency – Online Guidance – Monitoring stack emissions: Techniques and standards for periodic monitoring.

5. Environment Agency - MID 15259 - Stationary source emissions - Requirements for the measurement sections and sites and for the measurement objective, plan and report.

6. Guidance on Assessing Measurement Uncertainty in Stack Emissions Monitoring, by Pullen J and Robinson R, Source Testing Association, Quality Guidance Note QGN1.

APPENDIX ONE

2.1.1 Emissions Testing Personnel Details

Name	Role	MCERTS Number	Certification Level & Expiry Dates					
			Level 1	Level 2	TE1	TE2	TE3	TE4
Matthew Ellison	Team Leader	MM-05-682	N/A	Jul-2023	Sep-2023	Sep-2023	Dec-2023	Sep-2023
Jonny Guy	Site Assistant	MM-16-1388	Jul-2022	N/A	Sep-2025	N/A	N/A	N/A

2.1.2 Emissions Testing Procedures

	Instrumental Methods			Manual Methods		
Determinand	**NOx**	**CO**	**O_2**	**H_2O**	**Stack Flow**	**Temperature**
SRM Standard	BS EN 14792:2017	BS EN 15058:2017	BS EN 14789:2017	BS EN 14790:2017	BS ISO 16911:2013	BS ISO 16911:2013
Instrument	Horiba PG-250	Horiba PG-250	Horiba PG-250	Saturation Chart	Pitot	Type K Thermocouple
Instrument Serial No.	AS0246	AS0246	AS0246	N/A	AS0681	AS0451a
Principle	Chemiluminescence	NDIR	Zirconia	N/A	Flow	Temperature
Operational Range	0 - 250 ppm	0 - 500 ppm	0 - 25%	N/A	N/A	N/A
Certified Range	0 - 125 mg/m^3	0 - 95 mg/m^3	0 - 25%	N/A	N/A	N/A
Uncertainty	10%	6%	6%	20%	10%	1%
NPL Procedure	QPAS B 538	QPAS B 538	QPAS B 538	QPAS B 540	QPAS B 567	QPAS B 567
UKAS Accreditation	YES	YES	YES	YES	YES	YES

The sample gas was extracted from the stack via a chemically inert heated line and drawn through a conditioning unit. All moisture in the gas sample was removed and cooled down to 4^oC before it was pumped down another line to the NPL Mobile Source Emissions Laboratory and analysed using a Horiba PG-250. The entire sampling system had been leak tested before testing was carried out to ensure no dilution of the sample gas.

The conventional analyser zero and span settings were checked before and after each test run using zero grade nitrogen (ex BOC), a suitable gas mixture (BOC beta gas standard), traceable to national reference standards and a gas dilution system. The certified accuracies of the gas standards are listed below: -

Component	Sample Location	Cylinder ID	Certified Amount	Certified Uncertainty
Carbon Monoxide	Phase 1 & 2 SCVs	183642SG	154.9 ppm	1%
Nitrogen Oxide		183642SG	79.4 ppm	1%
Oxygen		253223SG	15.30%	1%

These measurement uncertainties are expressed at a 95% level of confidence.

The ranges of the Horiba PG-250 and PG-250 SRM analysers used for the testing and the values used to calibrate the instrument before and after the testing are listed below: -

Gaseous Components	Horiba Ranges	Calibrated Values
Carbon Monoxide	0 - 200 ppm	154.9 ppm
Oxides of Nitrogen (as NO_2)	0 - 100 ppm	79.4 ppm
Oxygen	0 - 25%	15.30%

A leak test was conducted before testing to confirm hydraulic integrity of the gaseous sampling system. This was conducted by sending nitrogen down the entire sample line and ensuring a zero reading was obtained.

The electrical volt/millivolt outputs from the PG-250 gas analyser was collected by data logger software on a PC and downloaded to digital media at the end of each day. Under the program used during the tests, the software records and stores individual readings either every 1 or 10 seconds. From this data, the logger can perform a series of calculations to output 1 minute averaged measurement on a volume/volume or mass/volume basis. After each 1 minute average has been established the data buffer is reset and the process repeats.

2.1.3 Equipment Checklist Reference

See workfile INTK52FEB21/Equipment Checklist.

2.1.4 Data Capture Location Reference

All data collected using the NPL computer system on site is backed up at the end of each day onto a memory stick. When the team returns to site this information is then uploaded onto the NPL servers and stored in the relevant location for that job. The link below is where the South Hook emissions data is stored:

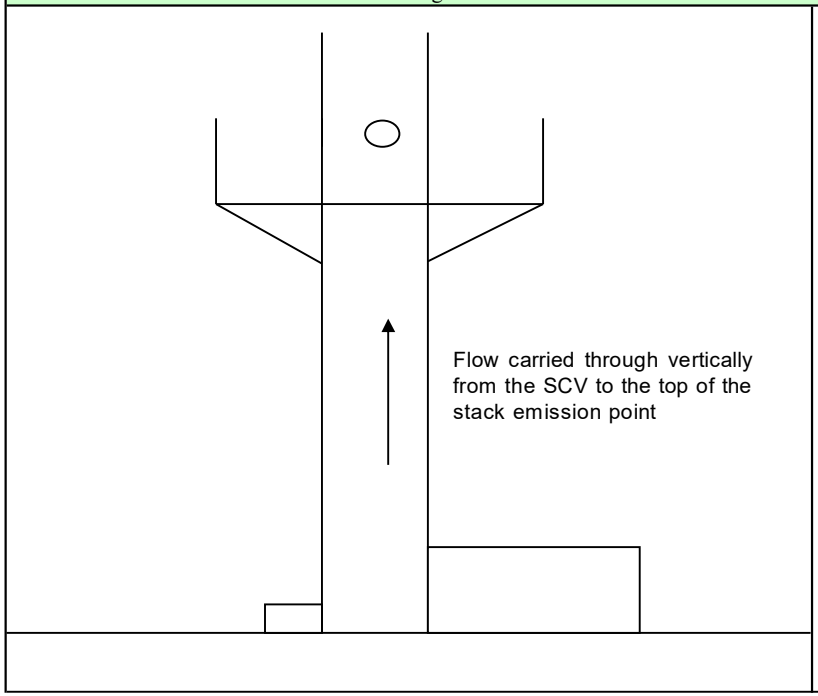
P:\Stack Emissions Team\South Hook LNG - Intertek\INTK52FEB21\7. Monitoring Record Sheets

APPENDIX TWO

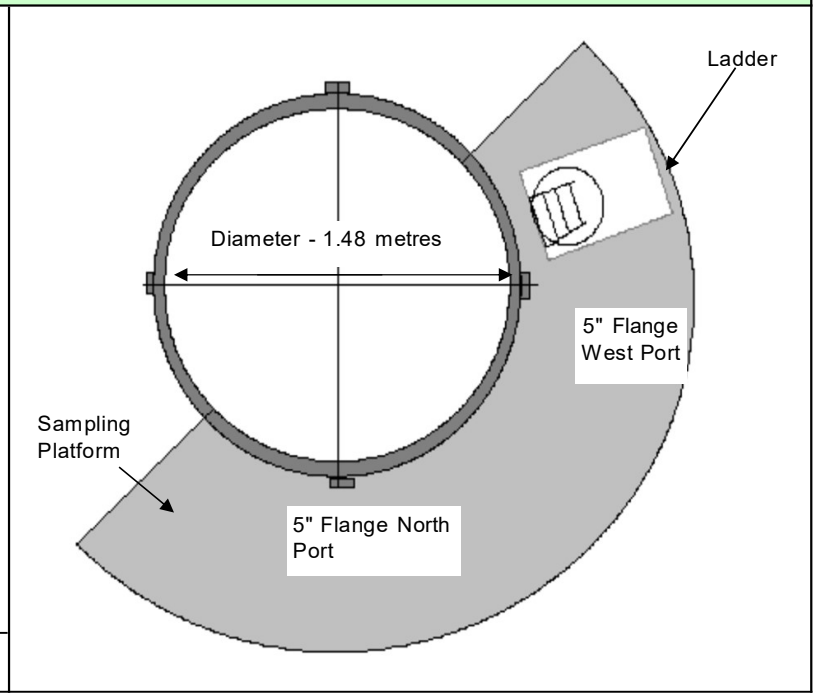
2.2.1 - Stack Diagram

Company	Installation	Stack	Substances Monitored	Permit
Intertek	South Hook LNG	SCVs Phases One & Two	CO, NOx, O_2 and H_2O	XP3538LD

Stack Diagram



Stack Cross-Section



Position	1	2	3	4	5	6
% of Diameter	4.1	14.9	29.7	70.3	85.1	95.9
Insertion, m	0.06	0.22	0.44	1.04	1.26	1.42
Insertion plus offset, m	0.16	0.32	0.54	1.14	1.36	1.52

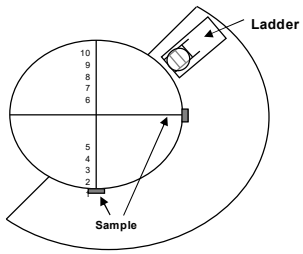
Notes - The circular stack diameter was measured as 1.48 metres, whilst the port offset (distance between the edge of the stack to the end of the port) was measured as 23 centimetres. Access to the top of the stack was by a series of three ladders. Each one had a resting platform in-between with a self closing gate installed. The main platform itself is a permanent structure with toe boards, railings and self closing gate.

2.2.2 - Flow Criteria Measurements

Monitoring Objective	Traverse	Site:	South Hook LNG Terminal	Stack ID:	SCV 1A
Date	02/03/2021	Site Team:	MRE/JG	Time of Survey:	11:15

Tape Measure ID	AS0589
Barometer ID	AS0500
Traverse Pitot Type	S-Type
Traverse Pitot Tube ID	AS0681
Pitot Assembly Visual Inspection (Pre)	Pass
Pre Test Leak Check <2.5 mm H2O	Pass
Traverse Manometer Type	Digital
Traverse Manometer ID	AS0638
Traverse Manometer Range	255
Traverse Temp. Readout ID	AS0638
Traverse Thermocouple ID	AS0451a
Static Pressure	Δp (mmH20)
	24.73
	Pass
Swirl Test Conducted	Yes
Protractor ID	AS0626
Post-Test Blockage Test (L-Type only)	
Post Test Leak Check <2.5 mm H2O	Pass
Pitot Assembly Visual Inspection (Post)	Pass

Diagram of Sample Location:



Comments/Deviations:

None

Conditions	Value	Units
Stack pressure	774.65	mmHg
Ref O_2 Value	3	%
Moisture Content	1.49	%
CO	60	ppm
CO_2	6.2	%
N_2	83.89	%
O_2	9.90	%
Dry Molecular wt	29.39	
Stack Molecular wt	29.22	
Duct Diameter	1.48	m
Duct Depth		m
Duct Width		m
Area of stack	1.72	m^2
Pbar	1030.1	mbar
Pbar	772.8	mmHg
Pitot tube coeft	0.833	
Reference Temp	273	K
Reference Pressure	760	mmHg
Ambient Temperature		° C

Duct Dimensions

Port ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Port Depth
A					
B					
C					
D					

Circular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Diameter
A					
B					

Rectangular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Depth
A					
B					
C					
D					

	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Width
Outside Side Division					

Enter manually from previous visit	Circular Duct	Rectangular Duct
Duct Diameter (m)	1.48	
Duct Depth (m)		
Duct Width (m)		

Post-Test Blockage Test (L-Type)	Traverse Point	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Average (mm H_2O)
Reading 1					
Reading 2					

Static Measurement	Δp (mmH20)	
Measurement Line	Reading 1	Reading 2(180°)
A	24.60	25.00
B	24.50	24.80
C		
D		

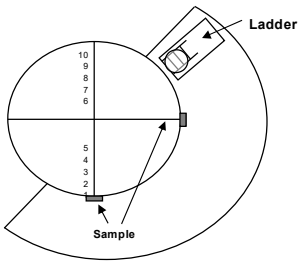
SAMPLING LINE: North										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	4.50	4.50	4.50	4.50	44.11	13.3	6.95	4	2.12
2	1.26	5.60	5.60	5.60	5.60	54.90	13.4	7.75	3	2.37
3	1.04	5.50	5.50	5.50	5.50	53.92	13.3	7.68	4	2.35
4	0.44	5.20	5.20	5.20	5.20	50.98	13.3	7.47	6	2.28
5	0.22	4.70	4.70	4.70	4.70	46.07	13.3	7.10	6	2.17
6	0.06	5.30	5.30	5.30	5.30	51.96	13.3	7.54	7	2.30
SAMPLING LINE: West										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	3.50	3.50	3.50	3.50	34.31	12.9	6.12	6	1.87
2	1.26	4.00	4.00	4.00	4.00	39.21	13.0	6.55	6	2.00
3	1.04	4.60	4.60	4.60	4.60	45.09	12.9	7.02	6	2.14
4	0.44	5.40	5.40	5.40	5.40	52.94	12.8	7.61	5	2.32
5	0.22	5.90	5.90	5.90	5.90	57.84	12.8	7.95	4	2.43
6	0.06	7.40	7.40	7.40	7.40	72.54	12.7	8.90	6	2.72
Average values		**5.1**	**5.1**	**5.1**	**5.1**	**50.3**	**13.1**	**7.4**	**5.3**	**2.3**

Duct / Stack Flow Characteristics:	Average	Units	Flow Criteria Measurements	
Stack Velocity at stack gas T & P and a wet gas basis	7.39	ms^{-1}	Is the Flow Ratio 3:1 or less?	2.1 :1
Stack flow @ STP, O_2 (ref) and on a dry gas basis	7.48	m^3s^{-1}		
Stack flow @ stack gas T & P and on a wet gas basis	12.70	m^3s^{-1}	Any local negative flow?	NO
Stack flow @ stack gas T & P and on a dry gas basis	12.51	m^3s^{-1}	Flow <15° of duct axis?	YES
Stack flow @ STP and on a wet gas basis	12.36	m^3s^{-1}	Minimum Δp detected > 5 Pa	YES
Stack flow @ STP, O_2 (ref) and on a wet gas basis	7.59	m^3s^{-1}		

Monitoring Objective	Traverse	Site:	South Hook LNG Terminal	Stack ID:	SCV 1C
Date	02/03/2021	Site Team:	MRE/JG	Time of Survey:	13:30

Tape Measure ID	AS0589
Barometer ID	AS0500
Traverse Pitot Type	S-Type
Traverse Pitot Tube ID	AS0681
Pitot Assembly Visual Inspection (Pre)	Pass
Pre Test Leak Check <2.5 mm H2O	Pass
Traverse Manometer Type	Digital
Traverse Manometer ID	AS0638
Traverse Manometer Range	255
Traverse Temp. Readout ID	AS0638
Traverse Thermocouple ID	AS0451a
Static Pressure	Δp (mmH20)
	23.28
	Pass
Swirl Test Conducted	Yes
Protractor ID	AS0626
Post-Test Blockage Test (L-Type only)	
Post Test Leak Check <2.5 mm H2O	Pass
Pitot Assembly Visual Inspection (Post)	Pass

Diagram of Sample Location:



Comments/Deviations:

None

Conditions	Value	Units
Stack pressure	774.54	mmHg
Ref O_2 Value	3	%
Moisture Content	1.5	%
CO	96	ppm
CO_2	5.6	%
N_2	83.39	%
O_2	11.00	%
Dry Molecular wt	29.34	
Stack Molecular wt	29.17	
Duct Diameter	1.48	m
Duct Depth		m
Duct Width		m
Area of stack	1.72	m^2
Pbar	1030.1	mbar
Pbar	772.8	mmHg
Pitot tube coeft	0.833	
Reference Temp	273	K
Reference Pressure	760	mmHg
Ambient Temperature		° C

Duct Dimensions

Port ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Port Depth
A					
B					
C					
D					

Circular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Diameter
A					
B					

Rectangular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Depth
A					
B					
C					
D					

	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Width
Outside Side Division					

Enter manually from previous visit	Circular Duct	Rectangular Duct
Duct Diameter (m)	1.48	
Duct Depth (m)		
Duct Width (m)		

Static Measurement	Δp (mmH20)	
Measurement Line	Reading 1	Reading 2(180°)
A	23.00	23.40
B	23.10	23.60
C		
D		

Post-Test Blockage Test (L-Type)	Traverse Point	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Average (mm H_2O)
Reading 1					
Reading 2					

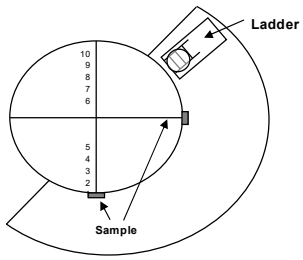
SAMPLING LINE: North										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	4.60	4.60	4.60	4.60	45.09	13.0	7.03	5	2.14
2	1.26	4.50	4.50	4.50	4.50	44.11	13.1	6.95	6	2.12
3	1.04	4.80	4.80	4.80	4.80	47.05	13.2	7.18	6	2.19
4	0.44	3.70	3.70	3.70	3.70	36.27	13.2	6.31	7	1.92
5	0.22	3.80	3.80	3.80	3.80	37.25	13.0	6.39	6	1.95
6	0.06	3.80	3.80	3.80	3.80	37.25	13.0	6.39	6	1.95
SAMPLING LINE: West										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	3.20	3.20	3.20	3.20	31.37	12.6	5.86	3	1.79
2	1.26	3.80	3.80	3.80	3.80	37.25	12.5	6.38	3	1.95
3	1.04	4.50	4.50	4.50	4.50	44.11	12.5	6.95	4	2.12
4	0.44	4.80	4.80	4.80	4.80	47.05	12.4	7.17	4	2.19
5	0.22	5.90	5.90	5.90	5.90	57.84	12.4	7.95	5	2.43
6	0.06	5.80	5.80	5.80	5.80	56.86	12.5	7.89	6	2.41
Average values		**4.4**	**4.4**	**4.4**	**4.4**	**43.5**	**12.8**	**6.9**	**5.1**	**2.1**

Duct / Stack Flow Characteristics:	Average	Units	Flow Criteria Measurements	
Stack Velocity at stack gas T & P and a wet gas basis	6.87	ms^{-1}	Is the Flow Ratio 3:1 or less?	1.8 :1
Stack flow @ STP, O_2 (ref) and on a dry gas basis	6.27	m^3s^{-1}		
Stack flow @ stack gas T & P and on a wet gas basis	11.81	m^3s^{-1}	Any local negative flow?	NO
Stack flow @ stack gas T & P and on a dry gas basis	11.64	m^3s^{-1}	Flow <15° of duct axis?	YES
Stack flow @ STP and on a wet gas basis	11.50	m^3s^{-1}	Minimum Δp detected > 5 Pa	YES
Stack flow @ STP, O_2 (ref) and on a wet gas basis	6.36	m^3s^{-1}		

Monitoring Objective	Traverse	Site:	South Hook LNG Terminal	Stack ID:	SCV 1D
Date	02/03/2021	Site Team:	MRE/JG	Time of Survey:	15:05

Tape Measure ID	AS0589
Barometer ID	AS0500
Traverse Pitot Type	S-Type
Traverse Pitot Tube ID	AS0681
Pitot Assembly Visual Inspection (Pre)	Pass
Pre Test Leak Check <2.5 mm H2O	Pass
Traverse Manometer Type	Digital
Traverse Manometer ID	AS0638
Traverse Manometer Range	255
Traverse Temp. Readout ID	AS0638
Traverse Thermocouple ID	AS0451a
Static Pressure	Δp (mmH20)
	28.20
	Pass
Swirl Test Conducted	Yes
Protractor ID	AS0626
Post-Test Blockage Test (L-Type only)	
Post Test Leak Check <2.5 mm H2O	Pass
Pitot Assembly Visual Inspection (Post)	Pass

Diagram of Sample Location:



Comments/Deviations:

None

Conditions	Value	Units
Stack pressure	774.90	mmHg
Ref O_2 Value	3	%
Moisture Content	1.7	%
CO	140	ppm
CO_2	6	%
N_2	83.69	%
O_2	10.30	%
Dry Molecular wt	29.37	
Stack Molecular wt	29.18	
Duct Diameter	1.48	m
Duct Depth		m
Duct Width		m
Area of stack	1.72	m^2
Pbar	1030.1	mbar
Pbar	772.8	mmHg
Pitot tube coeft	0.833	
Reference Temp	273	K
Reference Pressure	760	mmHg
Ambient Temperature		° C

Duct Dimensions

Port ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Port Depth
A					
B					
C					
D					

Circular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Diameter
A					
B					

Rectangular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Depth
A					
B					
C					
D					

	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Width
Outside Side Division					

Enter manually from previous visit	Circular Duct	Rectangular Duct
Duct Diameter (m)	1.48	
Duct Depth (m)		
Duct Width (m)		

Post-Test Blockage Test (L-Type)	Traverse Point	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Average (mm H_2O)
Reading 1					
Reading 2					

	Static Measurement	Δp (mmH20)	
	Measurement Line	Reading 1	Reading 2(180°)
	A	28.80	27.90
	B	28.10	28.00
	C		
	D		

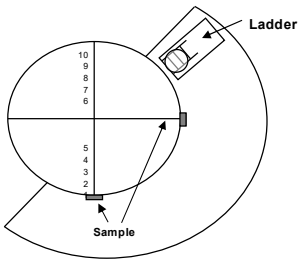
SAMPLING LINE: North										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	6.20	6.20	6.20	6.20	60.78	14.5	8.18	4	2.49
2	1.26	7.20	7.20	7.20	7.20	70.58	14.6	8.82	4	2.68
3	1.04	6.00	6.00	6.00	6.00	58.82	15.0	8.05	5	2.45
4	0.44	6.20	6.20	6.20	6.20	60.78	15.1	8.19	5	2.49
5	0.22	6.00	6.00	6.00	6.00	58.82	15.1	8.05	5	2.45
6	0.06	6.70	6.70	6.70	6.70	65.68	15.0	8.51	7	2.59
SAMPLING LINE: West										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	4.70	4.70	4.70	4.70	46.07	15.0	7.13	4	2.17
2	1.26	5.10	5.10	5.10	5.10	50.00	15.0	7.42	6	2.26
3	1.04	5.40	5.40	5.40	5.40	52.94	14.9	7.64	6	2.32
4	0.44	6.00	6.00	6.00	6.00	58.82	14.8	8.05	7	2.45
5	0.22	6.50	6.50	6.50	6.50	63.72	14.7	8.38	6	2.55
6	0.06	7.30	7.30	7.30	7.30	71.56	14.6	8.88	7	2.70
Average values		**6.1**	**6.1**	**6.1**	**6.1**	**59.9**	**14.9**	**8.1**	**5.5**	**2.5**

Duct / Stack Flow Characteristics:	Average	Units	Flow Criteria Measurements	
Stack Velocity at stack gas T & P and a wet gas basis	8.11	ms^{-1}	Is the Flow Ratio 3:1 or less?	1.6 :1
Stack flow @ STP, O_2 (ref) and on a dry gas basis	7.85	m^3s^{-1}		
Stack flow @ stack gas T & P and on a wet gas basis	13.94	m^3s^{-1}	Any local negative flow?	NO
Stack flow @ stack gas T & P and on a dry gas basis	13.71	m^3s^{-1}	Flow <15° of duct axis?	YES
Stack flow @ STP and on a wet gas basis	13.48	m^3s^{-1}	Minimum Δp detected > 5 Pa	YES
Stack flow @ STP, O_2 (ref) and on a wet gas basis	7.98	m^3s^{-1}		

Monitoring Objective	Traverse	Site:	South Hook LNG Terminal	Stack ID:	SCV 1E
Date	03/03/2021	Site Team:	MRE/JG	Time of Survey:	15:45

Tape Measure ID	AS0589
Barometer ID	AS0500
Traverse Pitot Type	S-Type
Traverse Pitot Tube ID	AS0681
Pitot Assembly Visual Inspection (Pre)	Pass
Pre Test Leak Check <2.5 mm H2O	Pass
Traverse Manometer Type	Digital
Traverse Manometer ID	AS0638
Traverse Manometer Range	255
Traverse Temp. Readout ID	AS0638
Traverse Thermocouple ID	AS0451a
Static Pressure	Δp (mmH20)
	22.35
	Pass
Swirl Test Conducted	Yes
Protractor ID	AS0626
Post-Test Blockage Test (L-Type only)	
Post Test Leak Check <2.5 mm H2O	Pass
Pitot Assembly Visual Inspection (Post)	Pass

Diagram of Sample Location:



Comments/Deviations:

None

Conditions	Value	Units
Stack pressure	770.72	mmHg
Ref O_2 Value	3	%
Moisture Content	1.0	%
CO	100	ppm
CO_2	4.3	%
N_2	82.69	%
O_2	13.00	%
Dry Molecular wt	29.21	
Stack Molecular wt	29.10	
Duct Diameter	1.48	m
Duct Depth		m
Duct Width		m
Area of stack	1.72	m^2
Pbar	1025.1	mbar
Pbar	769.1	mmHg
Pitot tube coeft	0.833	
Reference Temp	273	K
Reference Pressure	760	mmHg
Ambient Temperature		° C

Duct Dimensions

Port ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Port Depth
A					
B					
C					
D					

Circular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Diameter
A					
B					

Rectangular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Depth
A					
B					
C					
D					

	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Width
Outside Side Division					

Enter manually from previous visit	Circular Duct	Rectangular Duct
Duct Diameter (m)	1.48	
Duct Depth (m)		
Duct Width (m)		

Post-Test Blockage Test (L-Type)	Traverse Point	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Average (mm H_2O)
Reading 1					
Reading 2					

Static Measurement	Δp (mmH20)	
Measurement Line	Reading 1	Reading 2(180°)
A	22.40	22.60
B	22.40	22.00
C		
D		

SAMPLING LINE: North										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	3.30	3.30	3.30	3.30	32.35	7.0	5.91	4	1.82
2	1.26	3.70	3.70	3.70	3.70	36.27	7.0	6.26	4	1.92
3	1.04	4.50	4.50	4.50	4.50	44.11	7.0	6.90	6	2.12
4	0.44	5.00	5.00	5.00	5.00	49.02	7.0	7.28	4	2.24
5	0.22	4.30	4.30	4.30	4.30	42.15	6.9	6.75	6	2.07
6	0.06	4.40	4.40	4.40	4.40	43.13	7.0	6.83	6	2.10
SAMPLING LINE: West										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	1.80	1.80	1.80	1.80	17.65	7.2	4.37	4	1.34
2	1.26	2.20	2.20	2.20	2.20	21.57	7.2	4.83	3	1.48
3	1.04	2.40	2.40	2.40	2.40	23.53	7.0	5.04	3	1.55
4	0.44	3.00	3.00	3.00	3.00	29.41	7.0	5.64	4	1.73
5	0.22	3.60	3.60	3.60	3.60	35.29	7.0	6.18	5	1.90
6	0.06	4.10	4.10	4.10	4.10	40.19	7.1	6.59	5	2.02
Average values		**3.5**	**3.5**	**3.5**	**3.5**	**34.6**	**7.0**	**6.0**	**4.5**	**1.9**

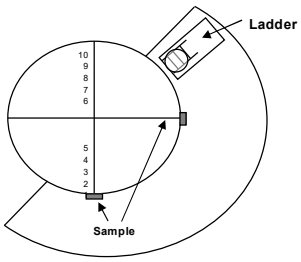
Duct / Stack Flow Characteristics:	Average	Units
Stack Velocity at stack gas T & P and a wet gas basis	6.05	ms^{-1}
Stack flow @ STP, O_2 (ref) and on a dry gas basis	4.49	m^3s^{-1}
Stack flow @ stack gas T & P and on a wet gas basis	10.40	m^3s^{-1}
Stack flow @ stack gas T & P and on a dry gas basis	10.30	m^3s^{-1}
Stack flow @ STP and on a wet gas basis	10.28	m^3s^{-1}
Stack flow @ STP, O_2 (ref) and on a wet gas basis	4.54	m^3s^{-1}

Flow Criteria Measurements	
Is the Flow Ratio 3:1 or less?	2.8 :1
Any local negative flow?	NO
Flow <15° of duct axis?	YES
Minimum Δp detected > 5 Pa	YES

Monitoring Objective	Traverse	Site:	South Hook LNG Terminal	Stack ID:	SCV 1F
Date	03/02/2021	Site Team:	MRE/JG	Time of Survey:	14:00

Tape Measure ID	AS0589
Barometer ID	AS0500
Traverse Pitot Type	S-Type
Traverse Pitot Tube ID	AS0681
Pitot Assembly Visual Inspection (Pre)	Pass
Pre Test Leak Check <2.5 mm H2O	Pass
Traverse Manometer Type	Digital
Traverse Manometer ID	AS0638
Traverse Manometer Range	255
Traverse Temp. Readout ID	AS0638
Traverse Thermocouple ID	AS0451a
Static Pressure	Δp (mmH20)
	17.98
	Pass
Swirl Test Conducted	Yes
Protractor ID	AS0626
Post-Test Blockage Test (L-Type only)	
Post Test Leak Check <2.5 mm H2O	Pass
Pitot Assembly Visual Inspection (Post)	Pass

Diagram of Sample Location:



Comments/Deviations:

None

Conditions	Value	Units
Stack pressure	770.40	mmHg
Ref O_2 Value	3	%
Moisture Content	1.2	%
CO	100	ppm
CO_2	4.3	%
N_2	82.49	%
O_2	13.20	%
Dry Molecular wt	29.22	
Stack Molecular wt	29.08	
Duct Diameter	1.48	m
Duct Depth		m
Duct Width		m
Area of stack	1.72	m^2
Pbar	1025.1	mbar
Pbar	769.1	mmHg
Pitot tube coeft	0.833	
Reference Temp	273	K
Reference Pressure	760	mmHg
Ambient Temperature		° C

Duct Dimensions

Port ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Port Depth
A					
B					
C					
D					

Circular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Diameter
A					
B					

Rectangular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Depth
A					
B					
C					
D					

	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Width
Outside Side Division					

Enter manually from previous visit	Circular Duct	Rectangular Duct
Duct Diameter (m)	1.48	
Duct Depth (m)		
Duct Width (m)		

Static Measurement	Δp (mmH20)	
Measurement Line	Reading 1	Reading 2(180°)
A	17.60	18.20
B	17.80	18.30
C		
D		

Post-Test Blockage Test (L-Type)	Traverse Point	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Average (mm H_2O)
Reading 1					
Reading 2					

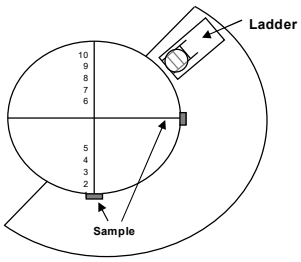
SAMPLING LINE: North										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	3.50	3.50	3.50	3.50	34.31	10	6.12	6	1.87
2	1.26	4.70	4.70	4.70	4.70	46.07	10	7.10	7	2.17
3	1.04	4.20	4.20	4.20	4.20	41.17	10	6.71	6	2.05
4	0.44	3.60	3.60	3.60	3.60	35.29	11	6.22	6	1.90
5	0.22	3.50	3.50	3.50	3.50	34.31	11	6.13	5	1.87
6	0.06	5.30	5.30	5.30	5.30	51.96	11	7.55	7	2.30
SAMPLING LINE: West										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	2.70	2.70	2.70	2.70	26.47	10	5.38	4	1.64
2	1.26	3.20	3.20	3.20	3.20	31.37	10	5.86	5	1.79
3	1.04	3.20	3.20	3.20	3.20	31.37	10	5.86	6	1.79
4	0.44	5.10	5.10	5.10	5.10	50.00	10	7.39	6	2.26
5	0.22	5.50	5.50	5.50	5.50	53.92	10	7.68	7	2.35
6	0.06	7.40	7.40	7.40	7.40	72.54	10	8.90	6	2.72
Average values		**4.3**	**4.3**	**4.3**	**4.3**	**42.4**	**10.1**	**6.7**	**5.9**	**2.1**

Duct / Stack Flow Characteristics:	Average	Units	Flow Criteria Measurements	
Stack Velocity at stack gas T & P and a wet gas basis	6.74	ms^{-1}	Is the Flow Ratio 3:1 or less?	2.7 :1
Stack flow @ STP, O_2 (ref) and on a dry gas basis	4.81	m^3s^{-1}		
Stack flow @ stack gas T & P and on a wet gas basis	11.59	m^3s^{-1}	Any local negative flow?	NO
Stack flow @ stack gas T & P and on a dry gas basis	11.45	m^3s^{-1}	Flow <15° of duct axis?	YES
Stack flow @ STP and on a wet gas basis	11.33	m^3s^{-1}	Minimum Δp detected > 5 Pa	YES
Stack flow @ STP, O_2 (ref) and on a wet gas basis	4.87	m^3s^{-1}		

Monitoring Objective	Traverse	Site:	South Hook LNG Terminal	Stack ID:	SCV 1G
Date	03/03/2021	Site Team:	MRE/JG	Time of Survey:	11:40

Tape Measure ID	AS0589
Barometer ID	AS0500
Traverse Pitot Type	S-Type
Traverse Pitot Tube ID	AS0681
Pitot Assembly Visual Inspection (Pre)	Pass
Pre Test Leak Check <2.5 mm H2O	Pass
Traverse Manometer Type	Digital
Traverse Manometer ID	AS0638
Traverse Manometer Range	255
Traverse Temp. Readout ID	AS0638
Traverse Thermocouple ID	AS0451a
Static Pressure	Δp (mmH20)
	22.28
	Pass
Swirl Test Conducted	Yes
Protractor ID	AS0626
Post-Test Blockage Test (L-Type only)	
Post Test Leak Check <2.5 mm H2O	Pass
Pitot Assembly Visual Inspection (Post)	Pass

Diagram of Sample Location:



Comments/Deviations:

None

Conditions	Value	Units
Stack pressure	770.72	mmHg
Ref O_2 Value	3	%
Moisture Content	1.4	%
CO	233	ppm
CO_2	5.7	%
N_2	83.48	%
O_2	10.80	%
Dry Molecular wt	29.34	
Stack Molecular wt	29.19	
Duct Diameter	1.48	m
Duct Depth		m
Duct Width		m
Area of stack	1.72	m^2
Pbar	1025.1	mbar
Pbar	769.1	mmHg
Pitot tube coeft	0.833	
Reference Temp	273	K
Reference Pressure	760	mmHg
Ambient Temperature		° C

Duct Dimensions

Port ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Port Depth
A					
B					
C					
D					

Circular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Diameter
A					
B					

Rectangular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Depth
A					
B					
C					
D					

	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Width
Outside Side Division					

Enter manually from previous visit	Circular Duct	Rectangular Duct
Duct Diameter (m)	1.48	
Duct Depth (m)		
Duct Width (m)		

Static Measurement	Δp (mmH20)	
Measurement Line	Reading 1	Reading 2(180°)
A	22.40	21.80
B	22.30	22.60
C		
D		

Post-Test Blockage Test (L-Type)	Traverse Point	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Average (mm H_2O)
Reading 1					
Reading 2					

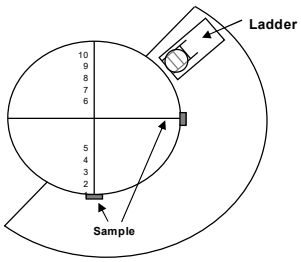
SAMPLING LINE: North										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	4.10	4.10	4.10	4.10	40.19	11.5	6.63	6	2.02
2	1.26	5.00	5.00	5.00	5.00	49.02	11.7	7.33	6	2.24
3	1.04	5.50	5.50	5.50	5.50	53.92	11.7	7.69	6	2.35
4	0.44	5.60	5.60	5.60	5.60	54.90	11.7	7.75	7	2.37
5	0.22	5.70	5.70	5.70	5.70	55.88	11.6	7.82	7	2.39
6	0.06	5.90	5.90	5.90	5.90	57.84	11.6	7.96	7	2.43
SAMPLING LINE: West										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	4.50	4.50	4.50	4.50	44.11	11.4	6.95	6	2.12
2	1.26	4.60	4.60	4.60	4.60	45.09	11.7	7.03	6	2.14
3	1.04	5.50	5.50	5.50	5.50	53.92	11.7	7.69	6	2.35
4	0.44	7.00	7.00	7.00	7.00	68.62	11.7	8.67	7	2.65
5	0.22	6.70	6.70	6.70	6.70	65.68	11.6	8.48	8	2.59
6	0.06	5.50	5.50	5.50	5.50	53.92	11.6	7.68	8	2.35
Average values		**5.5**	**5.5**	**5.5**	**5.5**	**53.6**	**11.6**	**7.6**	**6.7**	**2.3**

Duct / Stack Flow Characteristics:	Average	Units	Flow Criteria Measurements	
Stack Velocity at stack gas T & P and a wet gas basis	7.64	ms^{-1}	Is the Flow Ratio 3:1 or less?	1.7 :1
Stack flow @ STP, O_2 (ref) and on a dry gas basis	7.11	m^3s^{-1}		
Stack flow @ stack gas T & P and on a wet gas basis	13.14	m^3s^{-1}	Any local negative flow?	NO
Stack flow @ stack gas T & P and on a dry gas basis	12.96	m^3s^{-1}	Flow <15° of duct axis?	YES
Stack flow @ STP and on a wet gas basis	12.78	m^3s^{-1}	Minimum Δp detected > 5 Pa	YES
Stack flow @ STP, O_2 (ref) and on a wet gas basis	7.21	m^3s^{-1}		

Monitoring Objective	Traverse	Site:	South Hook LNG Terminal	Stack ID:	SCV 1H
Date	03/02/2021	Site Team:	MRE/JG	Time of Survey:	10:15

Tape Measure ID	AS0589
Barometer ID	AS0500
Traverse Pitot Type	S-Type
Traverse Pitot Tube ID	AS0681
Pitot Assembly Visual Inspection (Pre)	Pass
Pre Test Leak Check <2.5 mm H2O	Pass
Traverse Manometer Type	Digital
Traverse Manometer ID	AS0638
Traverse Manometer Range	255
Traverse Temp. Readout ID	AS0638
Traverse Thermocouple ID	AS0451a
Static Pressure	Δp (mmH20)
	27.08
	Pass
Swirl Test Conducted	Yes
Protractor ID	AS0626
Post-Test Blockage Test (L-Type only)	
Post Test Leak Check <2.5 mm H2O	Pass
Pitot Assembly Visual Inspection (Post)	Pass

Diagram of Sample Location:



Comments/Deviations:

None

Conditions	Value	Units
Stack pressure	771.07	mmHg
Ref O_2 Value	3	%
Moisture Content	1.5	%
CO	80	ppm
CO_2	6.2	%
N_2	83.59	%
O_2	10.20	%
Dry Molecular wt	29.40	
Stack Molecular wt	29.23	
Duct Diameter	1.48	m
Duct Depth		m
Duct Width		m
Area of stack	1.72	m^2
Pbar	1025.1	mbar
Pbar	769.1	mmHg
Pitot tube coeft	0.833	
Reference Temp	273	K
Reference Pressure	760	mmHg
Ambient Temperature		° C

Duct Dimensions

Port ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Port Depth
A					
B					
C					
D					

Circular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Diameter
A					
B					

Rectangular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Depth
A					
B					
C					
D					

	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Width
Outside Side Division					

Enter manually from previous visit	Circular Duct	Rectangular Duct
Duct Diameter (m)	1.48	
Duct Depth (m)		
Duct Width (m)		

Static Measurement	Δp (mmH20)	
Measurement Line	Reading 1	Reading 2(180°)
A	27.40	26.80
B	27.20	26.90
C		
D		

Post-Test Blockage Test (L-Type)	Traverse Point	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Average (mm H_2O)
Reading 1					
Reading 2					

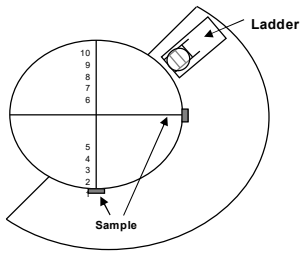
SAMPLING LINE: North										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	3.80	3.80	3.80	3.80	37.25	12.4	6.39	6	1.95
2	1.26	5.50	5.50	5.50	5.50	53.92	12.7	7.69	7	2.35
3	1.04	6.70	6.70	6.70	6.70	65.68	12.7	8.49	6	2.59
4	0.44	6.80	6.80	6.80	6.80	66.66	12.8	8.55	5	2.61
5	0.22	6.10	6.10	6.10	6.10	59.80	12.9	8.10	6	2.47
6	0.06	6.80	6.80	6.80	6.80	66.66	12.8	8.55	7	2.61
SAMPLING LINE: West										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	4.50	4.50	4.50	4.50	44.11	12.9	6.96	5	2.12
2	1.26	5.70	5.70	5.70	5.70	55.88	13.0	7.83	6	2.39
3	1.04	6.80	6.80	6.80	6.80	66.66	13.1	8.56	6	2.61
4	0.44	6.80	6.80	6.80	6.80	66.66	13.0	8.56	7	2.61
5	0.22	6.80	6.80	6.80	6.80	66.66	13.0	8.56	7	2.61
6	0.06	7.50	7.50	7.50	7.50	73.52	12.7	8.98	7	2.74
Average values		**6.2**	**6.2**	**6.2**	**6.2**	**60.3**	**12.8**	**8.1**	**6.3**	**2.5**

Duct / Stack Flow Characteristics:	Average	Units	Flow Criteria Measurements	
Stack Velocity at stack gas T & P and a wet gas basis	8.10	ms^{-1}	Is the Flow Ratio 3:1 or less?	2.0 :1
Stack flow @ STP, O_2 (ref) and on a dry gas basis	7.95	m^3s^{-1}		
Stack flow @ stack gas T & P and on a wet gas basis	13.93	m^3s^{-1}	Any local negative flow?	NO
Stack flow @ stack gas T & P and on a dry gas basis	13.73	m^3s^{-1}	Flow <15° of duct axis?	YES
Stack flow @ STP and on a wet gas basis	13.50	m^3s^{-1}	Minimum Δp detected > 5 Pa	YES
Stack flow @ STP, O_2 (ref) and on a wet gas basis	8.07	m^3s^{-1}		

Monitoring Objective	Traverse	Site:	South Hook LNG Terminal	Stack ID:	SCV 2A
Date	04/03/2021	Site Team:	MRE/JG	Time of Survey:	10:10

Tape Measure ID	AS0589
Barometer ID	AS0500
Traverse Pitot Type	S-Type
Traverse Pitot Tube ID	AS0681
Pitot Assembly Visual Inspection (Pre)	Pass
Pre Test Leak Check <2.5 mm H2O	Pass
Traverse Manometer Type	Digital
Traverse Manometer ID	AS0638
Traverse Manometer Range	255
Traverse Temp. Readout ID	AS0638
Traverse Thermocouple ID	AS0451a
Static Pressure	Δp (mmH20)
	24.63
	Pass
Swirl Test Conducted	Yes
Protractor ID	AS0626
Post-Test Blockage Test (L-Type only)	
Post Test Leak Check <2.5 mm H2O	Pass
Pitot Assembly Visual Inspection (Post)	Pass

Diagram of Sample Location:



Comments/Deviations:

None

Conditions	Value	Units
Stack pressure	769.61	mmHg
Ref O_2 Value	3	%
Moisture Content	1.4	%
CO	126	ppm
CO_2	6	%
N_2	83.59	%
O_2	10.40	%
Dry Molecular wt	29.38	
Stack Molecular wt	29.22	
Duct Diameter	1.48	m
Duct Depth		m
Duct Width		m
Area of stack	1.72	m^2
Pbar	1023.4	mbar
Pbar	767.8	mmHg
Pitot tube coeft	0.833	
Reference Temp	273	K
Reference Pressure	760	mmHg
Ambient Temperature		° C

Duct Dimensions

Port ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Port Depth
A					
B					
C					
D					

Circular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Diameter
A					
B					

Rectangular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Depth
A					
B					
C					
D					

	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Width
Outside Side Division					

Enter manually from previous visit	Circular Duct	Rectangular Duct
Duct Diameter (m)	1.48	
Duct Depth (m)		
Duct Width (m)		

Post-Test Blockage Test (L-Type)	Traverse Point	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Average (mm H_2O)
Reading 1					
Reading 2					

Static Measurement	Δp (mmH20)	
Measurement Line	Reading 1	Reading 2(180°)
A	24.80	24.20
B	25.00	24.50
C		
D		

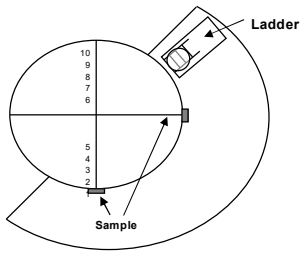
SAMPLING LINE: South										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	3.90	3.90	3.90	3.90	38.23	12.2	6.48	8	1.97
2	1.26	5.10	5.10	5.10	5.10	50.00	12.2	7.41	9	2.26
3	1.04	5.80	5.80	5.80	5.80	56.86	12.3	7.90	10	2.41
4	0.44	7.00	7.00	7.00	7.00	68.62	12.3	8.68	9	2.65
5	0.22	7.00	7.00	7.00	7.00	68.62	12.2	8.68	8	2.65
6	0.06	6.80	6.80	6.80	6.80	66.66	12.0	8.55	9	2.61
SAMPLING LINE: West										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	4.00	4.00	4.00	4.00	39.21	12.2	6.56	10	2.00
2	1.26	5.00	5.00	5.00	5.00	49.02	12.2	7.34	9	2.24
3	1.04	5.80	5.80	5.80	5.80	56.86	12.3	7.90	8	2.41
4	0.44	7.20	7.20	7.20	7.20	70.58	12.3	8.80	10	2.68
5	0.22	7.80	7.80	7.80	7.80	76.46	12.1	9.16	11	2.79
6	0.06	7.20	7.20	7.20	7.20	70.58	12.0	8.80	10	2.68
Average values		**6.1**	**6.1**	**6.1**	**6.1**	**59.3**	**12.2**	**8.0**	**9.3**	**2.4**

Duct / Stack Flow Characteristics:	Average	Units	Flow Criteria Measurements	
Stack Velocity at stack gas T & P and a wet gas basis	8.02	ms^{-1}	Is the Flow Ratio 3:1 or less?	2.0 :1
Stack flow @ STP, O_2 (ref) and on a dry gas basis	7.73	m^3s^{-1}		
Stack flow @ stack gas T & P and on a wet gas basis	13.79	m^3s^{-1}	Any local negative flow?	NO
Stack flow @ stack gas T & P and on a dry gas basis	13.60	m^3s^{-1}	Flow <15° of duct axis?	YES
Stack flow @ STP and on a wet gas basis	13.37	m^3s^{-1}	Minimum Δp detected > 5 Pa	YES
Stack flow @ STP, O_2 (ref) and on a wet gas basis	7.84	m^3s^{-1}		

Monitoring Objective	Traverse	Site:	South Hook LNG Terminal	Stack ID:	SCV 2D
Date	04/03/2021	Site Team:	MRE/JG	Time of Survey:	11:45

Tape Measure ID	AS0589
Barometer ID	AS0500
Traverse Pitot Type	S-Type
Traverse Pitot Tube ID	AS0681
Pitot Assembly Visual Inspection (Pre)	Pass
Pre Test Leak Check <2.5 mm H2O	Pass
Traverse Manometer Type	Digital
Traverse Manometer ID	AS0638
Traverse Manometer Range	255
Traverse Temp. Readout ID	AS0638
Traverse Thermocouple ID	AS0451a
	Δp (mmH20)
Static Pressure	21.00
	Pass
Swirl Test Conducted	Yes
Protractor ID	AS0626
Post-Test Blockage Test (L-Type only)	
Post Test Leak Check <2.5 mm H2O	Pass
Pitot Assembly Visual Inspection (Post)	Pass

Diagram of Sample Location:



Comments/Deviations:

None

Conditions	Value	Units
Stack pressure	769.35	mmHg
Ref O_2 Value	3	%
Moisture Content	1.3	%
CO	238	ppm
CO_2	5.4	%
N_2	82.98	%
O_2	11.60	%
Dry Molecular wt	29.33	
Stack Molecular wt	29.18	
Duct Diameter	1.48	m
Duct Depth		m
Duct Width		m
Area of stack	1.72	m^2
Pbar	1023.4	mbar
Pbar	767.8	mmHg
Pitot tube coeft	0.833	
Reference Temp	273	K
Reference Pressure	760	mmHg
Ambient Temperature		° C

Duct Dimensions

Port ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Port Depth
A					
B					
C					
D					

Circular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Diameter
A					
B					

Rectangular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Depth
A					
B					
C					
D					

	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Width
Outside Side Division					

Enter manually from previous visit	Circular Duct	Rectangular Duct
Duct Diameter (m)	1.48	
Duct Depth (m)		
Duct Width (m)		

Post-Test Blockage Test (L-Type)	Traverse Point	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Average (mm H_2O)
Reading 1					
Reading 2					

Static Measurement	Δp (mmH20)	
Measurement Line	Reading 1	Reading 2(180°)
A	21.10	20.80
B	21.40	20.70
C		
D		

SAMPLING LINE: North

Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	3.60	3.60	3.60	3.60	35.29	10.7	6.21	5	1.90
2	1.26	4.80	4.80	4.80	4.80	47.05	10.7	7.17	7	2.19
3	1.04	5.00	5.00	5.00	5.00	49.02	10.7	7.32	7	2.24
4	0.44	4.10	4.10	4.10	4.10	40.19	10.7	6.63	6	2.02
5	0.22	4.70	4.70	4.70	4.70	46.07	10.9	7.10	7	2.17
6	0.06	4.00	4.00	4.00	4.00	39.21	11.2	6.55	7	2.00
Average values		**4.4**	**4.4**	**4.4**	**4.4**	**42.8**	**10.8**	**6.8**	**6.5**	**2.1**

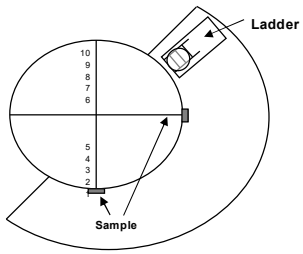
Duct / Stack Flow Characteristics:	Average	Units
Stack Velocity at stack gas T & P and a wet gas basis	6.83	ms^{-1}
Stack flow @ STP, O_2 (ref) and on a dry gas basis	5.87	m^3s^{-1}
Stack flow @ stack gas T & P and on a wet gas basis	11.75	m^3s^{-1}
Stack flow @ stack gas T & P and on a dry gas basis	11.60	m^3s^{-1}
Stack flow @ STP and on a wet gas basis	11.44	m^3s^{-1}
Stack flow @ STP, O_2 (ref) and on a wet gas basis	5.94	m^3s^{-1}

Flow Criteria Measurements	
Is the Flow Ratio 3:1 or less?	1.4 :1
Any local negative flow?	NO
Flow <15° of duct axis?	YES
Minimum Δp detected > 5 Pa	YES

Monitoring Objective	Traverse	Site:	South Hook LNG Terminal	Stack ID:	SCV 2E
Date	04/03/2021	Site Team:	MRE/JG	Time of Survey:	14:30

Tape Measure ID	AS0589
Barometer ID	AS0500
Traverse Pitot Type	S-Type
Traverse Pitot Tube ID	AS0681
Pitot Assembly Visual Inspection (Pre)	Pass
Pre Test Leak Check <2.5 mm H2O	Pass
Traverse Manometer Type	Digital
Traverse Manometer ID	AS0638
Traverse Manometer Range	255
Traverse Temp. Readout ID	AS0638
Traverse Thermocouple ID	AS0451a
Static Pressure	Δp (mmH20)
	26.23
	Pass
Swirl Test Conducted	Yes
Protractor ID	AS0626
Post-Test Blockage Test (L-Type only)	
Post Test Leak Check <2.5 mm H2O	Pass
Pitot Assembly Visual Inspection (Post)	Pass

Diagram of Sample Location:



Comments/Deviations:

None

Conditions	Value	Units
Stack pressure	769.73	mmHg
Ref O_2 Value	3	%
Moisture Content	1.7	%
CO	160	ppm
CO_2	6.3	%
N_2	83.98	%
O_2	9.70	%
Dry Molecular wt	29.40	
Stack Molecular wt	29.20	
Duct Diameter	1.48	m
Duct Depth		m
Duct Width		m
Area of stack	1.72	m^2
Pbar	1023.4	mbar
Pbar	767.8	mmHg
Pitot tube coeft	0.833	
Reference Temp	273	K
Reference Pressure	760	mmHg
Ambient Temperature		° C

Duct Dimensions

Port ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Port Depth
A					
B					
C					
D					

Circular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Diameter
A					
B					

Rectangular Duct

Line ID	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Depth
A					
B					
C					
D					

	Reading 1 (m)	Reading 2 (m)	Reading 3 (m)	Average	Duct Width
Outside Side Division					

Enter manually from previous visit	Circular Duct	Rectangular Duct
Duct Diameter (m)	1.48	
Duct Depth (m)		
Duct Width (m)		

Post-Test Blockage Test (L-Type)	Traverse Point	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Reading (mm H_2O)	Δp Average (mm H_2O)
Reading 1					
Reading 2					

Static Measurement	Δp (mmH20)	
Measurement Line	Reading 1	Reading 2(180°)
A	26.30	26.40
B	26.00	26.20
C		
D		

SAMPLING LINE: North										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	5.00	5.00	5.00	5.00	49.02	16	7.38	7	2.24
2	1.26	6.10	6.10	6.10	6.10	59.80	16	8.16	8	2.47
3	1.04	6.50	6.50	6.50	6.50	63.72	15	8.41	7	2.55
4	0.44	5.70	5.70	5.70	5.70	55.88	15	7.87	8	2.39
5	0.22	5.00	5.00	5.00	5.00	49.02	15	7.37	8	2.24
6	0.06	5.10	5.10	5.10	5.10	50.00	14	7.44	9	2.26
SAMPLING LINE: West										
Traverse Point	Distance into duct (m)	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Spot Reading mm H2O	Δp Average mm H_2O	Δp Pa	Stack Temp Ts °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	√Δp
1	1.42	4.90	4.90	4.90	4.90	48.04	15	7.30	6	2.21
2	1.26	4.80	4.80	4.80	4.80	47.05	15	7.23	7	2.19
3	1.04	5.60	5.60	5.60	5.60	54.90	16	7.81	7	2.37
4	0.44	6.70	6.70	6.70	6.70	65.68	16	8.55	8	2.59
5	0.22	6.90	6.90	6.90	6.90	67.64	16	8.68	7	2.63
6	0.06	7.10	7.10	7.10	7.10	69.60	15	8.79	7	2.66
Average values		**5.8**	**5.8**	**5.8**	**5.8**	**56.7**	**15.4**	**7.9**	**7.4**	**2.4**

Duct / Stack Flow Characteristics:	Average	Units	Flow Criteria Measurements	
Stack Velocity at stack gas T & P and a wet gas basis	7.92	ms^{-1}	Is the Flow Ratio 3:1 or less?	1.5 :1
Stack flow @ STP, O_2 (ref) and on a dry gas basis	8.02	m^3s^{-1}		
Stack flow @ stack gas T & P and on a wet gas basis	13.61	m^3s^{-1}	Any local negative flow?	NO
Stack flow @ stack gas T & P and on a dry gas basis	13.38	m^3s^{-1}	Flow <15° of duct axis?	YES
Stack flow @ STP and on a wet gas basis	13.05	m^3s^{-1}	Minimum Δp detected > 5 Pa	YES
Stack flow @ STP, O_2 (ref) and on a wet gas basis	8.17	m^3s^{-1}		

2.2.3 - One Minute Averaged Gaseous Emissions Data

One Minute Averaged Gaseous Emissions Results

South Hook LNG - SCV 1A			
273K, 101.3 kPa, 3% Oxygen on a dry basis			
Species	Carbon Monoxide	Oxides of Nitrogen	Oxygen
Units	mg/m3	mg/m3	%
02/03/2021 12:00	121.4	57.9	10.0
02/03/2021 12:01	122.8	57.9	10.1
02/03/2021 12:02	124.7	58.0	10.1
02/03/2021 12:03	125.7	58.0	10.1
02/03/2021 12:04	125.4	58.0	10.1
02/03/2021 12:05	128.3	57.9	10.1
02/03/2021 12:06	123.7	57.9	10.1
02/03/2021 12:07	125.8	57.8	10.0
02/03/2021 12:08	121.6	57.6	10.0
02/03/2021 12:09	114.4	58.3	10.0
02/03/2021 12:10	83.0	61.5	9.9
02/03/2021 12:11	119.2	57.5	9.9
02/03/2021 12:12	123.3	57.1	9.9
02/03/2021 12:13	124.2	57.4	9.9
02/03/2021 12:14	120.5	57.1	9.9
02/03/2021 12:15	122.5	57.0	9.9
02/03/2021 12:16	116.6	57.1	9.9
02/03/2021 12:17	120.9	57.1	9.9
02/03/2021 12:18	119.8	57.1	9.9
02/03/2021 12:19	120.7	57.2	9.9
02/03/2021 12:20	107.5	58.3	9.9
02/03/2021 12:21	92.3	60.7	9.9
02/03/2021 12:22	124.8	57.3	9.9
02/03/2021 12:23	122.4	57.5	9.9
02/03/2021 12:24	128.1	57.4	9.9
02/03/2021 12:25	121.7	57.6	9.9
02/03/2021 12:26	121.0	57.6	9.9
02/03/2021 12:27	123.2	57.6	9.9
02/03/2021 12:28	121.9	57.5	9.9
02/03/2021 12:29	123.7	57.8	10.0
02/03/2021 12:30	125.7	58.0	10.0
02/03/2021 12:31	104.0	59.7	10.0
02/03/2021 12:32	97.6	60.8	10.0
02/03/2021 12:33	122.8	57.8	10.0
02/03/2021 12:34	129.8	57.9	10.0
02/03/2021 12:35	123.5	58.1	10.0
02/03/2021 12:36	125.8	57.9	10.0
02/03/2021 12:37	127.7	58.2	10.0
02/03/2021 12:38	123.5	58.2	10.0
02/03/2021 12:39	120.0	57.8	9.9
02/03/2021 12:40	119.9	57.3	9.9
02/03/2021 12:41	125.8	57.1	9.9
02/03/2021 12:42	91.1	59.7	9.9
02/03/2021 12:43	104.5	59.0	9.9
02/03/2021 12:44	125.3	56.6	9.9
02/03/2021 12:45	128.9	56.7	9.9
02/03/2021 12:46	122.5	57.0	9.9
02/03/2021 12:47	120.6	57.2	9.9
02/03/2021 12:48	126.5	56.9	9.9
02/03/2021 12:49	121.2	57.3	9.9
02/03/2021 12:50	125.7	57.3	10.0
02/03/2021 12:51	114.3	57.6	9.9
02/03/2021 12:52	118.1	57.7	9.9
02/03/2021 12:53	85.1	61.2	10.0
02/03/2021 12:54	113.7	59.2	10.0
02/03/2021 12:55	122.9	57.6	10.0
02/03/2021 12:56	122.0	57.9	10.0
02/03/2021 12:57	118.8	57.4	9.9
02/03/2021 12:58	122.9	57.7	10.0
02/03/2021 12:59	121.7	57.7	9.9
02/03/2021 13:00	123.4	57.4	9.9
Minimum	83.0	56.6	9.9
Maximum	129.8	61.5	10.1
Average	119.1	57.9	10.0

One Minute Averaged Gaseous Emissions Results

South Hook LNG - SCV 1C			
273K, 101.3 kPa, 3% Oxygen on a dry basis			
Species	Carbon Monoxide	Oxides of Nitrogen	Oxygen
Units	mg/m3	mg/m3	%
02/03/2021 13:40	224.9	55.4	11.3
02/03/2021 13:41	221.1	55.5	11.3
02/03/2021 13:42	212.7	55.7	11.2
02/03/2021 13:43	216.4	56.0	11.1
02/03/2021 13:44	222.8	56.1	11.2
02/03/2021 13:45	226.8	55.9	11.3
02/03/2021 13:46	230.7	56.0	11.4
02/03/2021 13:47	163.7	59.3	11.4
02/03/2021 13:48	188.6	58.7	11.4
02/03/2021 13:49	229.9	56.6	11.3
02/03/2021 13:50	225.5	56.6	11.3
02/03/2021 13:51	233.2	56.7	11.4
02/03/2021 13:52	239.2	56.5	11.4
02/03/2021 13:53	228.3	56.6	11.4
02/03/2021 13:54	233.4	56.6	11.4
02/03/2021 13:55	226.1	56.7	11.3
02/03/2021 13:56	226.8	56.6	11.3
02/03/2021 13:57	230.6	56.5	11.3
02/03/2021 13:58	151.0	59.9	11.2
02/03/2021 13:59	193.8	58.0	11.1
02/03/2021 14:00	219.7	56.4	11.1
02/03/2021 14:01	225.1	56.2	11.2
02/03/2021 14:02	228.1	56.4	11.2
02/03/2021 14:03	231.3	56.5	11.3
02/03/2021 14:04	219.9	56.9	11.3
02/03/2021 14:05	208.0	57.1	11.3
02/03/2021 14:06	209.1	57.1	11.3
02/03/2021 14:07	210.0	57.3	11.4
02/03/2021 14:08	214.8	57.4	11.5
02/03/2021 14:09	139.9	61.4	11.5
02/03/2021 14:10	213.4	58.0	11.6
02/03/2021 14:11	221.1	57.0	11.5
02/03/2021 14:12	210.3	56.8	11.3
02/03/2021 14:13	216.1	56.4	11.2
02/03/2021 14:14	199.2	56.5	11.0
02/03/2021 14:15	191.8	56.6	10.9
02/03/2021 14:16	197.6	56.4	10.9
02/03/2021 14:17	191.1	56.4	10.9
02/03/2021 14:18	204.6	56.2	11.0
02/03/2021 14:19	207.3	56.4	11.0
02/03/2021 14:20	126.3	61.0	11.1
02/03/2021 14:21	202.9	57.2	11.2
02/03/2021 14:22	215.2	56.8	11.2
02/03/2021 14:23	212.5	56.9	11.3
02/03/2021 14:24	212.8	56.6	11.3
02/03/2021 14:25	218.1	56.6	11.3
02/03/2021 14:26	234.5	56.3	11.4
02/03/2021 14:27	249.3	56.0	11.4
02/03/2021 14:28	244.0	56.1	11.4
02/03/2021 14:29	223.8	56.2	11.3
02/03/2021 14:30	202.1	57.2	11.2
02/03/2021 14:31	150.8	60.4	11.2
02/03/2021 14:32	220.1	56.4	11.2
02/03/2021 14:33	223.4	56.2	11.2
02/03/2021 14:34	215.2	56.2	11.1
02/03/2021 14:35	226.4	56.4	11.2
02/03/2021 14:36	227.2	56.4	11.3
02/03/2021 14:37	230.9	56.3	11.3
02/03/2021 14:38	227.9	56.3	11.3
02/03/2021 14:39	225.0	56.4	11.4
02/03/2021 14:40	234.3	56.3	11.3
Minimum	126.3	55.4	10.9
Maximum	249.3	61.4	11.6
Average	213.2	56.9	11.3

One Minute Averaged Gaseous Emissions Results

South Hook LNG - SCV 1D			
273K, 101.3 kPa, 3% Oxygen on a dry basis			
Species	Carbon Monoxide	Oxides of Nitrogen	Oxygen
Units	mg/m3	mg/m3	%
02/03/2021 15:15	232.7	52.7	10.0
02/03/2021 15:16	237.8	51.6	10.0
02/03/2021 15:17	258.3	51.8	10.1
02/03/2021 15:18	272.0	51.8	10.1
02/03/2021 15:19	272.7	51.8	10.2
02/03/2021 15:20	283.5	52.1	10.3
02/03/2021 15:21	291.8	52.0	10.3
02/03/2021 15:22	294.1	52.0	10.3
02/03/2021 15:23	290.8	51.9	10.3
02/03/2021 15:24	260.9	52.9	10.2
02/03/2021 15:25	177.3	57.9	10.2
02/03/2021 15:26	268.5	52.4	10.1
02/03/2021 15:27	285.8	52.0	10.2
02/03/2021 15:28	286.6	52.2	10.3
02/03/2021 15:29	294.2	52.0	10.3
02/03/2021 15:30	299.2	52.0	10.3
02/03/2021 15:31	300.2	52.2	10.3
02/03/2021 15:32	297.9	52.0	10.3
02/03/2021 15:33	281.9	52.0	10.2
02/03/2021 15:34	280.8	52.1	10.2
02/03/2021 15:35	234.4	54.2	10.2
02/03/2021 15:36	190.7	57.4	10.2
02/03/2021 15:37	265.8	52.6	10.2
02/03/2021 15:38	271.0	52.4	10.2
02/03/2021 15:39	270.1	52.4	10.1
02/03/2021 15:40	270.5	52.6	10.1
02/03/2021 15:41	276.1	52.2	10.1
02/03/2021 15:42	268.2	52.3	10.1
02/03/2021 15:43	266.7	52.4	10.1
02/03/2021 15:44	269.9	52.3	10.1
02/03/2021 15:45	272.1	52.3	10.1
02/03/2021 15:46	206.7	55.5	10.1
02/03/2021 15:47	205.0	56.3	10.1
02/03/2021 15:48	256.5	52.6	10.1
02/03/2021 15:49	266.7	52.3	10.1
02/03/2021 15:50	273.6	52.1	10.1
02/03/2021 15:51	272.1	52.5	10.1
02/03/2021 15:52	268.9	52.5	10.1
02/03/2021 15:53	268.2	52.5	10.1
02/03/2021 15:54	266.5	52.8	10.1
02/03/2021 15:55	278.8	52.9	10.1
02/03/2021 15:56	286.0	52.5	10.2
02/03/2021 15:57	209.9	56.5	10.3
02/03/2021 15:58	244.0	55.5	10.2
02/03/2021 15:59	292.4	52.3	10.2
02/03/2021 16:00	278.3	52.3	10.2
02/03/2021 16:01	278.1	52.3	10.2
02/03/2021 16:02	273.7	52.4	10.1
02/03/2021 16:03	266.4	52.3	10.1
02/03/2021 16:04	265.4	52.5	10.1
02/03/2021 16:05	270.8	52.4	10.1
02/03/2021 16:06	276.0	52.5	10.1
02/03/2021 16:07	275.6	52.3	10.1
02/03/2021 16:08	178.9	57.7	10.1
02/03/2021 16:09	259.5	54.3	10.2
02/03/2021 16:10	290.0	52.5	10.2
02/03/2021 16:11	281.2	52.5	10.2
02/03/2021 16:12	290.0	52.3	10.2
02/03/2021 16:13	292.5	52.3	10.2
02/03/2021 16:14	282.7	52.5	10.2
02/03/2021 16:15	284.1	52.4	10.2
Minimum	177.3	51.6	10.0
Maximum	300.2	57.9	10.3
Average	266.6	52.9	10.2

One Minute Averaged Gaseous Emissions Results

South Hook LNG - SCV 1E			
273K, 101.3 kPa, 3% Oxygen on a dry basis			
Species	Carbon Monoxide	Oxides of Nitrogen	Oxygen
Units	mg/m3	mg/m3	%
03/03/2021 16:00	195.6	75.4	13.8
03/03/2021 16:01	183.7	74.1	13.6
03/03/2021 16:02	178.3	73.3	13.5
03/03/2021 16:03	171.4	72.5	13.4
03/03/2021 16:04	164.5	71.8	13.3
03/03/2021 16:05	157.0	72.0	13.2
03/03/2021 16:06	153.2	72.9	13.3
03/03/2021 16:07	170.7	73.5	13.4
03/03/2021 16:08	222.5	74.4	13.6
03/03/2021 16:09	251.0	76.5	13.8
03/03/2021 16:10	324.3	72.1	14.1
03/03/2021 16:11	373.8	69.3	14.3
03/03/2021 16:12	439.4	65.9	14.5
03/03/2021 16:13	497.9	61.0	14.7
03/03/2021 16:14	514.9	59.9	14.7
03/03/2021 16:15	540.5	58.5	14.7
03/03/2021 16:16	524.8	59.3	14.6
03/03/2021 16:17	527.7	59.7	14.6
03/03/2021 16:18	494.3	60.1	14.6
03/03/2021 16:19	441.7	62.8	14.5
03/03/2021 16:20	353.1	68.0	14.3
03/03/2021 16:21	295.3	71.4	14.1
03/03/2021 16:22	254.4	72.3	14.1
03/03/2021 16:23	204.4	74.2	13.9
03/03/2021 16:24	191.4	74.0	13.8
03/03/2021 16:25	182.2	73.8	13.7
03/03/2021 16:26	188.9	73.6	13.8
03/03/2021 16:27	181.6	74.4	13.6
03/03/2021 16:28	194.3	74.8	13.6
03/03/2021 16:29	235.6	74.4	13.7
03/03/2021 16:30	257.4	74.4	13.7
03/03/2021 16:31	284.0	73.7	13.9
03/03/2021 16:32	307.8	74.3	14.0
03/03/2021 16:33	382.3	68.7	14.2
03/03/2021 16:34	403.0	66.6	14.2
03/03/2021 16:35	436.1	64.9	14.3
03/03/2021 16:36	449.0	63.9	14.4
03/03/2021 16:37	436.9	64.8	14.3
03/03/2021 16:38	419.6	66.0	14.2
03/03/2021 16:39	418.8	65.7	14.3
03/03/2021 16:40	397.5	66.3	14.3
03/03/2021 16:41	390.3	66.4	14.3
03/03/2021 16:42	356.6	67.8	14.3
03/03/2021 16:43	294.8	72.6	14.2
03/03/2021 16:44	299.3	71.7	14.1
03/03/2021 16:45	265.1	72.8	14.0
03/03/2021 16:46	252.6	73.8	13.9
03/03/2021 16:47	232.0	73.8	13.9
03/03/2021 16:48	222.2	74.7	13.8
03/03/2021 16:49	219.8	74.9	13.7
03/03/2021 16:50	235.5	75.0	13.7
03/03/2021 16:51	254.2	74.9	13.7
03/03/2021 16:52	270.2	74.4	13.8
03/03/2021 16:53	301.0	73.2	13.9
03/03/2021 16:54	315.2	73.0	14.0
03/03/2021 16:55	326.6	73.2	14.1
03/03/2021 16:56	372.8	69.5	14.1
03/03/2021 16:57	385.4	68.4	14.1
03/03/2021 16:58	394.3	67.5	14.2
03/03/2021 16:59	404.0	66.8	14.2
03/03/2021 17:00	403.0	67.2	14.1
Minimum	153.2	58.5	13.2
Maximum	540.5	76.5	14.7
Average	314.7	70.1	14.0

One Minute Averaged Gaseous Emissions Results

South Hook LNG - SCV 1F			
273K, 101.3 kPa, 3% Oxygen on a dry basis			
Species	Carbon Monoxide	Oxides of Nitrogen	Oxygen
Units	mg/m3	mg/m3	%
03/03/2021 14:05	223.0	72.7	12.9
03/03/2021 14:06	242.5	72.0	13.2
03/03/2021 14:07	250.8	72.5	13.3
03/03/2021 14:08	267.2	71.4	13.4
03/03/2021 14:09	283.8	70.4	13.4
03/03/2021 14:10	286.5	70.2	13.4
03/03/2021 14:11	304.5	69.2	13.5
03/03/2021 14:12	301.0	69.8	13.3
03/03/2021 14:13	261.5	73.1	13.2
03/03/2021 14:14	258.2	72.7	13.1
03/03/2021 14:15	259.3	70.2	13.0
03/03/2021 14:16	252.9	69.8	13.0
03/03/2021 14:17	256.2	69.4	13.0
03/03/2021 14:18	255.8	69.4	12.9
03/03/2021 14:19	253.5	69.4	12.9
03/03/2021 14:20	252.3	69.5	12.9
03/03/2021 14:21	251.9	69.8	12.9
03/03/2021 14:22	243.4	71.6	12.8
03/03/2021 14:23	226.4	73.4	12.7
03/03/2021 14:24	230.8	73.7	12.8
03/03/2021 14:25	218.2	76.3	13.0
03/03/2021 14:26	249.6	73.5	13.0
03/03/2021 14:27	248.4	73.3	13.0
03/03/2021 14:28	254.7	73.3	13.1
03/03/2021 14:29	264.2	72.8	13.2
03/03/2021 14:30	266.4	72.3	13.2
03/03/2021 14:31	276.8	72.1	13.2
03/03/2021 14:32	281.7	71.5	13.2
03/03/2021 14:33	281.0	71.6	13.2
03/03/2021 14:34	285.6	70.9	13.3
03/03/2021 14:35	266.8	72.1	13.1
03/03/2021 14:36	234.8	73.0	13.0
03/03/2021 14:37	202.1	76.3	12.9
03/03/2021 14:38	242.8	72.5	12.9
03/03/2021 14:39	241.1	71.0	12.9
03/03/2021 14:40	245.2	70.8	12.9
03/03/2021 14:41	245.8	71.3	12.9
03/03/2021 14:42	244.6	71.3	12.9
03/03/2021 14:43	249.5	71.7	13.0
03/03/2021 14:44	255.5	71.7	13.0
03/03/2021 14:45	230.5	73.1	12.9
03/03/2021 14:46	223.9	75.0	12.8
03/03/2021 14:47	226.3	74.7	12.9
03/03/2021 14:48	213.8	76.0	12.9
03/03/2021 14:49	216.5	77.7	13.0
03/03/2021 14:50	249.3	73.9	13.1
03/03/2021 14:51	252.0	74.0	13.1
03/03/2021 14:52	257.5	73.8	13.2
03/03/2021 14:53	262.9	73.7	13.2
03/03/2021 14:54	254.8	74.1	13.2
03/03/2021 14:55	257.9	74.1	13.2
03/03/2021 14:56	254.8	74.1	13.1
03/03/2021 14:57	255.6	73.0	13.2
03/03/2021 14:58	250.3	72.6	13.2
03/03/2021 14:59	251.9	72.3	13.2
03/03/2021 15:00	210.7	75.0	13.1
03/03/2021 15:01	235.2	73.6	13.1
03/03/2021 15:02	250.0	72.0	13.1
03/03/2021 15:03	239.4	72.1	13.0
03/03/2021 15:04	240.9	72.7	13.0
03/03/2021 15:05	243.7	72.8	13.0
Minimum	202.1	69.2	12.7
Maximum	304.5	77.7	13.5
Average	250.7	72.5	13.1

One Minute Averaged Gaseous Emissions Results

South Hook LNG - SCV 1G			
273K, 101.3 kPa, 3% Oxygen on a dry basis			
Species	Carbon Monoxide	Oxides of Nitrogen	Oxygen
Units	mg/m3	mg/m3	%
03/03/2021 12:15	603.2	49.4	10.7
03/03/2021 12:16	698.5	49.3	10.9
03/03/2021 12:17	775.6	49.0	11.1
03/03/2021 12:18	789.7	48.7	11.1
03/03/2021 12:19	617.2	49.9	10.9
03/03/2021 12:20	501.2	52.4	10.8
03/03/2021 12:21	704.6	49.1	10.9
03/03/2021 12:22	670.8	49.5	10.9
03/03/2021 12:23	766.7	49.7	11.1
03/03/2021 12:24	761.7	48.8	11.0
03/03/2021 12:25	670.3	49.1	10.8
03/03/2021 12:26	663.7	49.1	10.8
03/03/2021 12:27	762.3	48.7	11.0
03/03/2021 12:28	845.8	48.6	11.2
03/03/2021 12:29	869.6	48.2	11.2
03/03/2021 12:30	679.4	49.3	10.9
03/03/2021 12:31	437.9	52.7	10.7
03/03/2021 12:32	637.9	49.3	10.7
03/03/2021 12:33	740.8	48.9	11.0
03/03/2021 12:34	790.9	48.9	11.1
03/03/2021 12:35	729.2	48.8	11.0
03/03/2021 12:36	616.6	49.2	10.7
03/03/2021 12:37	623.9	49.3	10.8
03/03/2021 12:38	726.6	49.2	10.9
03/03/2021 12:39	799.2	48.7	11.1
03/03/2021 12:40	773.6	48.7	11.1
03/03/2021 12:41	646.2	49.2	10.9
03/03/2021 12:42	508.0	52.7	10.8
03/03/2021 12:43	754.5	48.7	11.0
03/03/2021 12:44	815.0	48.5	11.1
03/03/2021 12:45	768.7	49.0	11.1
03/03/2021 12:46	686.2	48.7	10.8
03/03/2021 12:47	638.8	48.8	10.7
03/03/2021 12:48	695.8	48.8	10.8
03/03/2021 12:49	773.0	48.7	11.1
03/03/2021 12:50	818.1	48.3	11.1
03/03/2021 12:51	728.9	48.3	10.9
03/03/2021 12:52	629.5	49.2	10.8
03/03/2021 12:53	520.9	52.2	10.9
03/03/2021 12:54	812.9	48.7	11.1
03/03/2021 12:55	826.6	48.6	11.2
03/03/2021 12:56	779.4	48.3	11.0
03/03/2021 12:57	684.5	48.7	10.9
03/03/2021 12:58	652.6	49.3	10.9
03/03/2021 12:59	664.6	49.6	11.0
03/03/2021 13:00	720.3	49.7	11.1
03/03/2021 13:01	735.5	48.9	11.0
03/03/2021 13:02	694.6	48.5	10.9
03/03/2021 13:03	702.2	49.3	11.0
03/03/2021 13:04	571.2	52.6	11.1
03/03/2021 13:05	766.0	48.5	11.1
03/03/2021 13:06	638.1	48.6	10.7
03/03/2021 13:07	604.1	48.7	10.6
03/03/2021 13:08	585.1	49.0	10.6
03/03/2021 13:09	597.6	48.9	10.7
03/03/2021 13:10	715.0	48.6	10.9
03/03/2021 13:11	705.6	48.0	10.8
03/03/2021 13:12	620.8	48.6	10.7
03/03/2021 13:13	650.6	48.9	10.8
03/03/2021 13:14	666.5	49.2	11.0
03/03/2021 13:15	532.4	52.6	11.1
Minimum	437.9	48.0	10.6
Maximum	869.6	52.7	11.2
Average	691.3	49.3	10.9

One Minute Averaged Gaseous Emissions Results

South Hook LNG - SCV 1H			
273K, 101.3 kPa, 3% Oxygen on a dry basis			
Species	Carbon Monoxide	Oxides of Nitrogen	Oxygen
Units	mg/m3	mg/m3	%
03/03/2021 10:00	155.1	49.5	10.1
03/03/2021 10:01	163.2	49.5	10.2
03/03/2021 10:02	162.2	49.3	10.2
03/03/2021 10:03	161.7	49.4	10.2
03/03/2021 10:04	157.0	49.5	10.1
03/03/2021 10:05	163.0	49.5	10.1
03/03/2021 10:06	167.5	49.4	10.2
03/03/2021 10:07	118.6	52.3	10.1
03/03/2021 10:08	126.6	52.2	10.1
03/03/2021 10:09	151.8	49.6	10.1
03/03/2021 10:10	148.8	49.6	10.0
03/03/2021 10:11	149.8	49.6	10.1
03/03/2021 10:12	144.9	49.6	10.0
03/03/2021 10:13	152.6	49.4	10.1
03/03/2021 10:14	144.1	49.6	10.0
03/03/2021 10:15	151.8	49.6	10.1
03/03/2021 10:16	154.2	49.4	10.1
03/03/2021 10:17	155.7	49.6	10.1
03/03/2021 10:18	116.3	52.5	10.1
03/03/2021 10:19	130.2	52.6	10.1
03/03/2021 10:20	160.5	50.0	10.2
03/03/2021 10:21	156.9	49.8	10.1
03/03/2021 10:22	157.5	49.8	10.1
03/03/2021 10:23	161.7	49.8	10.2
03/03/2021 10:24	165.0	49.6	10.2
03/03/2021 10:25	160.6	49.8	10.1
03/03/2021 10:26	159.2	49.6	10.1
03/03/2021 10:27	155.0	49.5	10.1
03/03/2021 10:28	159.8	49.4	10.1
03/03/2021 10:29	111.6	52.3	10.1
03/03/2021 10:30	124.5	52.0	10.0
03/03/2021 10:31	150.9	49.6	10.0
03/03/2021 10:32	150.1	49.5	10.0
03/03/2021 10:33	167.9	48.8	10.0
03/03/2021 10:34	174.2	48.0	10.1
03/03/2021 10:35	176.4	48.4	10.1
03/03/2021 10:36	182.0	48.5	10.1
03/03/2021 10:37	184.1	48.4	10.1
03/03/2021 10:38	198.7	48.7	10.2
03/03/2021 10:39	201.4	48.4	10.3
03/03/2021 10:40	165.0	50.1	10.2
03/03/2021 10:41	155.0	51.3	10.3
03/03/2021 10:42	189.4	48.6	10.2
03/03/2021 10:43	183.4	48.5	10.1
03/03/2021 10:44	175.2	48.1	10.1
03/03/2021 10:45	172.8	48.4	10.0
03/03/2021 10:46	168.0	48.4	10.0
03/03/2021 10:47	159.9	48.3	10.0
03/03/2021 10:48	166.6	48.2	10.0
03/03/2021 10:49	172.2	48.3	10.0
03/03/2021 10:50	175.9	48.5	10.1
03/03/2021 10:51	150.0	50.3	10.1
03/03/2021 10:52	141.7	51.5	10.1
03/03/2021 10:53	180.5	48.2	10.1
03/03/2021 10:54	186.8	48.5	10.2
03/03/2021 10:55	185.4	48.7	10.2
03/03/2021 10:56	191.7	48.6	10.2
03/03/2021 10:57	187.8	48.5	10.2
03/03/2021 10:58	196.7	48.7	10.2
03/03/2021 10:59	184.0	48.5	10.2
03/03/2021 11:00	182.6	48.6	10.1
Minimum	111.6	48.0	10.0
Maximum	201.4	52.6	10.3
Average	162.4	49.5	10.1

One Minute Averaged Gaseous Emissions Results

South Hook LNG - SCV 2A			
273K, 101.3 kPa, 3% Oxygen on a dry basis			
Species	Carbon Monoxide	Oxides of Nitrogen	Oxygen
Units	mg/m3	mg/m3	%
04/03/2021 10:00	300.1	48.6	10.5
04/03/2021 10:01	277.0	49.1	10.5
04/03/2021 10:02	290.4	49.3	10.5
04/03/2021 10:03	292.8	49.3	10.5
04/03/2021 10:04	306.7	49.2	10.6
04/03/2021 10:05	311.2	49.2	10.6
04/03/2021 10:06	314.7	49.2	10.6
04/03/2021 10:07	203.7	52.5	10.4
04/03/2021 10:08	229.2	52.0	10.3
04/03/2021 10:09	275.8	49.6	10.3
04/03/2021 10:10	260.6	50.1	10.3
04/03/2021 10:11	263.9	49.9	10.4
04/03/2021 10:12	256.4	49.8	10.3
04/03/2021 10:13	280.3	49.7	10.5
04/03/2021 10:14	303.3	49.7	10.5
04/03/2021 10:15	278.4	49.6	10.5
04/03/2021 10:16	206.4	53.1	10.5
04/03/2021 10:17	274.9	51.5	10.6
04/03/2021 10:18	320.4	49.5	10.6
04/03/2021 10:19	295.4	49.9	10.5
04/03/2021 10:20	292.3	49.9	10.5
04/03/2021 10:21	270.7	50.0	10.4
04/03/2021 10:22	253.3	50.0	10.3
04/03/2021 10:23	259.6	50.2	10.3
04/03/2021 10:24	264.1	50.2	10.4
04/03/2021 10:25	188.8	53.7	10.4
04/03/2021 10:26	255.8	51.4	10.4
04/03/2021 10:27	254.4	50.0	10.3
04/03/2021 10:28	268.5	49.9	10.4
04/03/2021 10:29	283.2	50.1	10.5
04/03/2021 10:30	285.7	50.0	10.5
04/03/2021 10:31	285.1	50.0	10.4
04/03/2021 10:32	280.0	49.8	10.4
04/03/2021 10:33	290.2	49.9	10.5
04/03/2021 10:34	186.9	54.1	10.5
04/03/2021 10:35	276.1	51.0	10.5
04/03/2021 10:36	303.9	50.0	10.5
04/03/2021 10:37	299.9	50.1	10.5
04/03/2021 10:38	272.2	50.2	10.4
04/03/2021 10:39	258.4	50.1	10.3
04/03/2021 10:40	257.2	50.4	10.3
04/03/2021 10:41	281.6	50.1	10.4
04/03/2021 10:42	278.3	50.2	10.5
04/03/2021 10:43	166.6	54.6	10.4
04/03/2021 10:44	251.4	51.2	10.3
04/03/2021 10:45	276.0	50.3	10.4
04/03/2021 10:46	304.1	50.1	10.6
04/03/2021 10:47	301.7	50.0	10.5
04/03/2021 10:48	273.5	50.3	10.4
04/03/2021 10:49	296.8	50.1	10.5
04/03/2021 10:50	284.9	49.9	10.5
04/03/2021 10:51	260.3	50.3	10.4
04/03/2021 10:52	153.5	54.8	10.3
04/03/2021 10:53	241.1	51.3	10.3
04/03/2021 10:54	255.6	50.6	10.3
04/03/2021 10:55	250.2	50.7	10.4
04/03/2021 10:56	276.4	50.2	10.4
04/03/2021 10:57	249.9	50.6	10.3
04/03/2021 10:58	247.6	50.5	10.3
04/03/2021 10:59	280.7	50.3	10.4
04/03/2021 11:00	259.2	50.6	10.4
Minimum	153.5	48.6	10.3
Maximum	320.4	54.8	10.6
Average	267.5	50.5	10.4

One Minute Averaged Gaseous Emissions Results

South Hook LNG - SCV 2D			
273K, 101.3 kPa, 3% Oxygen on a dry basis			
Species	Carbon Monoxide	Oxides of Nitrogen	Oxygen
Units	mg/m3	mg/m3	%
04/03/2021 12:00	440.8	52.8	12.2
04/03/2021 12:01	733.8	49.5	11.7
04/03/2021 12:02	554.8	51.1	10.4
04/03/2021 12:03	286.6	54.9	9.3
04/03/2021 12:04	150.3	58.3	8.9
04/03/2021 12:05	189.7	54.1	8.8
04/03/2021 12:06	188.3	54.0	8.8
04/03/2021 12:07	187.3	54.3	8.8
04/03/2021 12:08	250.7	53.9	9.4
04/03/2021 12:09	357.9	53.5	10.1
04/03/2021 12:10	486.7	51.9	11.0
04/03/2021 12:11	443.9	52.0	11.5
04/03/2021 12:12	373.2	54.4	11.6
04/03/2021 12:13	333.8	58.9	11.7
04/03/2021 12:14	508.5	53.0	11.9
04/03/2021 12:15	602.7	49.8	11.6
04/03/2021 12:16	574.9	50.8	10.7
04/03/2021 12:17	474.8	52.0	10.1
04/03/2021 12:18	361.8	53.2	9.7
04/03/2021 12:19	329.7	53.4	9.7
04/03/2021 12:20	294.9	53.7	9.6
04/03/2021 12:21	263.9	54.9	9.7
04/03/2021 12:22	233.9	57.2	9.8
04/03/2021 12:23	368.9	52.9	10.1
04/03/2021 12:24	471.5	51.6	10.6
04/03/2021 12:25	505.6	51.0	11.0
04/03/2021 12:26	491.4	51.4	11.2
04/03/2021 12:27	520.7	50.7	11.3
04/03/2021 12:28	597.3	49.5	11.4
04/03/2021 12:29	640.7	48.7	11.3
04/03/2021 12:30	488.0	52.7	10.7
04/03/2021 12:31	371.5	55.8	10.3
04/03/2021 12:32	433.3	52.4	10.2
04/03/2021 12:33	399.0	53.0	10.0
04/03/2021 12:34	374.7	53.0	10.1
04/03/2021 12:35	390.4	52.7	10.1
04/03/2021 12:36	397.5	52.5	10.2
04/03/2021 12:37	393.8	52.8	10.2
04/03/2021 12:38	453.2	52.4	10.4
04/03/2021 12:39	398.8	54.8	10.7
04/03/2021 12:40	451.8	54.7	11.0
04/03/2021 12:41	560.5	50.7	11.1
04/03/2021 12:42	571.0	50.7	11.1
04/03/2021 12:43	600.9	50.2	11.0
04/03/2021 12:44	594.7	50.4	10.8
04/03/2021 12:45	540.4	50.7	10.6
04/03/2021 12:46	482.2	51.6	10.3
04/03/2021 12:47	439.6	52.4	10.3
04/03/2021 12:48	332.5	55.8	10.2
04/03/2021 12:49	350.0	55.2	10.2
04/03/2021 12:50	392.8	53.0	10.1
04/03/2021 12:51	417.2	52.6	10.3
04/03/2021 12:52	447.2	52.3	10.3
04/03/2021 12:53	485.7	51.6	10.6
04/03/2021 12:54	524.0	50.6	10.8
04/03/2021 12:55	569.2	50.0	11.1
04/03/2021 12:56	580.2	50.0	11.2
04/03/2021 12:57	473.5	53.1	11.2
04/03/2021 12:58	543.8	51.6	11.2
04/03/2021 12:59	570.5	50.8	10.8
04/03/2021 13:00	545.4	50.6	10.6
Minimum	150.3	48.7	8.8
Maximum	733.8	58.9	12.2
Average	439.2	52.6	10.5

One Minute Averaged Gaseous Emissions Results

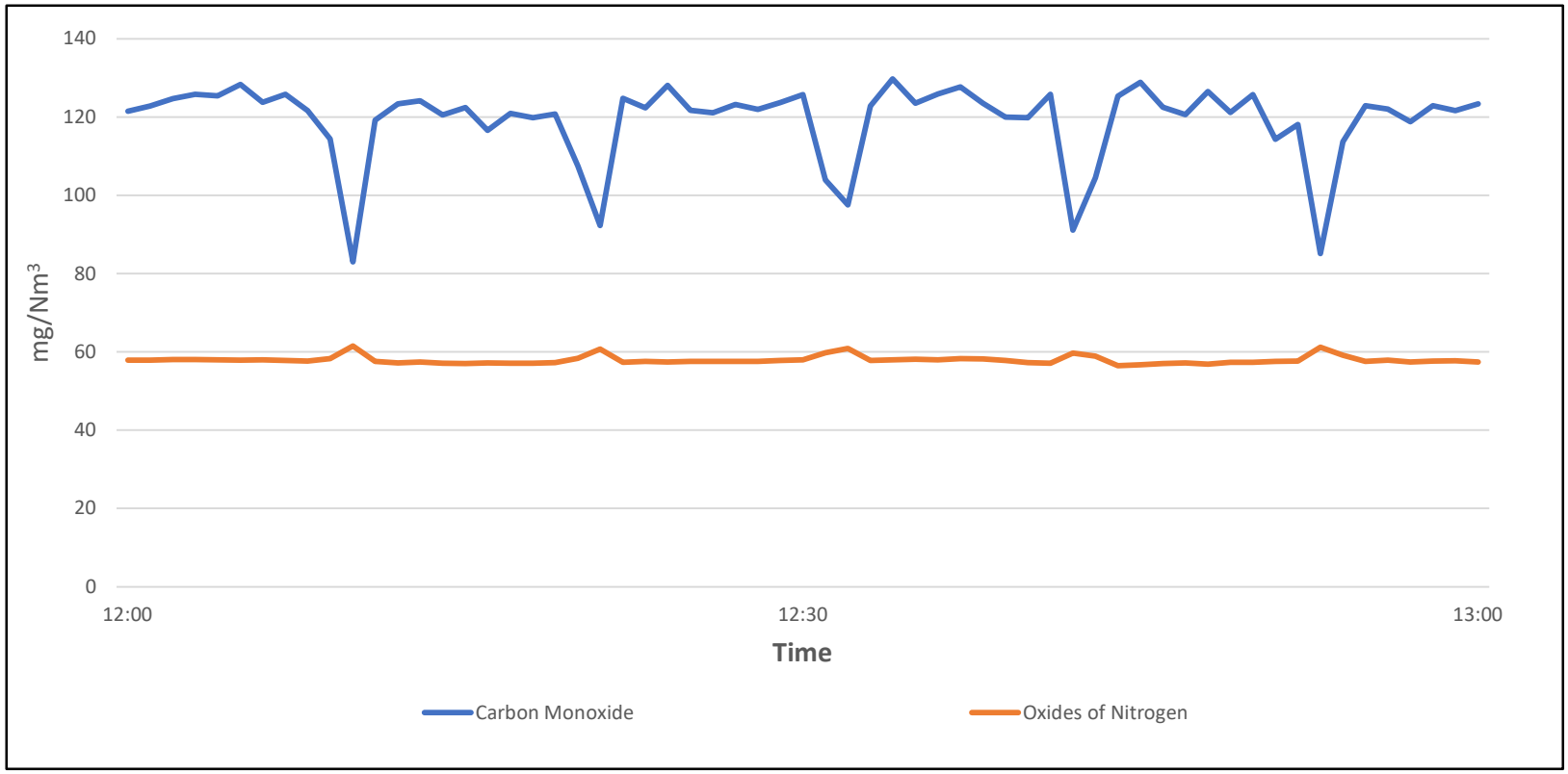
South Hook LNG - SCV 2E			
273K, 101.3 kPa, 3% Oxygen on a dry basis			
Species	Carbon Monoxide	Oxides of Nitrogen	Oxygen
Units	mg/m3	mg/m3	%
04/03/2021 14:02	127.8	54.3	9.6
04/03/2021 14:03	116.4	54.3	9.4
04/03/2021 14:04	106.3	54.5	9.3
04/03/2021 14:05	99.7	54.8	9.2
04/03/2021 14:06	100.9	55.0	9.2
04/03/2021 14:07	105.3	55.1	9.3
04/03/2021 14:08	103.2	56.6	9.4
04/03/2021 14:09	104.8	60.1	9.7
04/03/2021 14:10	204.3	55.3	10.2
04/03/2021 14:11	274.7	54.9	10.7
04/03/2021 14:12	382.4	53.8	11.1
04/03/2021 14:13	425.1	53.5	11.4
04/03/2021 14:14	453.5	53.1	11.6
04/03/2021 14:15	482.2	52.6	11.7
04/03/2021 14:16	470.1	52.4	11.6
04/03/2021 14:17	435.4	54.2	12.0
04/03/2021 14:18	417.0	55.4	11.9
04/03/2021 14:19	441.0	52.9	11.4
04/03/2021 14:20	289.2	54.8	10.8
04/03/2021 14:21	195.9	55.7	10.2
04/03/2021 14:22	146.8	56.0	9.7
04/03/2021 14:23	124.8	56.0	9.5
04/03/2021 14:24	123.3	55.9	9.5
04/03/2021 14:25	116.7	55.9	9.4
04/03/2021 14:26	89.0	58.6	9.3
04/03/2021 14:27	96.8	59.4	9.4
04/03/2021 14:28	145.2	56.0	9.7
04/03/2021 14:29	197.5	55.8	10.1
04/03/2021 14:30	254.8	55.4	10.5
04/03/2021 14:31	336.4	54.7	10.9
04/03/2021 14:32	388.8	54.2	11.2
04/03/2021 14:33	413.0	53.9	11.3
04/03/2021 14:34	479.6	52.8	11.5
04/03/2021 14:35	276.1	57.6	11.1
04/03/2021 14:36	198.2	58.4	10.6
04/03/2021 14:37	189.4	55.8	10.0
04/03/2021 14:38	146.6	56.0	9.6
04/03/2021 14:39	123.0	56.1	9.4
04/03/2021 14:40	119.4	56.1	9.3
04/03/2021 14:41	109.4	56.1	9.3
04/03/2021 14:42	113.3	56.2	9.3
04/03/2021 14:43	136.4	56.1	9.5
04/03/2021 14:44	115.2	60.3	9.9
04/03/2021 14:45	191.9	58.3	10.3
04/03/2021 14:46	308.2	55.5	10.8
04/03/2021 14:47	371.8	54.7	11.1
04/03/2021 14:48	412.5	54.0	11.3
04/03/2021 14:49	445.4	53.6	11.4
04/03/2021 14:50	351.2	54.3	11.1
04/03/2021 14:51	236.1	55.7	10.5
04/03/2021 14:52	176.9	56.1	10.0
04/03/2021 14:53	89.0	60.3	9.5
04/03/2021 14:54	96.2	58.1	9.3
04/03/2021 14:55	104.2	56.4	9.3
04/03/2021 14:56	104.9	56.3	9.3
04/03/2021 14:57	111.3	56.3	9.3
04/03/2021 14:58	111.1	56.4	9.3
04/03/2021 14:59	140.7	56.5	9.6
04/03/2021 15:00	181.2	56.2	10.0
04/03/2021 15:01	235.9	55.6	10.4
04/03/2021 15:02	192.4	60.2	10.8
Minimum	89.0	52.4	9.2
Maximum	482.2	60.3	12.0
Average	223.5	55.8	10.2

2.2.4 - Gaseous Emissions Graphical Data

South Hook LNG - SCV 1A

Gaseous Emissions Graphical Data for Carbon Monoxide, and Oxides of Nitrogen

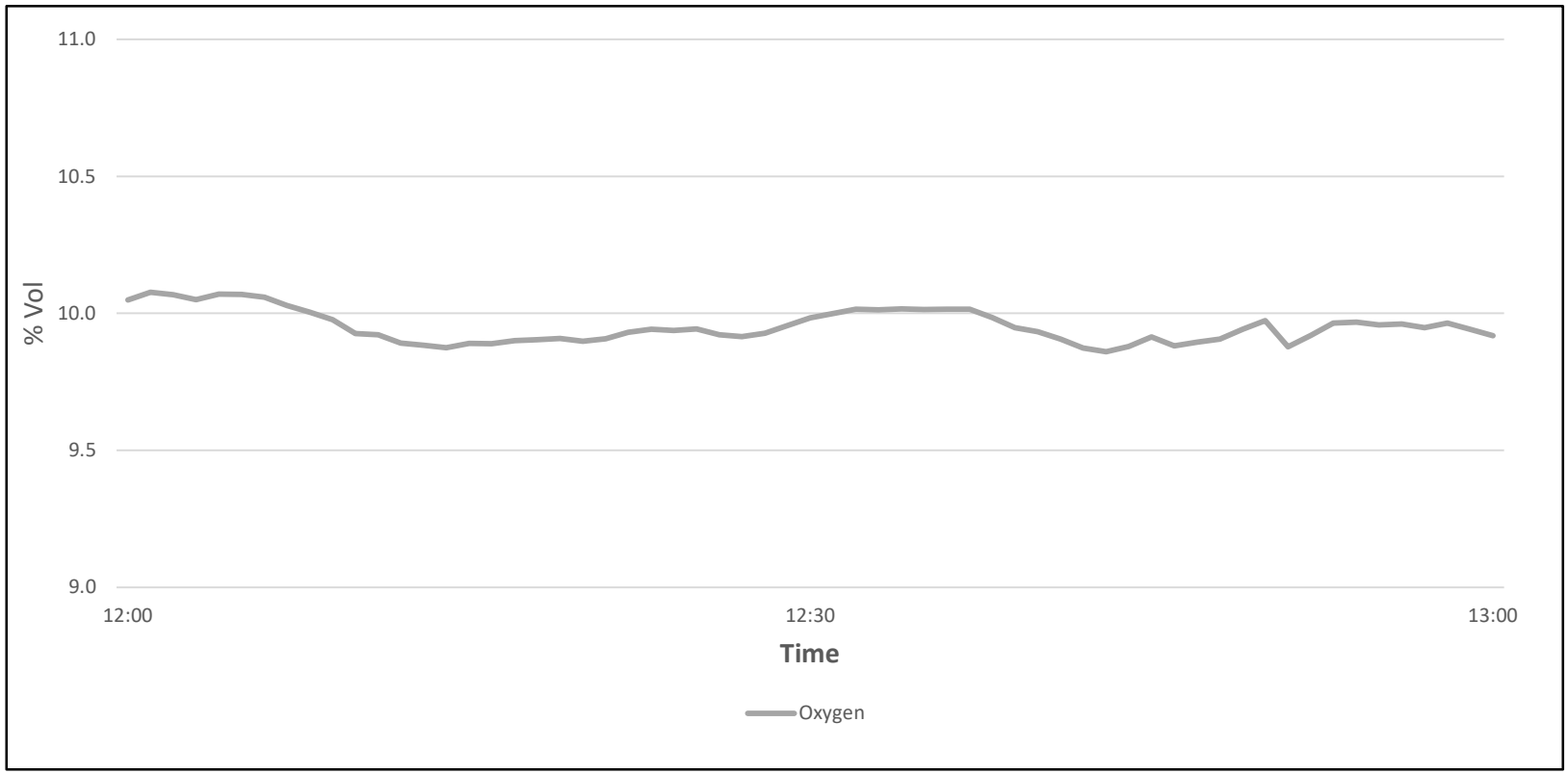
Reference Conditions - 273.15K, 101.3 kPa, 3% Oxygen on a dry gas basis



South Hook LNG - SCV 1A

Gaseous Emissions Graphical Data for Oxygen

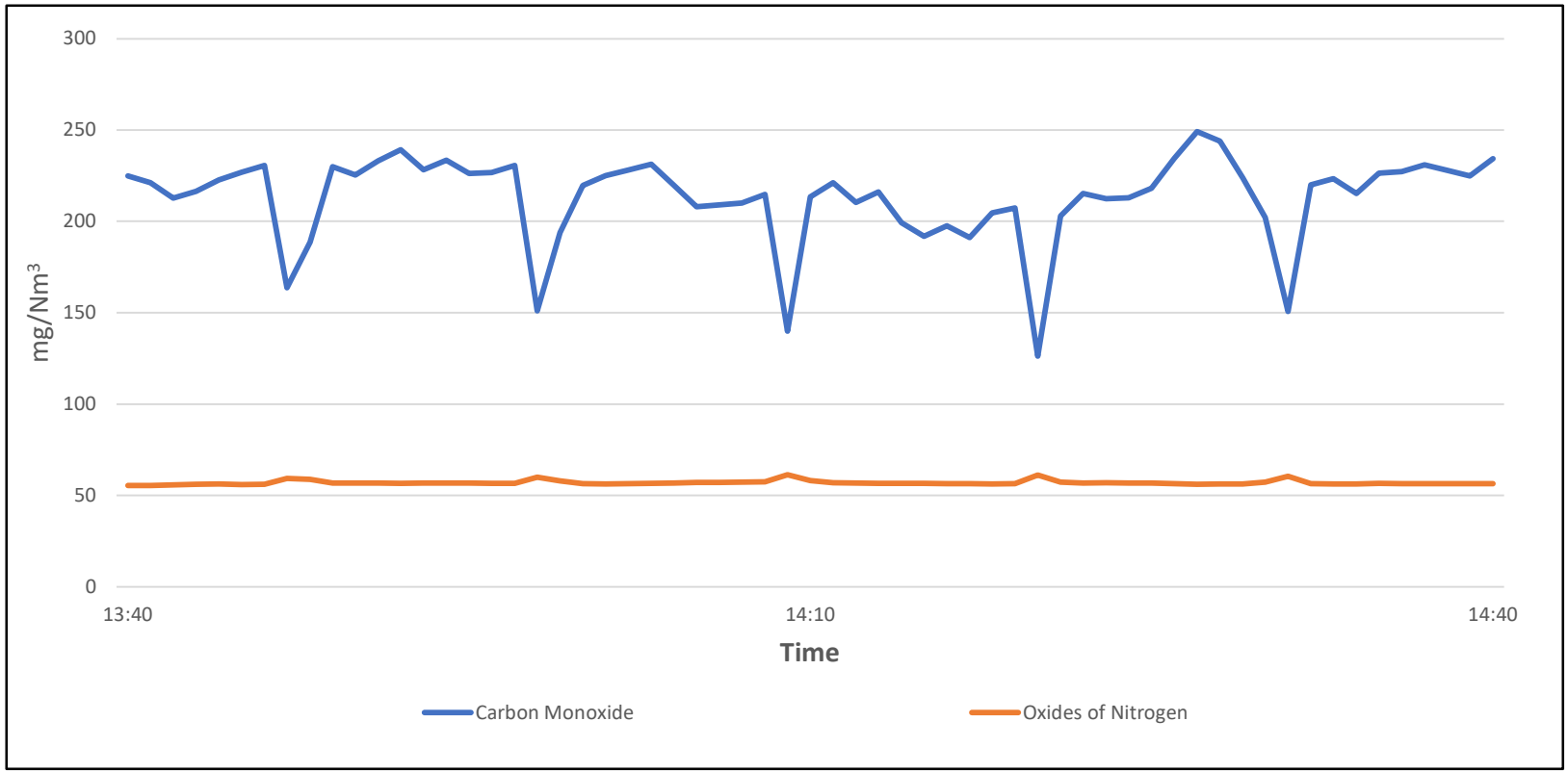
Reference Conditions - 273.15K, 101.3 kPa on a dry gas basis



South Hook LNG - SCV 1C

Gaseous Emissions Graphical Data for Carbon Monoxide, and Oxides of Nitrogen

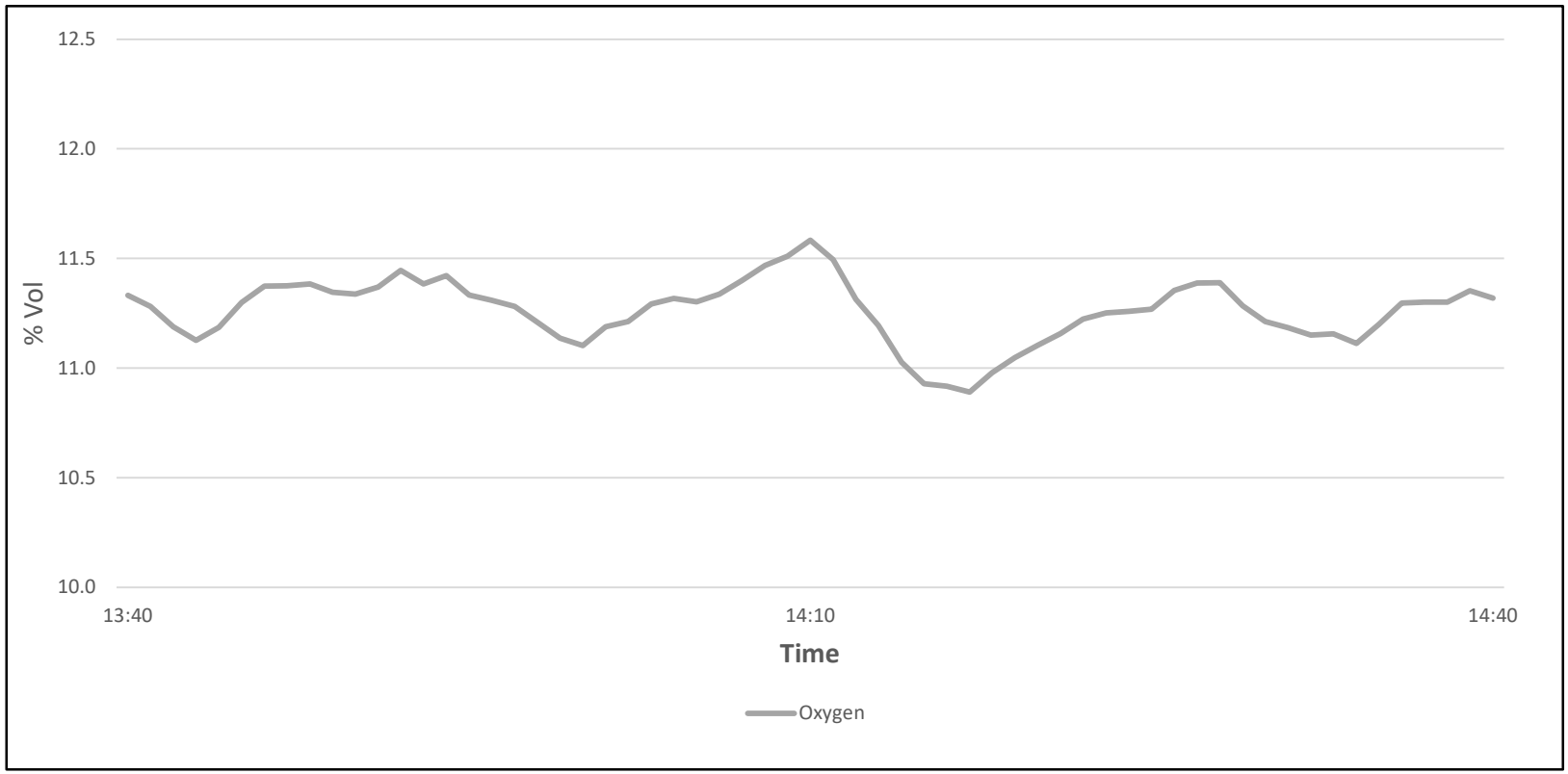
Reference Conditions - 273.15K, 101.3 kPa, 3% Oxygen on a dry gas basis



South Hook LNG - SCV 1C

Gaseous Emissions Graphical Data for Oxygen

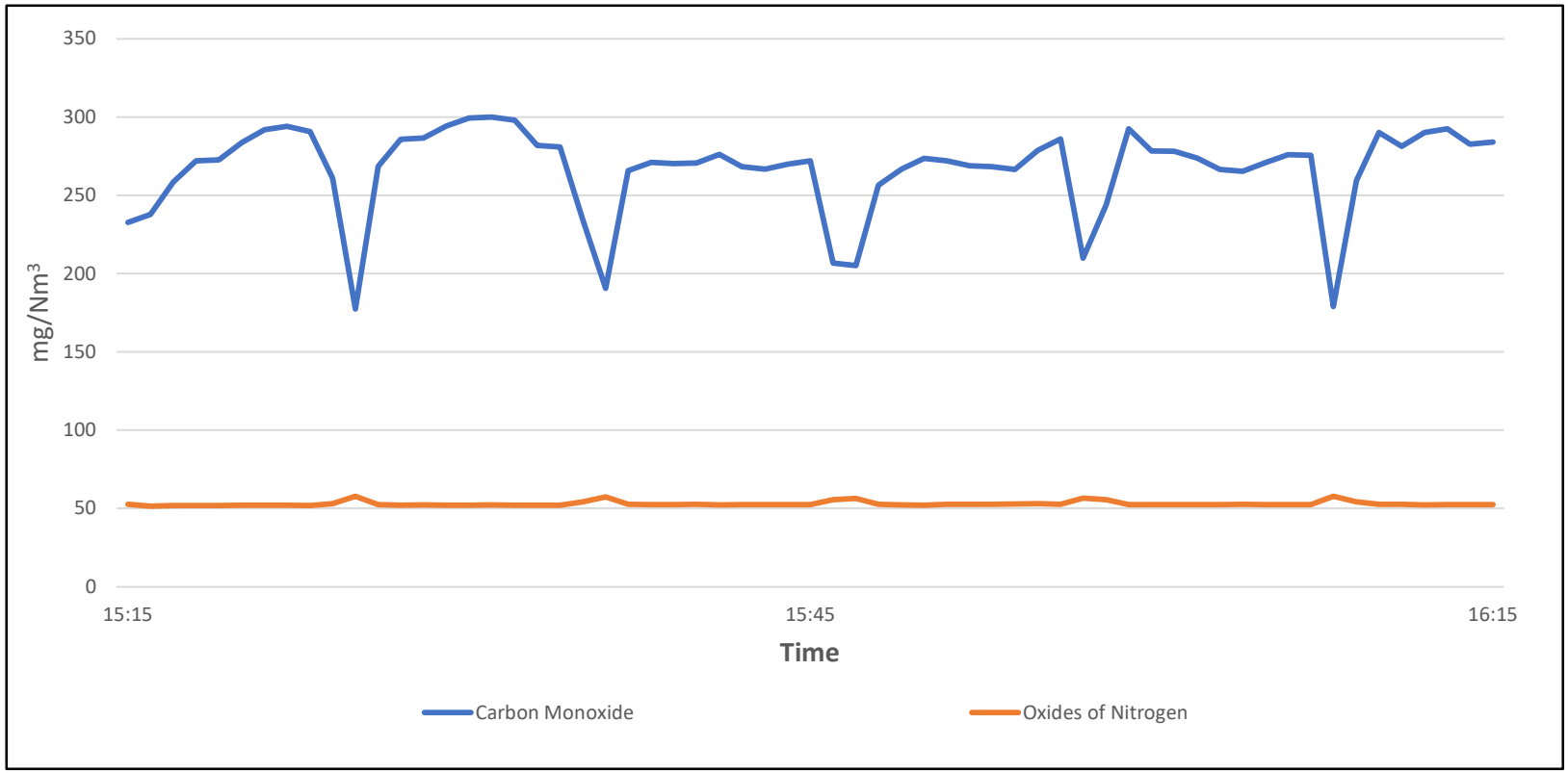
Reference Conditions - 273.15K, 101.3 kPa on a dry gas basis



South Hook LNG - SCV 1D

Gaseous Emissions Graphical Data for Carbon Monoxide, and Oxides of Nitrogen

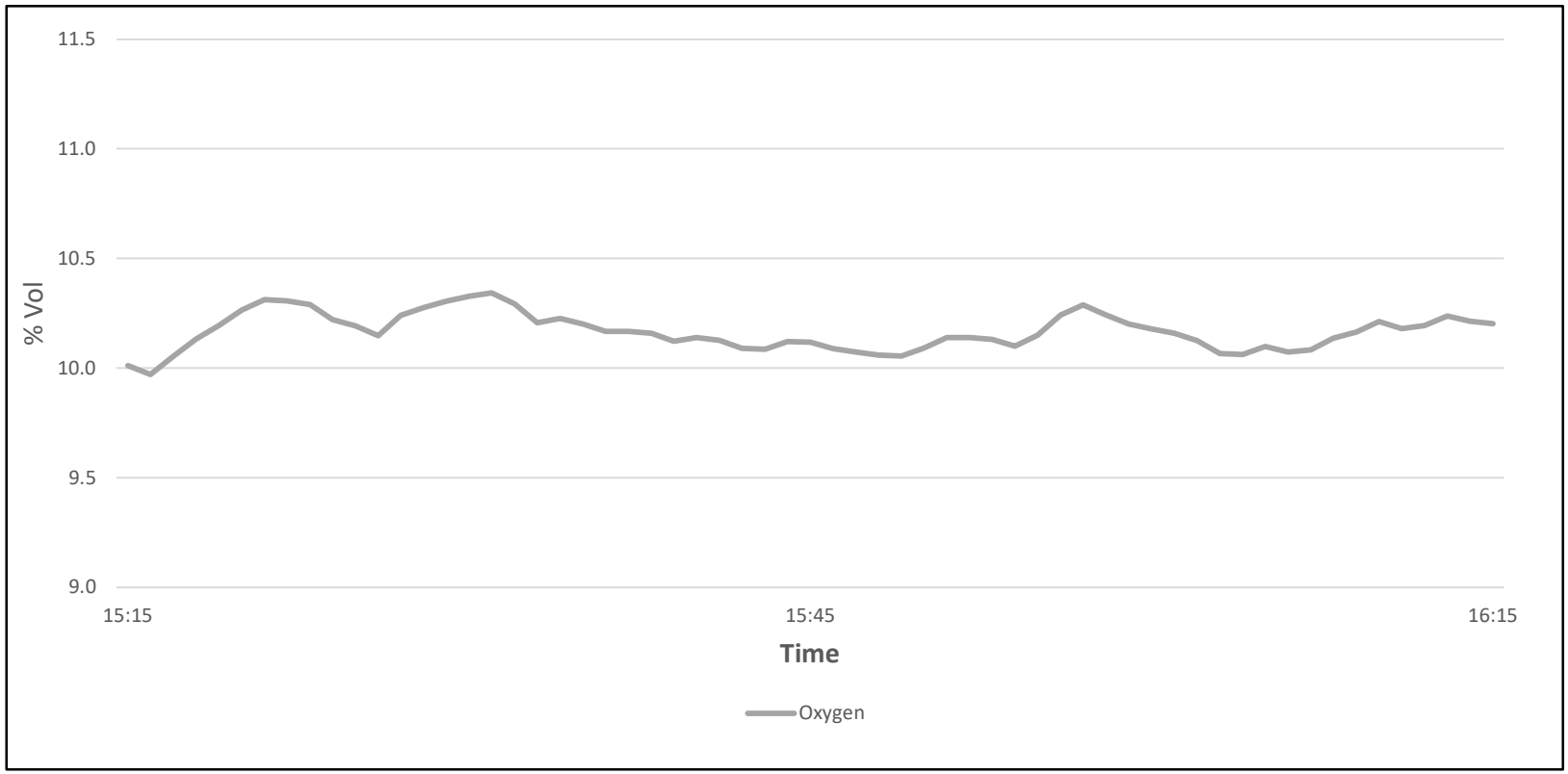
Reference Conditions - 273.15K, 101.3 kPa, 3% Oxygen on a dry gas basis



South Hook LNG - SCV 1D

Gaseous Emissions Graphical Data for Oxygen

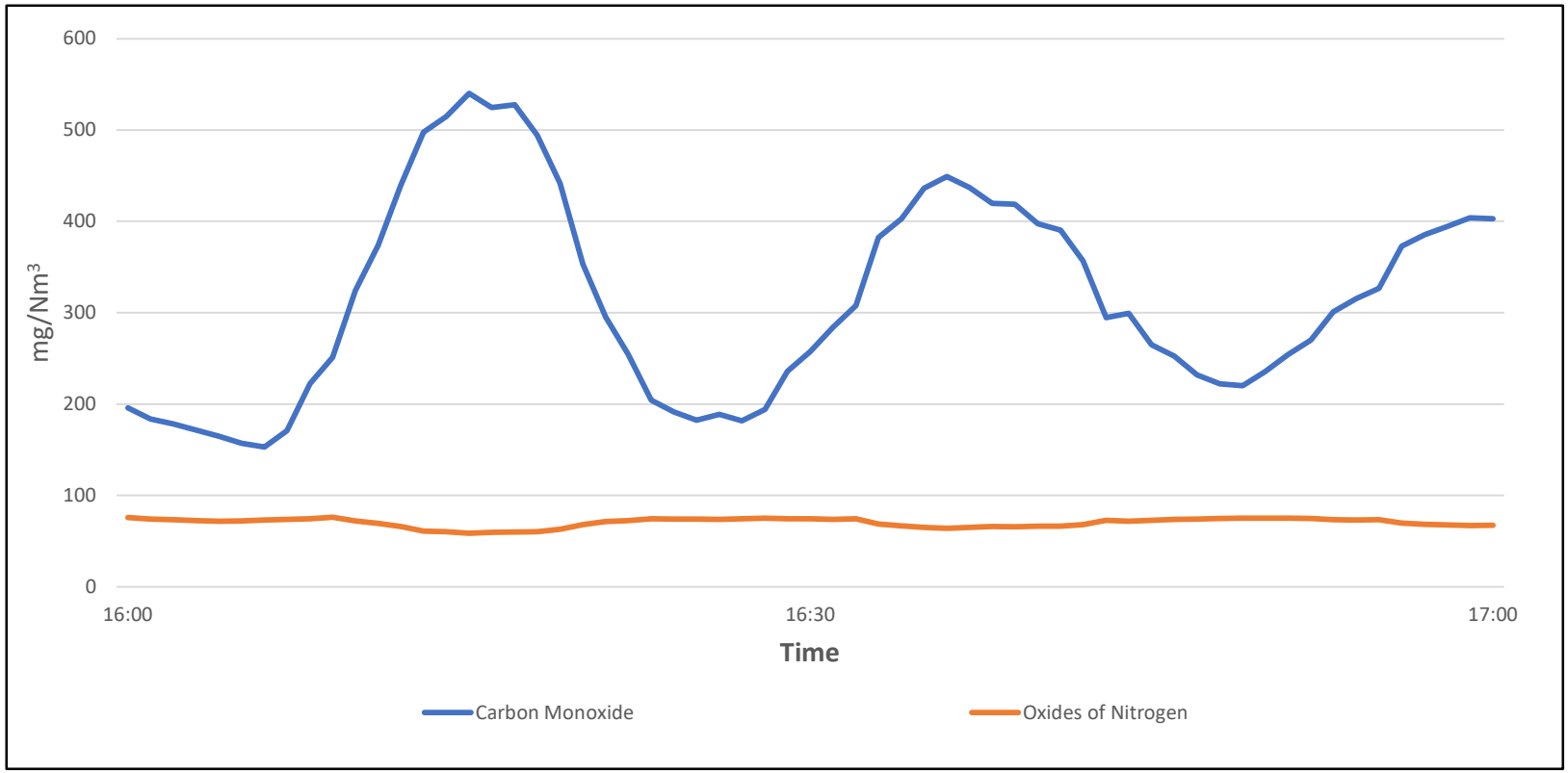
Reference Conditions - 273.15K, 101.3 kPa on a dry gas basis



South Hook LNG - SCV 1E

Gaseous Emissions Graphical Data for Carbon Monoxide, and Oxides of Nitrogen

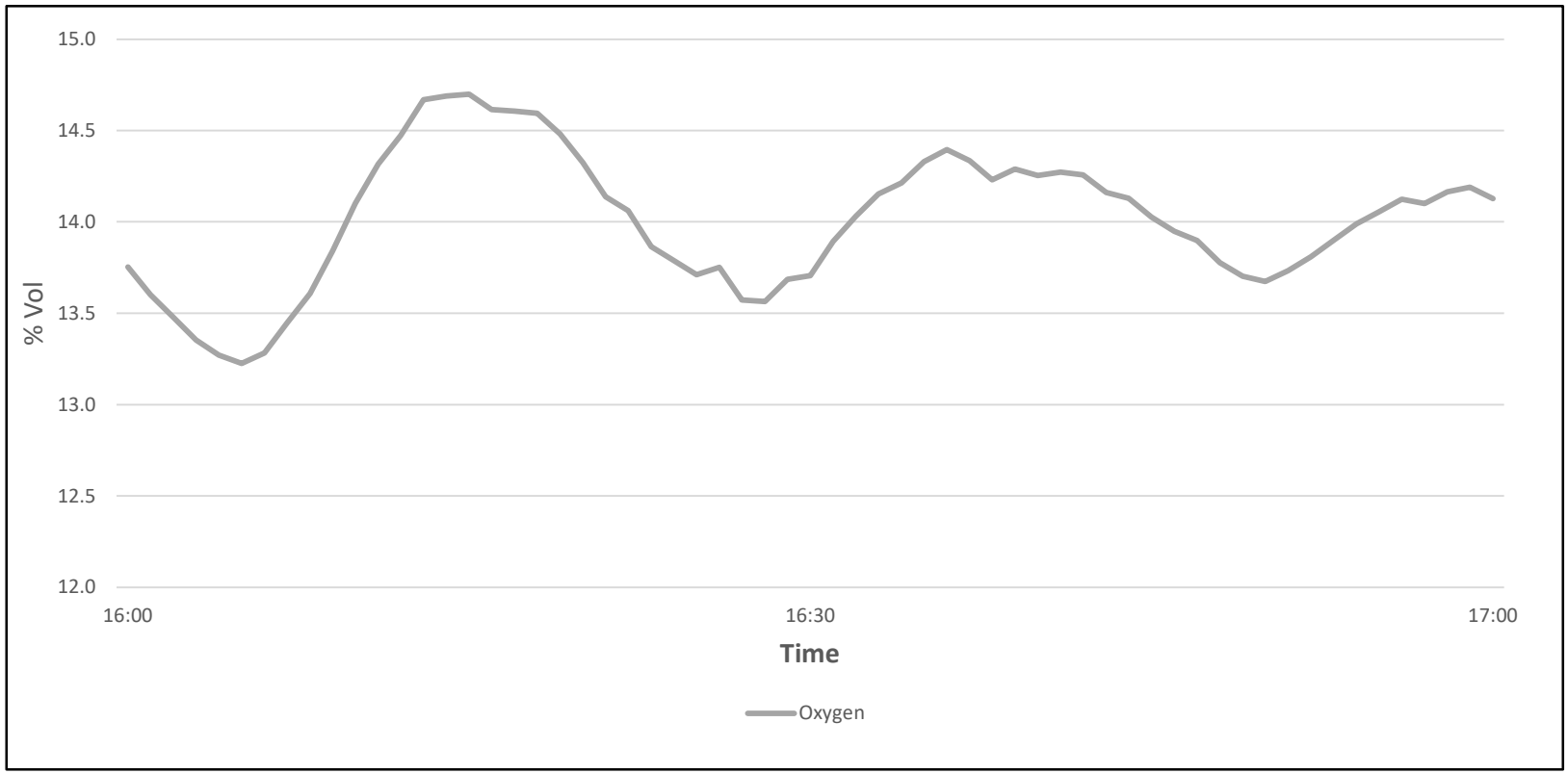
Reference Conditions - 273.15K, 101.3 kPa, 3% Oxygen on a dry gas basis



South Hook LNG - SCV 1E

Gaseous Emissions Graphical Data for Oxygen

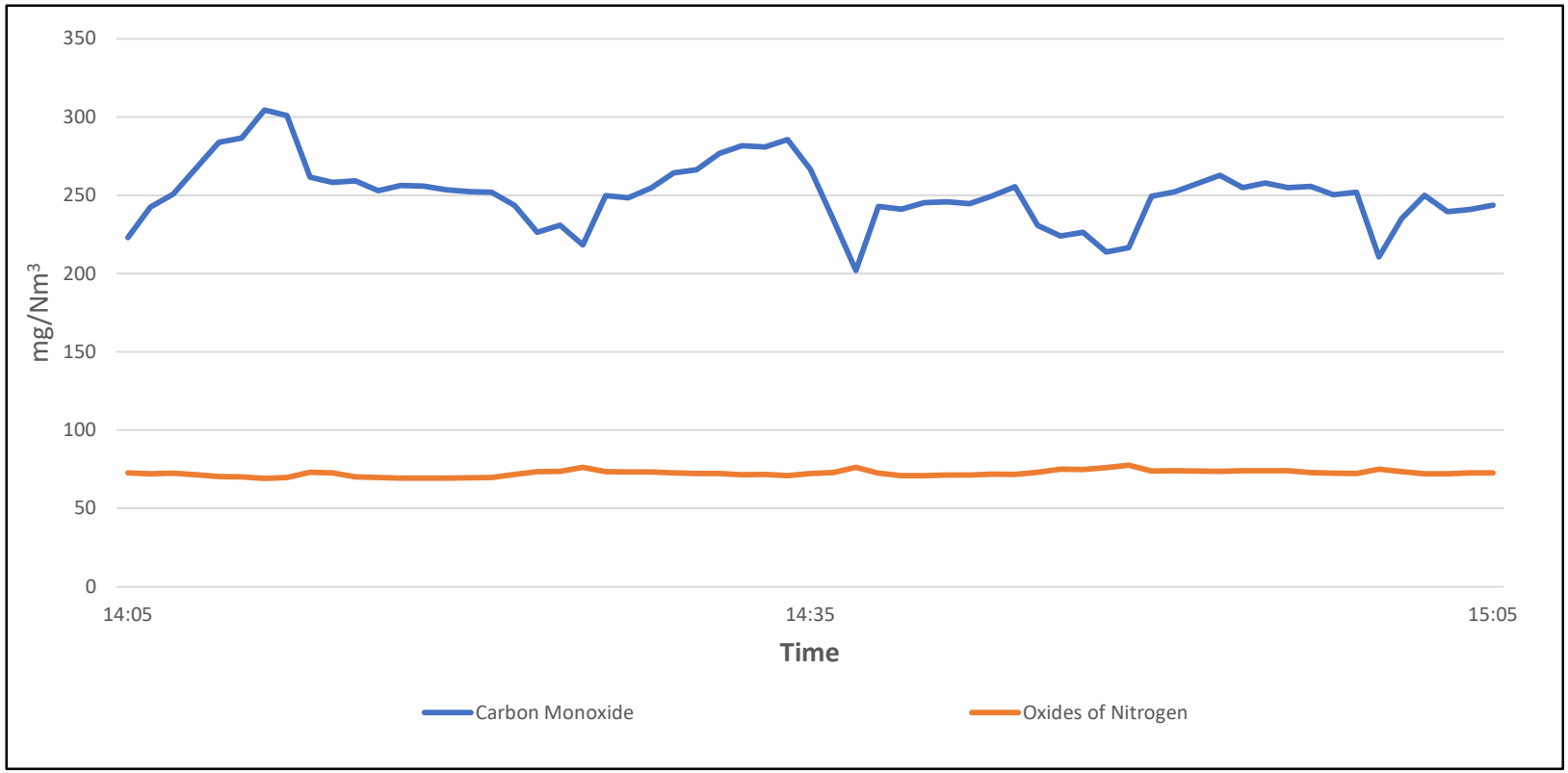
Reference Conditions - 273.15K, 101.3 kPa on a dry gas basis



South Hook LNG - SCV 1F

Gaseous Emissions Graphical Data for Carbon Monoxide, and Oxides of Nitrogen

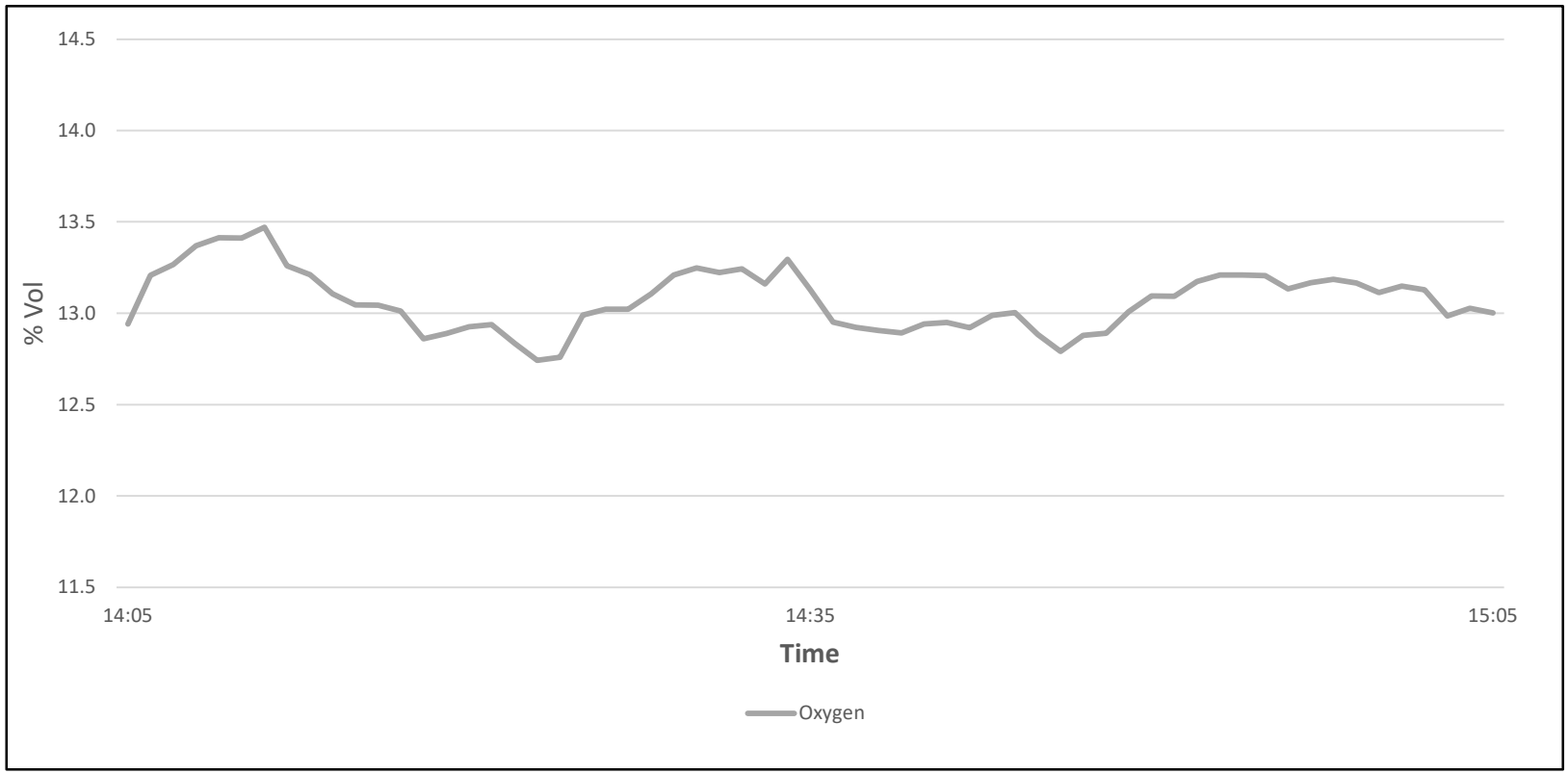
Reference Conditions - 273.15K, 101.3 kPa, 3% Oxygen on a dry gas basis



South Hook LNG - SCV 1F

Gaseous Emissions Graphical Data for Oxygen

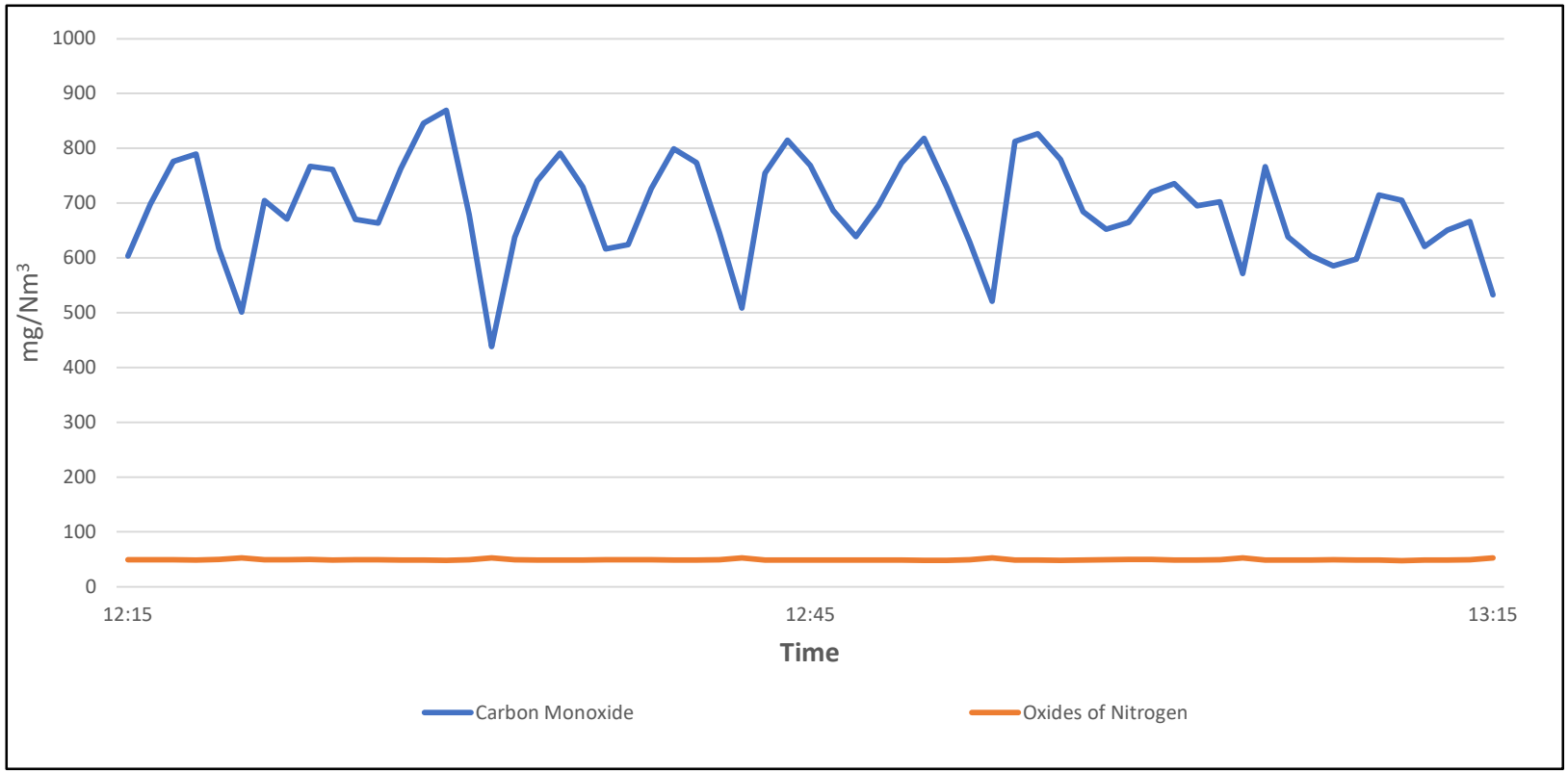
Reference Conditions - 273.15K, 101.3 kPa on a dry gas basis



South Hook LNG - SCV 1G

Gaseous Emissions Graphical Data for Carbon Monoxide, and Oxides of Nitrogen

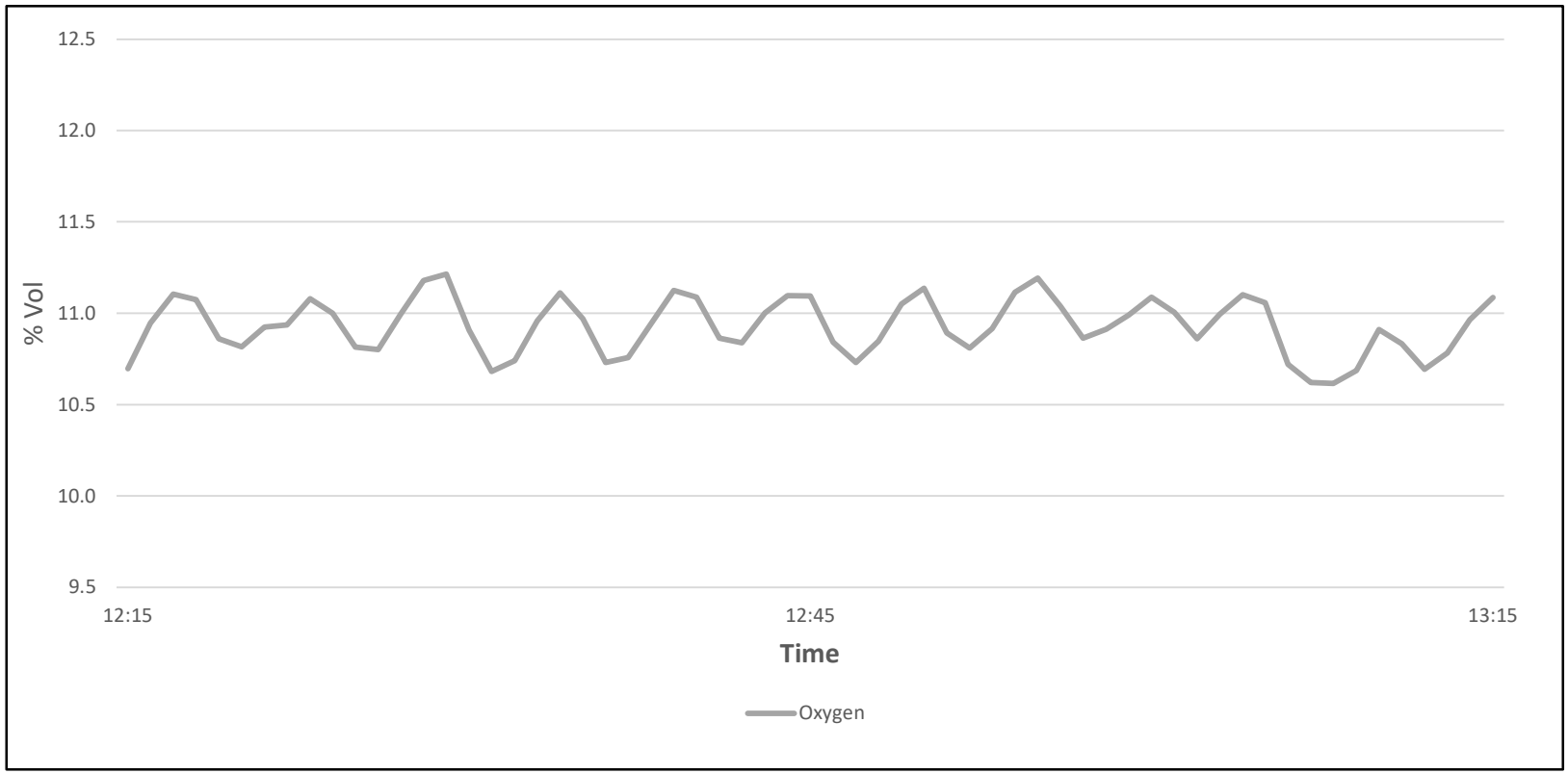
Reference Conditions - 273.15K, 101.3 kPa, 3% Oxygen on a dry gas basis



South Hook LNG - SCV 1G

Gaseous Emissions Graphical Data for Oxygen

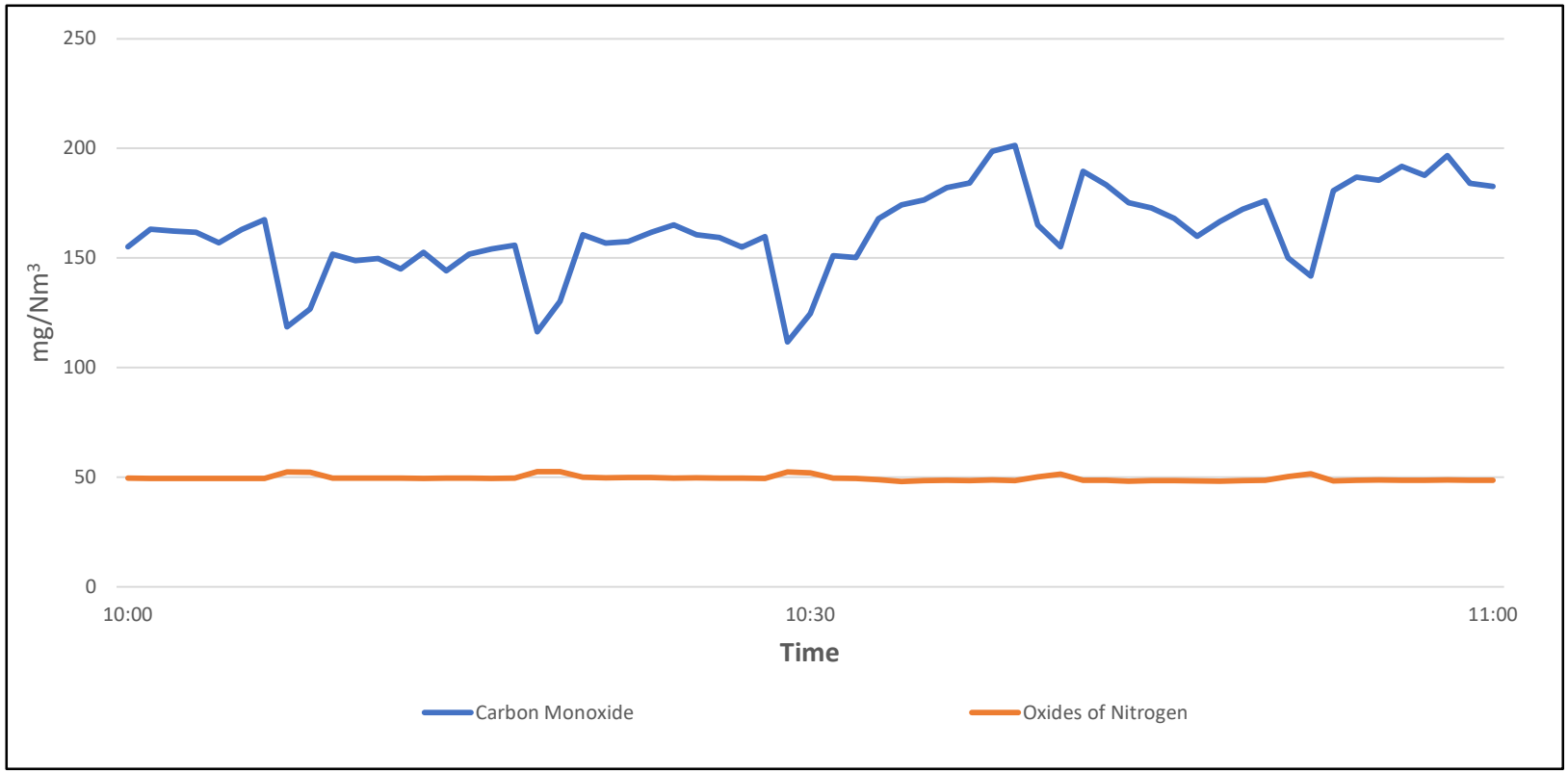
Reference Conditions - 273.15K, 101.3 kPa on a dry gas basis



South Hook LNG - SCV 1H

Gaseous Emissions Graphical Data for Carbon Monoxide, and Oxides of Nitrogen

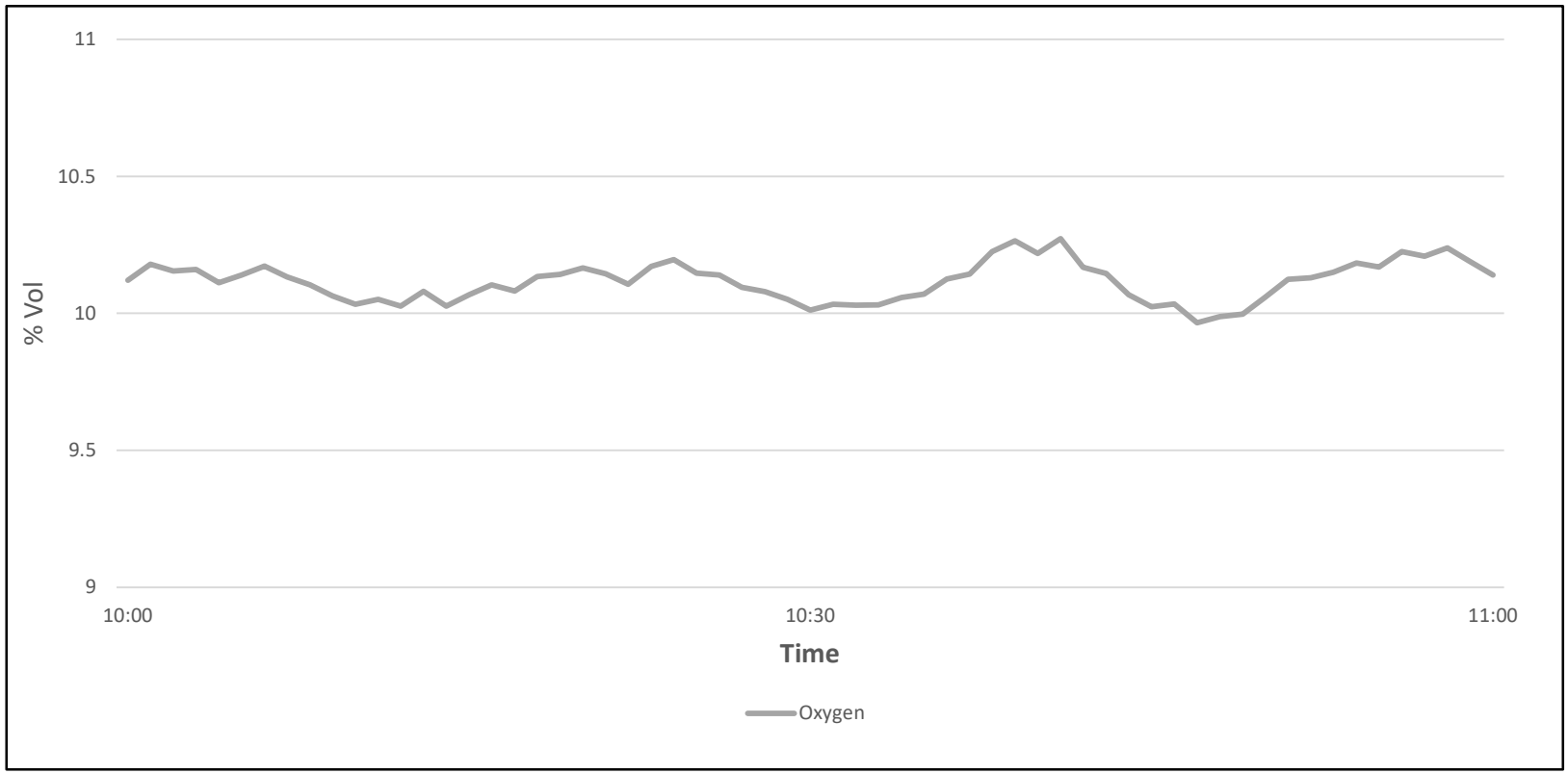
Reference Conditions - 273.15K, 101.3 kPa, 3% Oxygen on a dry gas basis



South Hook LNG - SCV 1H

Gaseous Emissions Graphical Data for Oxygen

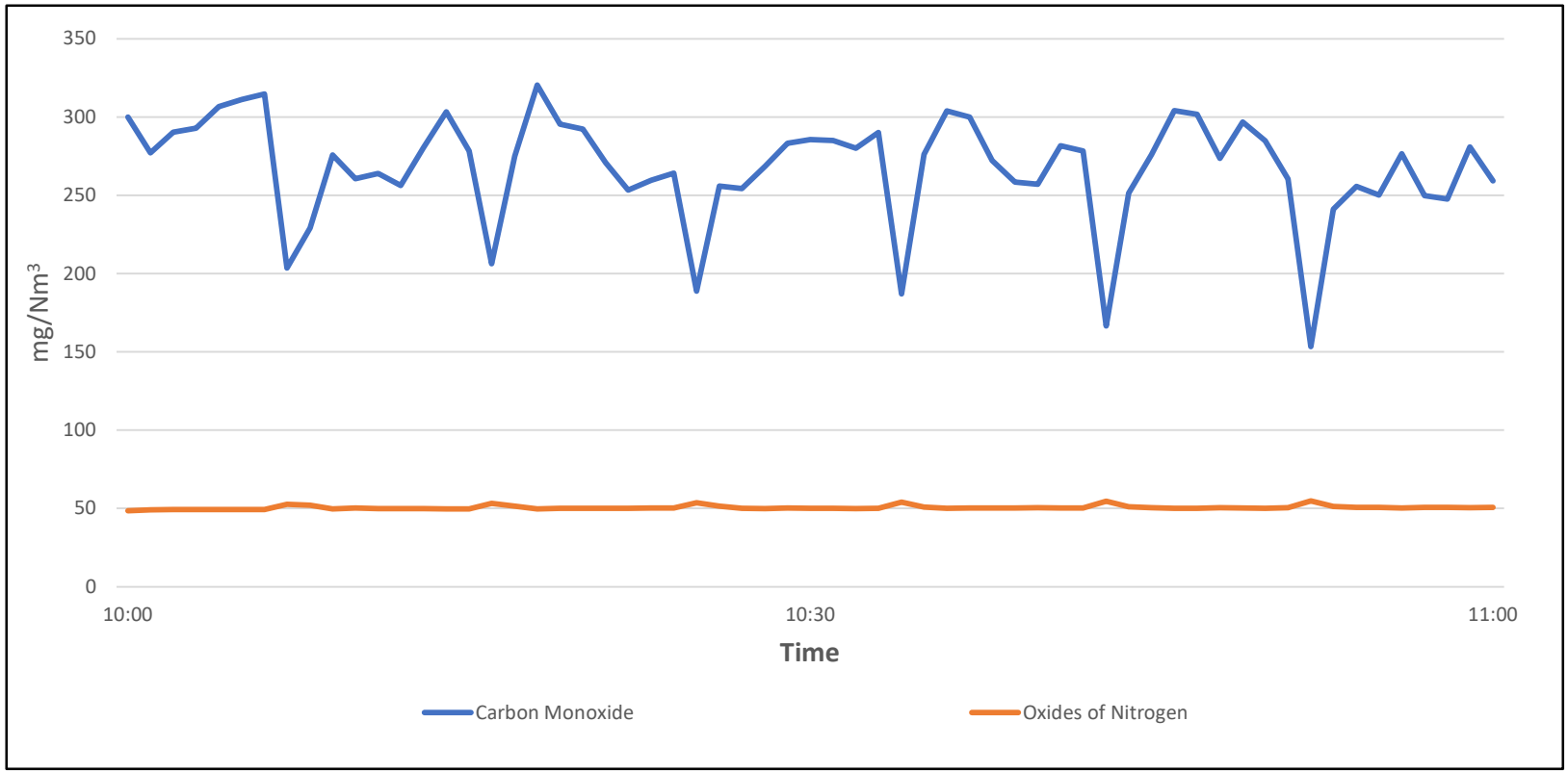
Reference Conditions - 273.15K, 101.3 kPa on a dry gas basis



South Hook LNG - SCV 2A

Gaseous Emissions Graphical Data for Carbon Monoxide, and Oxides of Nitrogen

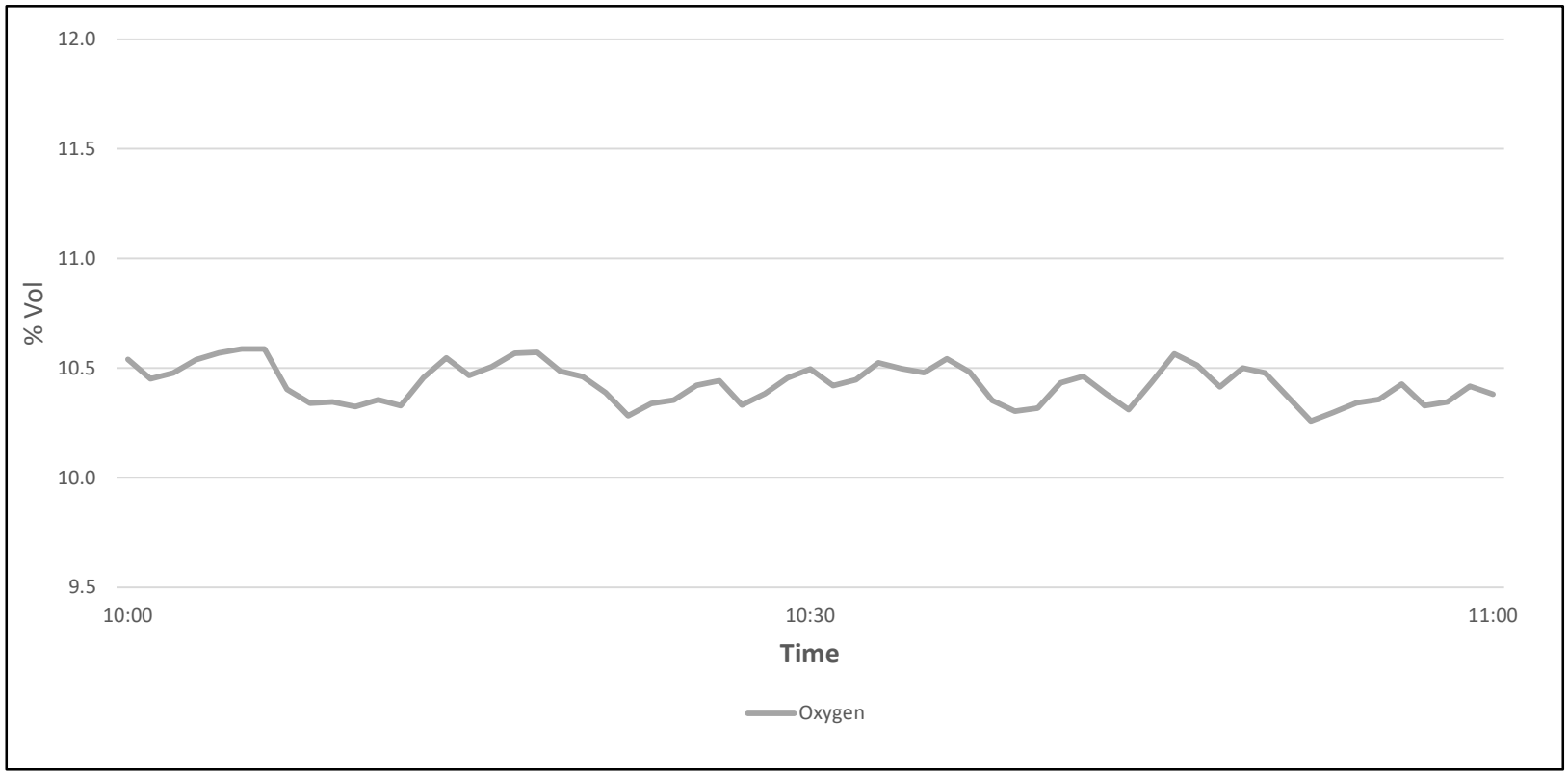
Reference Conditions - 273.15K, 101.3 kPa, 3% Oxygen on a dry gas basis



South Hook LNG - SCV 2A

Gaseous Emissions Graphical Data for Oxygen

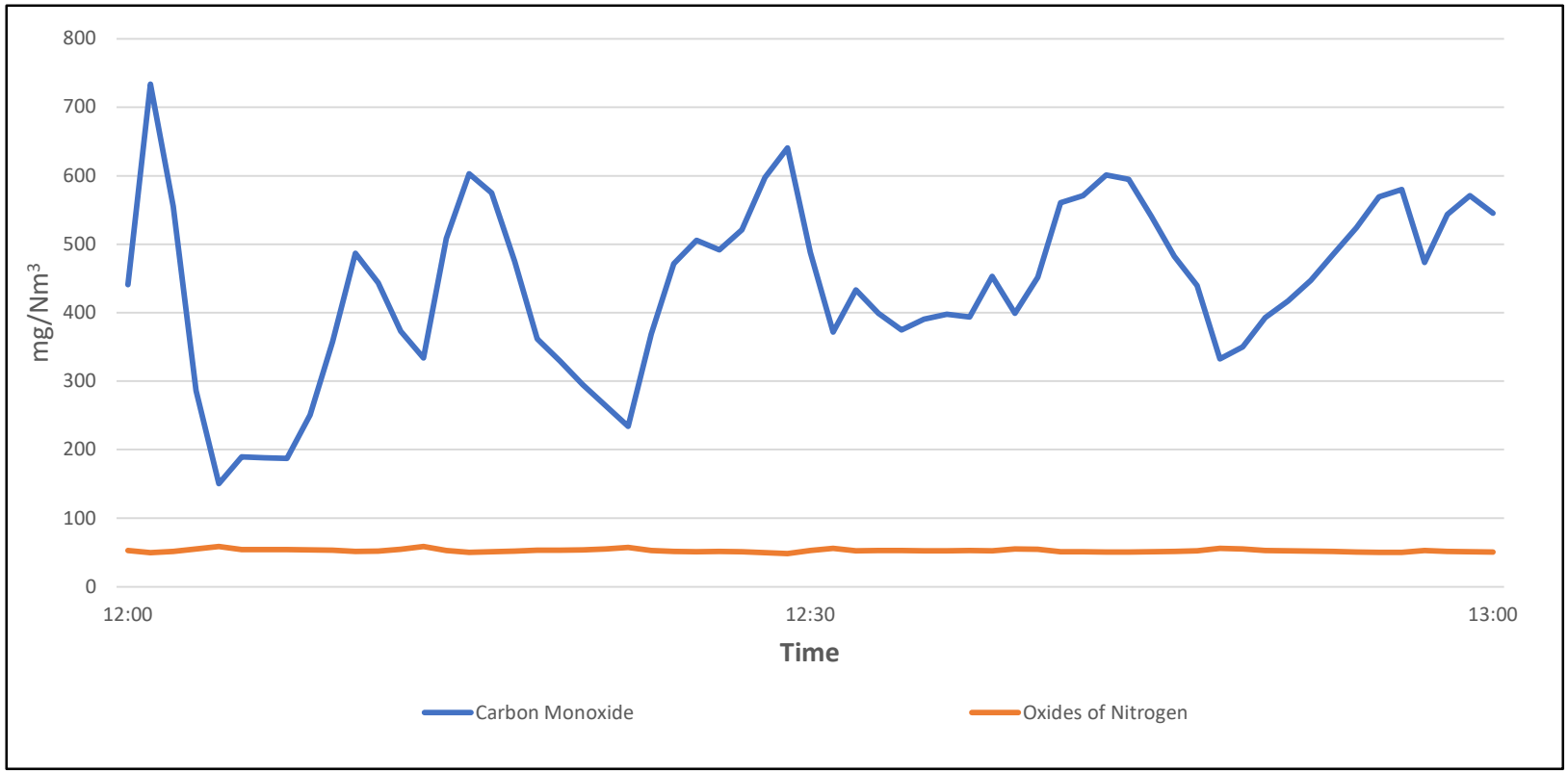
Reference Conditions - 273.15K, 101.3 kPa on a dry gas basis



South Hook LNG - SCV 2D

Gaseous Emissions Graphical Data for Carbon Monoxide, and Oxides of Nitrogen

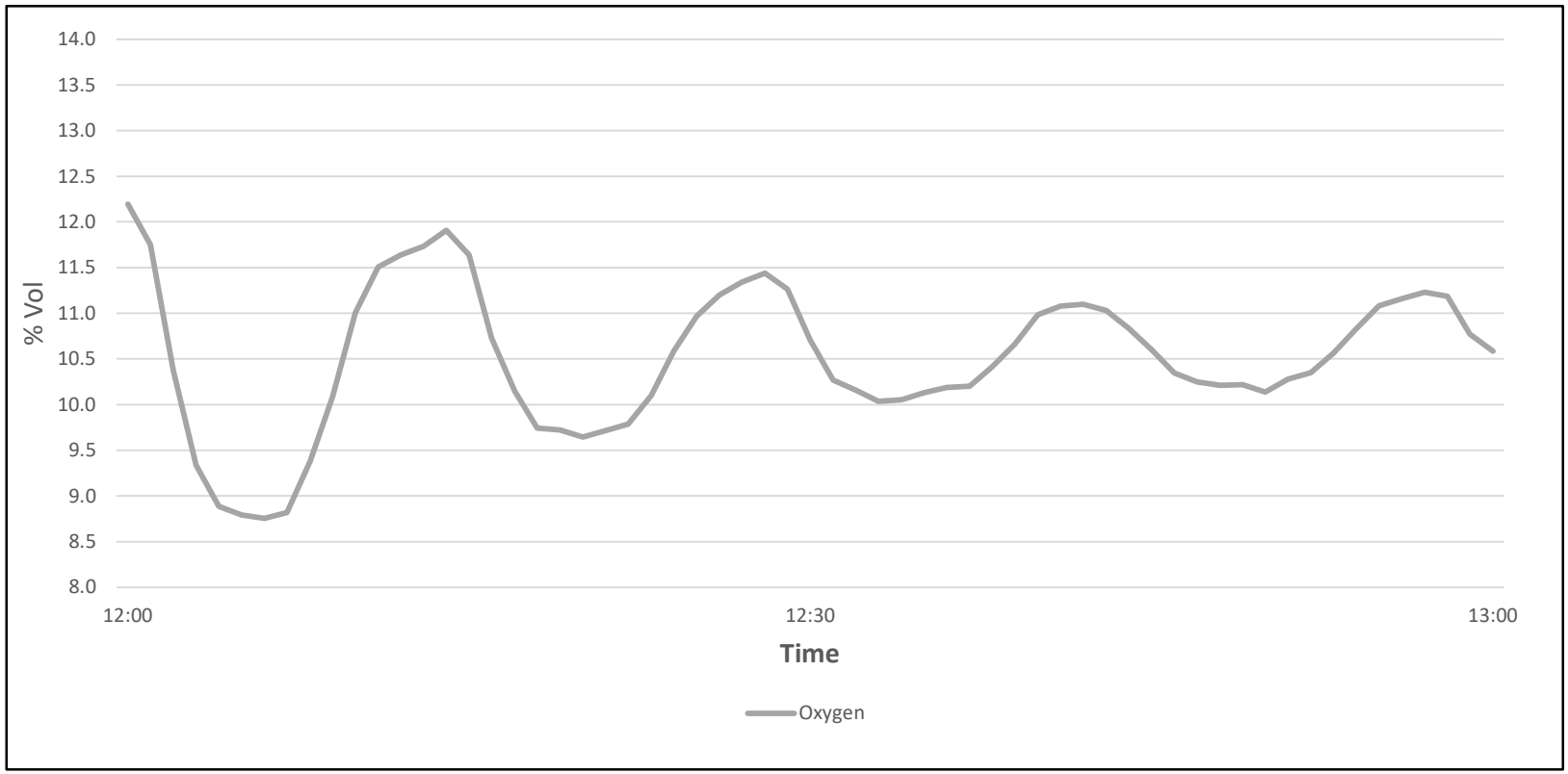
Reference Conditions - 273.15K, 101.3 kPa, 3% Oxygen on a dry gas basis



South Hook LNG - SCV 2D

Gaseous Emissions Graphical Data for Oxygen

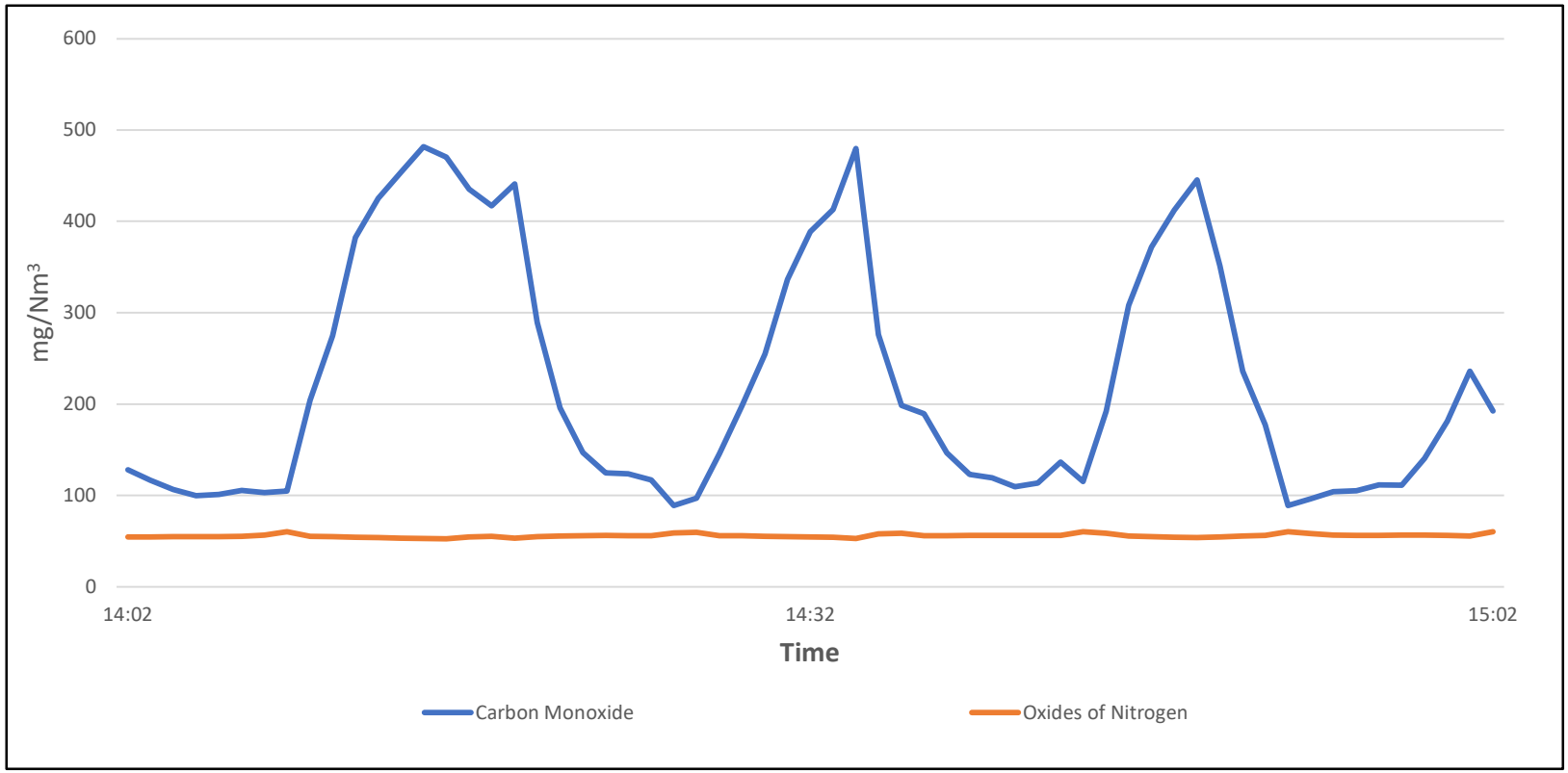
Reference Conditions - 273.15K, 101.3 kPa on a dry gas basis



South Hook LNG - SCV 2E

Gaseous Emissions Graphical Data for Carbon Monoxide, and Oxides of Nitrogen

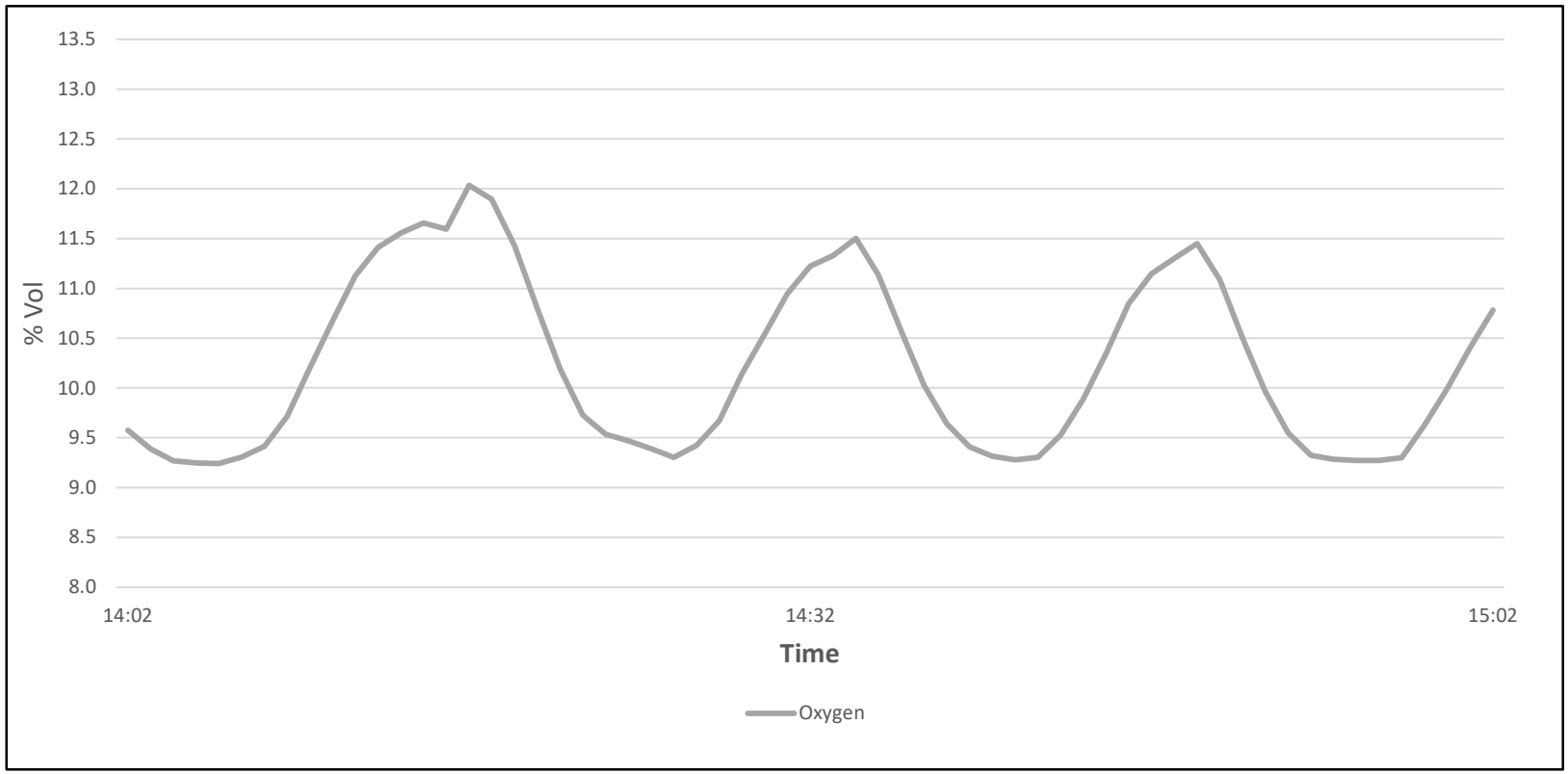
Reference Conditions - 273.15K, 101.3 kPa, 3% Oxygen on a dry gas basis



South Hook LNG - SCV 2E

Gaseous Emissions Graphical Data for Oxygen

Reference Conditions - 273.15K, 101.3 kPa on a dry gas basis



2.2.5 - Gas Calibration Log

GAS CALIBRATION RECORD

Client:		Intertek Ltd	Job Reference:	INTK52FEB21	Calibration By:	M Ellison	Comments:			
Site:		South Hook LNG	Date:	02/03/2021	MCERTs ID:	MM05-682				
Stack:		SCV 1A-C-D	Leak Check Method:	Flow Method	Test Team :	MRE/JG				
Species		**Carbon Monoxide**	**Oxides of Nitrogen**	**Oxygen**	**Carbon Dioxide**					
Analyser Type/ID		Horiba PG250 AS0246	Horiba PG250 AS0246	Horiba PG250 AS0246	Horiba PG250 AS0246					
Gas Cylinder ID		183642SG	183642SG	253223SG	253223SG					
Gas Cylinder Concentration		154.9 ppm	79.4 ppm	15.3 % Vol	15.24 % Vol					
Concentration Uncertainty		1 %	1 %	1 %	1 %					
Span Value		154.9 ppm	79.4 ppm	15.3 % Vol	15.24 % Vol					
Analyser Range 0 -		200 ppm	100 ppm	25 % Vol	20 % Vol					
ANALYSER ADJUSTMENT										
Check Zero	Time	11:36	11:36	11:36	11:36					
	Reading	-0.3 ppm	0 ppm	0 % Vol	0 % Vol					
	Gain	0	3	6	-1					
Adjust Zero	Time	11:37	11:37	11:37	11:37					
	Reading	0 ppm	0 ppm	0 % Vol	0 % Vol					
	Gain	0	3	6	-1					
Check Span	Time	11:51	11:51	11:44	11:44					
	Reading	151.2 ppm	83.8 ppm	14.96 % Vol	15.71 % Vol					
	Gain	1.51	0.966	1.042	0.978					
Adjust Span	Time	11:52	11:52	11:45	11:45					
	Reading	154.9 ppm	79.4 ppm	15.3 % Vol	15.24 % Vol					
	Gain	1.545	0.915	1.065	0.965					
Check Zero	Time	11:55	11:55	11:55	11:55					
	Reading	-0.1 ppm	0.1 ppm	-0.06 % Vol	0.01 % Vol					
Zero Drift		0.10 ppm	0.10 ppm	0.06 % Vol	0.01 % Vol					
Acceptance		**Accept <2% Range**	**Accept <2% Range**	**Accept <2% Range**	**Accept <2% Range**					
SAMPLING SYSTEM CHECK - FLOW METHOD		**Carbon Monoxide**	**Oxides of Nitrogen**	**Oxygen**	**Carbon Dioxide**					
Expected Flow		0.4 l/min	0.4 l/min	0.4 l/min	0.4 l/min					
Time		11:58	11:58	11:58	11:58					
Reading		0	0	0	0					
PASS/FAIL		**PASS**	**PASS**	**PASS**	**PASS**					
SAMPLING SYSTEM CHECK - CYLINDER METHOD										
Span Value										
Check Zero	Time									
	Reading									
	PASS/FAIL									
Check Span	Time									
	Reading									
	PASS/FAIL									
POST TEST DRIFT CHECK		**Carbon Monoxide**	**Oxides of Nitrogen**	**Oxygen**	**Carbon Dioxide**					
Span Value		154.9 ppm	79.4 ppm	15.3 % Vol	15.24 % Vol					
Check Zero	Time	16:18	16:18	16:18	16:18					
	Reading	0.4 ppm	0 ppm	0.02 % Vol	0.04 % Vol					
	Drift (%)	**0.3**	**0.0**	**0.1**	**0.3**					
	Acceptance	**Accept**	**Accept**	**Accept**	**Accept**					
Check Span	Time	16:24	16:24	16:30	16:30					
	Reading	151.9 ppm	76 ppm	15.16 % Vol	14.87 % Vol					
	Drift (%)	**1.9**	**4.3**	**0.9**	**2.4**					
	Acceptance	**Accept**	**Drift Correct**	**Accept**	**Drift Correct**					

GAS CALIBRATION RECORD

Client:		Intertek Ltd	Job Reference:	INTK52FEB21	Calibration By:	M Ellison	Comments:			
Site:		South Hook LNG	Date:	03/03/2021	MCERTs ID:	MM05-682				
Stack:		SCV 1E-F-G-H	Leak Check Method:	Flow Method	Test Team :	MRE/JG				
Species		**Carbon Monoxide**	**Oxides of Nitrogen**	**Oxygen**	**Carbon Dioxide**					
Analyser Type/ID		Horiba PG250 AS0246	Horiba PG250 AS0246	Horiba PG250 AS0246	Horiba PG250 AS0246					
Gas Cylinder ID		183642SG	183642SG	253223SG	253223SG					
Gas Cylinder Concentration		154.9 ppm	79.4 ppm	15.3 % Vol	15.24 % Vol					
Concentration Uncertainty		1 %	1 %	1 %	1 %					
Span Value		154.9 ppm	79.4 ppm	15.3 % Vol	15.24 % Vol					
Analyser Range 0 -		200 ppm	100 ppm	25 % Vol	20 % Vol					
ANALYSER ADJUSTMENT										
Check Zero	Time	09:41	09:41	09:41	09:41					
	Reading	0 ppm	0 ppm	-0.02 % Vol	0.01 % Vol					
	Gain	0	3	6	-1					
Adjust Zero	Time	09:42	09:42	09:42	09:42					
	Reading	0 ppm	0 ppm	0 % Vol	0 % Vol					
	Gain	0	3	6	0					
Check Span	Time	09:50	09:50	09:46	09:46					
	Reading	152.4 ppm	77.8 ppm	15.18 % Vol	15.24 % Vol					
	Gain	1.545	0.915	1.065	0.965					
Adjust Span	Time	09:51	09:51	09:47	09:47					
	Reading	154.9 ppm	79.4 ppm	15.3 % Vol	15.24 % Vol					
	Gain	1.57	0.933	1.073	0.965					
Check Zero	Time	09:53	09:53	09:53	09:53					
	Reading	0.9 ppm	0.4 ppm	-0.02 % Vol	0.02 % Vol					
Zero Drift		0.90 ppm	0.40 ppm	0.02 % Vol	0.02 % Vol					
Acceptance		**Accept <2% Range**	**Accept <2% Range**	**Accept <2% Range**	**Accept <2% Range**					
SAMPLING SYSTEM CHECK - FLOW METHOD		**Carbon Monoxide**	**Oxides of Nitrogen**	**Oxygen**	**Carbon Dioxide**					
Expected Flow		0.4 l/min	0.4 l/min	0.4 l/min	0.4 l/min					
Time		09:55	09:55	09:55	09:55					
Reading		0	0	0	0					
PASS/FAIL		**PASS**	**PASS**	**PASS**	**PASS**					
SAMPLING SYSTEM CHECK - CYLINDER METHOD										
Span Value										
Check Zero	Time									
	Reading									
	PASS/FAIL									
Check Span	Time									
	Reading									
	PASS/FAIL									
POST TEST DRIFT CHECK		**Carbon Monoxide**	**Oxides of Nitrogen**	**Oxygen**	**Carbon Dioxide**					
Span Value		154.9 ppm	79.4 ppm	15.3 % Vol	15.24 % Vol					
Check Zero	Time	17:06	17:06	17:06	17:06					
	Reading	-0.2 ppm	0 ppm	-0.01 % Vol	0.01 % Vol					
	Drift (%)	**0.1**	**0.0**	**0.1**	**0.1**					
	Acceptance	**Accept**	**Accept**	**Accept**	**Accept**					
Check Span	Time	17:12	17:12	17:16	17:16					
	Reading	152.7 ppm	77.5 ppm	15.27 % Vol	14.7 % Vol					
	Drift (%)	**1.4**	**2.4**	**0.2**	**3.5**					
	Acceptance	**Accept**	**Drift Correct**	**Accept**	**Drift Correct**					

GAS CALIBRATION RECORD

Client:		Intertek Ltd	Job Reference:	INTK52FEB21	Calibration By:	M Ellison	Comments:			
Site:		South Hook LNG	Date:	04/03/2021	MCERTs ID:	MM05-682				
Stack:		SCV 2A-D-E	Leak Check Method:	Flow Method	Test Team :	MRE/JG				
Species		**Carbon Monoxide**	**Oxides of Nitrogen**	**Oxygen**	**Carbon Dioxide**					
Analyser Type/ID		Horiba PG250 AS0246	Horiba PG250 AS0246	Horiba PG250 AS0246	Horiba PG250 AS0246					
Gas Cylinder ID		183642SG	183642SG	253223SG	253223SG					
Gas Cylinder Concentration		154.9 ppm	79.4 ppm	15.3 % Vol	15.24 % Vol					
Concentration Uncertainty		1 %	1 %	1 %	1 %					
Span Value		154.9 ppm	79.4 ppm	15.3 % Vol	15.24 % Vol					
Analyser Range 0 -		200 ppm	100 ppm	25 % Vol	20 % Vol					
ANALYSER ADJUSTMENT										
Check Zero	Time	09:35	09:35	09:35	09:35					
	Reading	0 ppm	-0.1 ppm	-0.05 % Vol	0 % Vol					
	Gain	0	3	6	0					
Adjust Zero	Time	09:37	09:37	09:37	09:37					
	Reading	0 ppm	0 ppm	0 % Vol	0 % Vol					
	Gain	0	3	0	5					
Check Span	Time	09:44	09:44	09:50	09:50					
	Reading	157.4 ppm	78.8 ppm	15.39 % Vol	15.21 % Vol					
	Gain	1.57	0.933	1.073	0.965					
Adjust Span	Time	09:45	09:45	09:51	09:51					
	Reading	154.9 ppm	79.4 ppm	15.3 % Vol	15.24 % Vol					
	Gain	1.545	0.94	1.065	0.965					
Check Zero	Time	09:55	09:55	09:55	09:55					
	Reading	-0.1 ppm	0.1 ppm	0.04 % Vol	0.04 % Vol					
Zero Drift		0.10 ppm	0.10 ppm	0.04 % Vol	0.04 % Vol					
Acceptance		**Accept <2% Range**	**Accept <2% Range**	**Accept <2% Range**	**Accept <2% Range**					
SAMPLING SYSTEM CHECK - FLOW METHOD		**Carbon Monoxide**	**Oxides of Nitrogen**	**Oxygen**	**Carbon Dioxide**					
Expected Flow		0.4 l/min	0.4 l/min	0.4 l/min	0.4 l/min					
Time		09:57	09:57	09:57	09:57					
Reading		0	0	0	0					
PASS/FAIL		**PASS**	**PASS**	**PASS**	**PASS**					
SAMPLING SYSTEM CHECK - CYLINDER METHOD										
Span Value										
Check Zero	Time									
	Reading									
	PASS/FAIL									
Check Span	Time									
	Reading									
	PASS/FAIL									
POST TEST DRIFT CHECK		**Carbon Monoxide**	**Oxides of Nitrogen**	**Oxygen**	**Carbon Dioxide**					
Span Value		154.9 ppm	79.4 ppm	15.3 % Vol	15.24 % Vol					
Check Zero	Time	15:10	15:10	15:10	15:10					
	Reading	0.1 ppm	-0.4 ppm	0.04 % Vol	0 % Vol					
	Drift (%)	**0.1**	**0.5**	**0.3**	**0.0**					
	Acceptance	**Accept**	**Accept**	**Accept**	**Accept**					
Check Span	Time	15:15	15:15	15:20	15:20					
	Reading	147.9 ppm	77.7 ppm	15.22 % Vol	14.62 % Vol					
	Drift (%)	**4.5**	**2.1**	**0.5**	**4.1**					
	Acceptance	**Drift Correct**	**Drift Correct**	**Accept**	**Drift Correct**					

2.2.6 - Uncertainty Calculations

SCV 1A Uncertainty Calculations

Uncertainty calculation for gaseous measurement of O2 according to BS EN 14789:2017 - Horiba PG250 AS0246

v1.0 May-20

		Cal gas conc	15.30	**% vol**
Measured concentration	9.95	**% vol**	**Full Scale**	25.00	**% vol**

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% range		≤0.2 % vol
Standard deviation of repeatability at span level	0.0	% range		≤0.2 % vol
Deviation from linearity(lack of fit)	0.7	% range		≤0.3 % vol
Zero drift	0.1	% of span value		≤±5% span value
Span drift	0.9	% of span value		≤±5% span value
Influence of sample gas flow	0.2	% vol/10l/h		≤0.2 % vol
Influence of atmospheric pressure	0.2	% vol/3kPa		≤0.2 % vol
Influence of ambient temperature	-0.1	% vol/20K		≤0.5 % vol
Cross sensitivity	0.6	% vol		≤0.4 % vol
Influence of voltage	0.0	% vol/10V		≤0.2 % vol
Influence from vibration	0.0	% vol		≤0.2 % vol
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges			
	min	max	value at calib	
flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**				**% vol**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.00
Lack of fit			u_{fit}				0.10
Zero drift			u_{0dr}				0.01
Span drift			u_{sdr}				0.08
Influence of sample gas flow			u_{spres}				0.001
Influence of atmospheric pressure			u_{apres}				0.014
Influence of ambient temperature			u_{temp}				-0.014
Cross sensitivity			u_{interf}				0.32
Influence of voltage			u_{volt}				0.000
Influence from vibration			u_{vib}				0.00
Uncertainty of calibration gas			u_{cal}				0.05

Measurement uncertainty				
Combined uncertainty			0.35	% vol
Expanded uncertainty	k =	2	0.71	% vol
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.71**	**% vol**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**7.09**	**% value**

Uncertainty calculation for gaseous measurement of CO according to BS EN 15058:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	N/A	mg/m^3 (Corrected)	**Cal gas conc.**	193.69	mg.m^{-3}
Measured concentration	73.06	mg/m3 (101.3kPa, 273K)	**Range**	250.09	mg/m^3
Measured concentration	119.05	mg/m^3 (Corrected)			

Gas	CO	
Full Scale	200.0	ppm
Cal gas conc	154.9	ppm
Conversion	1.25	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	9.95	0.0	101.3	273.0
	Uncert	0.71	0.0	0.0	0.0
Factors		1.63	1.00	1.00	1.00
Uncertainty in factor		0.10	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.63**	uf	**0.10**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.1	% of range		≤±1% range
Standard deviation of repeatability at span level	0.2	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	1.6	% of range		≤±2 % range
Zero drift	0.3	% of span value		≤±5% span value
Span drift	1.9	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.1	% full scale/20K		≤±5% range
Cross sensitivity	2.9	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.3	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.41
Standard deviation of reproducibility			u_{rp}				0.00
Lack of fit			u_{flt}				2.32
Zero drift			u_{0dr}				0.29
Span drift			u_{sdr}				2.17
Influence of sample gas flow			u_{spres}				0.03
Influence of atmospheric pressure			u_{apres}				0.35
Influence of ambient temperature			u_{temp}				0.03
Cross sensitivity			u_{interf}				4.19
Influence of voltage			u_{volt}				0.00
Influence from vibration			u_{vib}				0.00
Uncertainty of calibration gas			u_{cal}				0.37
Uncertainty in std conditions correction factor (no O_2 factor)			u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)			u_{of}				7.61

Measurement uncertainty				
Combined uncertainty			5.30	mg/m^3
Expanded uncertainty	k =	2	10.61	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			10.61	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**23.03**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**23.03**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**19.34**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**N/A**	**% ELV**

Uncertainty calculation for gaseous measurement of NOx according to BS EN 14792:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	107	mg/m^3 (Corrected)	**Cal gas conc.**	163.1	mg.m^{-3}
Measured concentration	35.55	mg/m3 (101.3kPa, 273K)	**Range**	205.4	mg/m^3
Measured concentration	57.92	mg/m^3 (Corrected)			
NO/NO2 ratio	99		**Gas**	NOx	
			Full Scale	100	ppm
			Cal gas conc	79.4	ppm
			Conversion	2.05	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	9.95	0.0	101.3	273.0
	Uncert	0.71	0.0	0.0	0.0
Factors		1.63	1.00	1.00	1.00
Uncertainty in factor		0.10	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.63**	uf	**0.10**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% of range		≤±1% range
Standard deviation of repeatability at span level	0.3	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	-1.6	% of range		≤±2 % range
Zero drift	0.0	% of span value		≤±5% span value
Span drift	0.0	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.2	% full scale/20K		≤±5% range
Cross sensitivity	0.7	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Converter efficiency	95.4	%		≥95%
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.62
Standard deviation of reproducibility			u_{rp}				0.00
Lack of fit			u_{fit}				-1.84
Zero drift			u_{0dr}				0.00
Span drift			u_{sdr}				0.00
Influence of sample gas flow			u_{spres}				0.02
Influence of atmospheric pressure			u_{apres}				0.28
Influence of ambient temperature			u_{temp}				0.07
Cross sensitivity			u_{interf}				0.83
Influence of voltage			u_{volt}				0.00
Influence from vibration			u_{vib}				0.00
Converter efficiency			u_{conv}				0.93
Uncertainty of calibration gas			u_{cal}				0.18
Uncertainty in std conditions correction factor (no O_2 factor)			u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)			u_{of}				3.70

Measurement uncertainty				
Combined uncertainty			2.33	mg/m^3
Expanded uncertainty	k =	2	4.67	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			4.67	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**10.61**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**10.61**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**18.32**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**4.36**	**% ELV**

Uncertainty calculation for Velocity and Volume Flow Rate Measurement by Pitot tube EN ISO 16911-1

v1.3 Jan-16

Enter data in orange cells only

Constants

Gas constant	8.314	J/(K.mol)
Velocity meas. during calibration	3.086	m/s
Air density meas. during calibration	1.213	kg/m^3
DP meas. during calibration	8.05	Pa
Uncertainty of velocity meas. at calibration	2.1	%
Uncertainty of air density meas. at calibration	0.075	%
Uncertainty of DP meas. at calibration	3.88	%
Pitot coefficient, K	0.833	-
Expanded uncertainty (95%, k=2) as % of value	8.8	%
Expanded uncertainty (95%, k=2)	0.07	

Characteristics of pressure sensor used for Delta P		
Enter uncertainties as (95%,k=2) where relevant		
Repeatability of Delta P transducer	1	% of value
Range of Delta P transducer	2451	Pa
Resolution of Delta P transducer	1.96	Pa
Drift of Delta P transducer	0.1	% of range between calibrations
Lack of fit of measurement system	0.1	% of range
Unertainty in Delta P transducer	10.0	Pa
Enter uncertainties as (95%,k=2) where relevant		
Uncertainty in temperature readout system	1	°C
Uncertainty in atmospheric pressure transducer	170	Pa
Uncertainty in duct area measurement	0.8	%

Uncertainty in stack gas composition		
Enter uncertainties as (95%,k=2) where relevant		
Water vapour measurement	20	% relative
CO content measurement	6	% relative
CO_2 content measurement	10	% relative
O_2 content measurement	6	% relative

Duct dimensions	Circular		Rectangular	
Diameter	1.48	m	a	m
Area	1.7	m2	b	m
			Area	0.0 m2

All Pressures should be entered in Pascals, Pa

Measurement Point	Atmospheric Pressure, Pa	Stack Pressure, Pa	Static Pressure, Pa	meas1, Pa	meas2, Pa	meas3, Pa	meas4, Pa	meas5, Pa	Delta P, Pa	Stack Temperature, C	Water Vapour Content, %	Dry gas basis: CO, ppm	Dry gas basis: CO_2, %	Dry gas basis: N_2, %	Dry gas basis: O_2, %	dry molecular wt, g/mol	stack molecular wt, g/mol
1	103010	103255.25	245.25	44.1	44.1	44.1			44.1	13.3	1.49	60	6.2	83.9	9.9	29.39	29.22
2	103010	103255.25	245.25	54.9	54.9	54.9			54.9	13.4	1.49	60	6.2	83.9	9.9	29.39	29.22
3	103010	103255.25	245.25	53.9	53.9	53.9			53.9	13.3	1.49	60	6.2	83.9	9.9	29.39	29.22
4	103010	103255.25	245.25	51.0	51.0	51.0			51.0	13.3	1.49	60	6.2	83.9	9.9	29.39	29.22
5	103010	103255.25	245.25	46.1	46.1	46.1			46.1	13.3	1.49	60	6.2	83.9	9.9	29.39	29.22
6	103010	103255.25	245.25	52.0	52.0	52.0			52.0	13.3	1.49	60	6.2	83.9	9.9	29.39	29.22
7	103010	103255.25	245.25	34.3	34.3	34.3			34.3	12.9	1.49	60	6.2	83.9	9.9	29.39	29.22
8	103010	103255.25	245.25	39.2	39.2	39.2			39.2	13.0	1.49	60	6.2	83.9	9.9	29.39	29.22
9	103010	103255.25	245.25	45.1	45.1	45.1			45.1	12.9	1.49	60	6.2	83.9	9.9	29.39	29.22
10	103010	103255.25	245.25	52.9	52.9	52.9			52.9	12.8	1.49	60	6.2	83.9	9.9	29.39	29.22
11	103010	103255.25	245.25	57.8	57.8	57.8			57.8	12.8	1.49	60	6.2	83.9	9.9	29.39	29.22
12	103010	103255.25	245.25	72.5	72.5	72.5			72.5	12.7	1.49	60	6.2	83.9	9.9	29.39	29.22
Mean	**103010**	**103255**	**245.3**	**50.3**	**50.3**	**50.3**	**#DIV/0!**	**#DIV/0!**	**50.3**	**13.1**	**1.5**	**60.0**	**6.2**	**90.3**	**9.9**	**28.83**	**28.73**

$$\rho = \frac{molar\ mass\ .absolute\ pressure}{R.gas\ temperature}$$

Mean density	**1.247**	**kg/m3**

$$Velocity = K.\sqrt{\frac{2.\Delta_p}{\rho}}$$

Mean velocity	**7.45**	**m/sec**		
Standard uncertainty of velocity	**0.33**	**m/sec**	**4.5**	**% of value**
Expanded uncertainty in velocity	**0.67**	**m/sec**	**9.0**	**% of value**

	Circular duct		Rectangular duct	
Flow rate	**46144**	**m^3/hour**	**0**	**m3/hour**
Volume flow rate expanded uncertainty	**4234**	**m^3/hour**	**#DIV/0!**	**m3/hour**
Volume flow rate expanded uncertainty	**9.2**	**% of value**	**#DIV/0!**	**% of value**

Developed for the STA by NPL, David Butterfield & Chris Dimopoulos

SCV 1C Uncertainty Calculations

Uncertainty calculation for gaseous measurement of O2 according to BS EN 14789:2017 - Horiba PG250 AS0246

v1.0 May-20

		Cal gas conc	15.30	**% vol**
Measured concentration	11.26	**% vol**	**Full Scale**	25.00	**% vol**

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% range		≤0.2 % vol
Standard deviation of repeatability at span level	0.0	% range		≤0.2 % vol
Deviation from linearity(lack of fit)	0.7	% range		≤0.3 % vol
Zero drift	0.1	% of span value		≤±5% span value
Span drift	0.9	% of span value		≤±5% span value
Influence of sample gas flow	0.2	% vol/10l/h		≤0.2 % vol
Influence of atmospheric pressure	0.2	% vol/3kPa		≤0.2 % vol
Influence of ambient temperature	-0.1	% vol/20K		≤0.5 % vol
Cross sensitivity	0.6	% vol		≤0.4 % vol
Influence of voltage	0.0	% vol/10V		≤0.2 % vol
Influence from vibration	0.0	% vol		≤0.2 % vol
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges			
	min	max	value at calib	
flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**				**% vol**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.00
Lack of fit			u_{fit}				0.10
Zero drift			u_{0dr}				0.01
Span drift			u_{sdr}				0.08
Influence of sample gas flow			u_{spres}				0.001
Influence of atmospheric pressure			u_{apres}				0.014
Influence of ambient temperature			u_{temp}				-0.014
Cross sensitivity			u_{interf}				0.32
Influence of voltage			u_{volt}				0.000
Influence from vibration			u_{vib}				0.00
Uncertainty of calibration gas			u_{cal}				0.06

Measurement uncertainty				
Combined uncertainty			0.35	% vol
Expanded uncertainty	k =	2	0.71	% vol
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.71**	**% vol**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**6.29**	**% value**

Uncertainty calculation for gaseous measurement of CO according to BS EN 15058:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	N/A	mg/m^3 (Corrected)	**Cal gas conc.**	193.69	mg.m^{-3}
Measured concentration	115.19	mg/m3 (101.3kPa, 273K)	**Range**	250.09	mg/m^3
Measured concentration	212.87	mg/m^3 (Corrected)			

Gas	CO	
Full Scale	200.0	ppm
Cal gas conc	154.9	ppm
Conversion	1.25	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	11.26	0.0	101.3	273.0
	Uncert	0.71	0.0	0.0	0.0
Factors		1.85	1.00	1.00	1.00
Uncertainty in factor		0.13	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.85**	uf	**0.13**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.1	% of range		≤±1% range
Standard deviation of repeatability at span level	0.2	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	1.6	% of range		≤±2 % range
Zero drift	0.3	% of span value		≤±5% span value
Span drift	1.9	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.1	% full scale/20K		≤±5% range
Cross sensitivity	2.9	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.3	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic		**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero		u_{r0}				0.00
Standard deviation of repeatability at span level		u_{rs}				0.41
Standard deviation of reproducibility		u_{rp}				0.00
Lack of fit		u_{fit}				2.32
Zero drift		u_{0dr}				0.29
Span drift		u_{sdr}				2.17
Influence of sample gas flow		u_{spres}				0.03
Influence of atmospheric pressure		u_{apres}				0.35
Influence of ambient temperature		u_{temp}				0.03
Cross sensitivity		u_{interf}				4.19
Influence of voltage		u_{volt}				0.00
Influence from vibration		u_{vib}				0.00
Uncertainty of calibration gas		u_{cal}				0.58
Uncertainty in std conditions correction factor (no O_2 factor)		u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)		u_{of}				15.47

Measurement uncertainty				
Combined uncertainty			5.32	mg/m^3
Expanded uncertainty	k =	2	10.65	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			10.65	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**36.67**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**36.67**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**17.23**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**N/A**	**% ELV**

Uncertainty calculation for gaseous measurement of NOx according to BS EN 14792:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	107	**mg/m^3 (Corrected)**	**Cal gas conc.**	163.1	**mg.m^{-3}**
Measured concentration	30.78	**mg/m3 (101.3kPa, 273K)**	**Range**	205.4	**mg/m^3**
Measured concentration	56.88	**mg/m^3 (Corrected)**			
NO/NO2 ratio	99				

Gas	NOx	
Full Scale	100	**ppm**
Cal gas conc	79.4	**ppm**
Conversion	2.05	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	11.26	0.0	101.3	273.0
	Uncert	0.71	0.0	0.0	0.0
Factors		1.85	1.00	1.00	1.00
Uncertainty in factor		0.13	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.85**	uf	**0.13**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% of range		≤±1% range
Standard deviation of repeatability at span level	0.3	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	-1.6	% of range		≤±2 % range
Zero drift	0.0	% of span value		≤±5% span value
Span drift	0.0	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.2	% full scale/20K		≤±5% range
Cross sensitivity	0.7	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Converter efficiency	95.4	%		≥95%
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.62
Standard deviation of reproducibility			u_{rp}				0.00
Lack of fit			u_{fit}				-1.84
Zero drift			u_{0dr}				0.00
Span drift			u_{sdr}				0.00
Influence of sample gas flow			u_{spres}				0.02
Influence of atmospheric pressure			u_{apres}				0.28
Influence of ambient temperature			u_{temp}				0.07
Cross sensitivity			u_{interf}				0.83
Influence of voltage			u_{volt}				0.00
Influence from vibration			u_{vib}				0.00
Converter efficiency			u_{conv}				0.81
Uncertainty of calibration gas			u_{cal}				0.15
Uncertainty in std conditions correction factor (no O_2 factor)			u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)			u_{of}				4.13

Measurement uncertainty				
Combined uncertainty			2.28	mg/m^3
Expanded uncertainty	k =	2	4.57	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			4.57	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**11.82**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**11.82**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**20.77**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**4.27**	**% ELV**

Uncertainty calculation for Velocity and Volume Flow Rate Measurement by Pitot tube EN ISO 16911-1

v1.3 Jan-16

Enter data in orange cells only

Constants

Gas constant	8.314	J/(K.mol)
Velocity meas. during calibration	3.086	m/s
Air density meas. during calibration	1.213	kg/m^3
DP meas. during calibration	8.05	Pa
Uncertainty of velocity meas. at calibration	2.1	%
Uncertainty of air density meas. at calibration	0.075	%
Uncertainty of DP meas. at calibration	3.88	%
Pitot coefficient, K	0.833	-
Expanded uncertainty (95%, k=2) as % of value	8.8	%
Expanded uncertainty (95%, k=2)	0.07	

Characteristics of pressure sensor used for Delta P		
Enter uncertainties as (95%,k=2) where relevant		
Repeatability of Delta P transducer	1	% of value
Range of Delta P transducer	2451	Pa
Resolution of Delta P transducer	1.96	Pa
Drift of Delta P transducer	0.1	% of range between calibrations
Lack of fit of measurement system	0.1	% of range
Unertainty in Delta P transducer	10.0	Pa
Enter uncertainties as (95%,k=2) where relevant		
Uncertainty in temperature readout system	1	°C
Uncertainty in atmospheric pressure transducer	170	Pa
Uncertainty in duct area measurement	0.8	%

Uncertainty in stack gas composition		
Enter uncertainties as (95%,k=2) where relevant		
Water vapour measurement	20	% relative
CO content measurement	6	% relative
CO_2 content measurement	10	% relative
O_2 content measurement	6	% relative

Duct dimensions	Circular		Rectangular	
Diameter	1.48	m	a	m
Area	1.7	m2	b	m
			Area	0.0 m2

All Pressures should be entered in Pascals, Pa

Measurement Point	Atmospheric Pressure, Pa	Stack Pressure, Pa	Static Pressure, Pa	meas1, Pa	meas2, Pa	meas3, Pa	meas4, Pa	meas5, Pa	Delta P, Pa	Stack Temperature, C	Water Vapour Content, %	Dry gas basis: CO, ppm	Dry gas basis: CO_2, %	Dry gas basis: N_2, %	Dry gas basis: O_2, %	dry molecular wt, g/mol	stack molecular wt, g/mol
1	103010	103239.554	229.554	45.1	45.1	45.1			45.1	13.0	1.46	96	5.6	83.4	11	29.34	29.17
2	103010	103239.554	229.554	44.1	44.1	44.1			44.1	13.1	1.46	96	5.6	83.4	11	29.34	29.17
3	103010	103239.554	229.554	47.1	47.1	47.1			47.1	13.2	1.46	96	5.6	83.4	11	29.34	29.17
4	103010	103239.554	229.554	36.3	36.3	36.3			36.3	13.2	1.46	96	5.6	83.4	11	29.34	29.17
5	103010	103239.554	229.554	37.3	37.3	37.3			37.3	13.0	1.46	96	5.6	83.4	11	29.34	29.17
6	103010	103239.554	229.554	37.3	37.3	37.3			37.3	13.0	1.46	96	5.6	83.4	11	29.34	29.17
7	103010	103239.554	229.554	31.4	31.4	31.4			31.4	12.6	1.46	96	5.6	83.4	11	29.34	29.17
8	103010	103239.554	229.554	37.3	37.3	37.3			37.3	12.5	1.46	96	5.6	83.4	11	29.34	29.17
9	103010	103239.554	229.554	44.1	44.1	44.1			44.1	12.5	1.46	96	5.6	83.4	11	29.34	29.17
10	103010	103239.554	229.554	47.1	47.1	47.1			47.1	12.4	1.46	96	5.6	83.4	11	29.34	29.17
11	103010	103239.554	229.554	57.8	57.8	57.8			57.8	12.4	1.46	96	5.6	83.4	11	29.34	29.17
12	103010	103239.554	229.554	56.9	56.9	56.9			56.9	12.5	1.46	96	5.6	83.4	11	29.34	29.17
Mean	**103010**	**103240**	**229.6**	**43.5**	**43.5**	**43.5**	**#DIV/0!**	**#DIV/0!**	**43.5**	**12.8**	**1.5**	**96.0**	**5.6**	**90.0**	**11.0**	**28.80**	**28.70**

$$\rho = \frac{molar\ mass\ .absolute\ pressure}{R.gas\ temperature}$$

Mean density	**1.247 kg/m3**

$$Velocity = K.\sqrt{\frac{2.\Delta_p}{\rho}}$$

Mean velocity	**6.93 m/sec**	
Standard uncertainty of velocity	**0.31 m/sec**	**4.5 % of value**
Expanded uncertainty in velocity	**0.63 m/sec**	**9.1 % of value**

	Circular duct		Rectangular duct	
Flow rate	**42899**	**m^3/hour**	**0**	**m3/hour**
Volume flow rate expanded uncertainty	**3968**	**m^3/hour**	**#DIV/0!**	**m3/hour**
Volume flow rate expanded uncertainty	**9.2**	**% of value**	**#DIV/0!**	**% of value**

Developed for the STA by NPL, David Butterfield & Chris Dimopoulos

SCV 1D Uncertainty Calculations

Uncertainty calculation for gaseous measurement of O2 according to BS EN 14789:2017 - Horiba PG250 AS0246

v1.0 May-20

		Cal gas conc	15.30	**% vol**
Measured concentration	10.17	**% vol**	**Full Scale**	25.00	**% vol**

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% range		≤0.2 % vol
Standard deviation of repeatability at span level	0.0	% range		≤0.2 % vol
Deviation from linearity(lack of fit)	0.7	% range		≤0.3 % vol
Zero drift	0.1	% of span value		≤±5% span value
Span drift	0.9	% of span value		≤±5% span value
Influence of sample gas flow	0.2	% vol/10l/h		≤0.2 % vol
Influence of atmospheric pressure	0.2	% vol/3kPa		≤0.2 % vol
Influence of ambient temperature	-0.1	% vol/20K		≤0.5 % vol
Cross sensitivity	0.6	% vol		≤0.4 % vol
Influence of voltage	0.0	% vol/10V		≤0.2 % vol
Influence from vibration	0.0	% vol		≤0.2 % vol
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges			
	min	max	value at calib	
flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**				**% vol**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.00
Lack of fit			u_{fit}				0.10
Zero drift			u_{0dr}				0.01
Span drift			u_{sdr}				0.08
Influence of sample gas flow			u_{spres}				0.001
Influence of atmospheric pressure			u_{apres}				0.014
Influence of ambient temperature			u_{temp}				-0.014
Cross sensitivity			u_{interf}				0.32
Influence of voltage			u_{volt}				0.000
Influence from vibration			u_{vib}				0.00
Uncertainty of calibration gas			u_{cal}				0.05

Measurement uncertainty				
Combined uncertainty			0.35	% vol
Expanded uncertainty	k =	2	0.71	% vol
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.71**	**% vol**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**6.95**	**% value**

Uncertainty calculation for gaseous measurement of CO according to BS EN 15058:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	N/A	mg/m^3 (Corrected)	**Cal gas conc.**	193.69	mg.m^{-3}
Measured concentration	160.27	mg/m3 (101.3kPa, 273K)	**Range**	250.09	mg/m^3
Measured concentration	266.28	mg/m^3 (Corrected)			

Gas	CO	
Full Scale	200.0	ppm
Cal gas conc	154.9	ppm
Conversion	1.25	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	10.17	0.0	101.3	273.0
	Uncert	0.71	0.0	0.0	0.0
Factors		1.66	1.00	1.00	1.00
Uncertainty in factor		0.11	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.66**	uf	**0.11**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.1	% of range		≤±1% range
Standard deviation of repeatability at span level	0.2	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	1.6	% of range		≤±2 % range
Zero drift	0.3	% of span value		≤±5% span value
Span drift	1.9	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.1	% full scale/20K		≤±5% range
Cross sensitivity	2.9	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.3	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic		**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero		u_{r0}				0.00
Standard deviation of repeatability at span level		u_{rs}				0.41
Standard deviation of reproducibility		u_{rp}				0.00
Lack of fit		u_{fit}				2.32
Zero drift		u_{0dr}				0.29
Span drift		u_{sdr}				2.17
Influence of sample gas flow		u_{spres}				0.03
Influence of atmospheric pressure		u_{apres}				0.35
Influence of ambient temperature		u_{temp}				0.03
Cross sensitivity		u_{interf}				4.19
Influence of voltage		u_{volt}				0.00
Influence from vibration		u_{vib}				0.00
Uncertainty of calibration gas		u_{cal}				0.80
Uncertainty in std conditions correction factor (no O_2 factor)		u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)		u_{of}				17.36

Measurement uncertainty				
Combined uncertainty			5.35	mg/m^3
Expanded uncertainty	k =	2	10.70	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			10.70	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**39.01**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**39.01**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**14.65**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**N/A**	**% ELV**

Uncertainty calculation for gaseous measurement of NOx according to BS EN 14792:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	107	**mg/m^3 (Corrected)**	**Cal gas conc.**	163.1	**mg.m^{-3}**
Measured concentration	31.82	**mg/m3 (101.3kPa, 273K)**	**Range**	205.4	**mg/m^3**
Measured concentration	52.88	**mg/m^3 (Corrected)**			
NO/NO2 ratio	99		**Gas**	NOx	
			Full Scale	100	**ppm**
			Cal gas conc	79.4	**ppm**
			Conversion	2.05	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	10.17	0.0	101.3	273.0
	Uncert	0.71	0.0	0.0	0.0
Factors		1.66	1.00	1.00	1.00
Uncertainty in factor		0.11	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.66**	uf	**0.11**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% of range		≤±1% range
Standard deviation of repeatability at span level	0.3	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	-1.6	% of range		≤±2 % range
Zero drift	0.0	% of span value		≤±5% span value
Span drift	0.0	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.2	% full scale/20K		≤±5% range
Cross sensitivity	0.7	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Converter efficiency	95.4	%		≥95%
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.62
Standard deviation of reproducibility			u_{rp}				0.00
Lack of fit			u_{fit}				-1.84
Zero drift			u_{0dr}				0.00
Span drift			u_{sdr}				0.00
Influence of sample gas flow			u_{spres}				0.02
Influence of atmospheric pressure			u_{apres}				0.28
Influence of ambient temperature			u_{temp}				0.07
Cross sensitivity			u_{interf}				0.83
Influence of voltage			u_{volt}				0.00
Influence from vibration			u_{vib}				0.00
Converter efficiency			u_{conv}				0.84
Uncertainty of calibration gas			u_{cal}				0.16
Uncertainty in std conditions correction factor (no O_2 factor)			u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)			u_{of}				3.45

Measurement uncertainty				
Combined uncertainty			2.29	mg/m^3
Expanded uncertainty	k =	2	4.59	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			4.59	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**10.28**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**10.28**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**19.44**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**4.29**	**% ELV**

Uncertainty calculation for Velocity and Volume Flow Rate Measurement by Pitot tube EN ISO 16911-1

v1.3 Jan-16

Enter data in orange cells only

Constants

Gas constant	8.314	J/(K.mol)
Velocity meas. during calibration	3.086	m/s
Air density meas. during calibration	1.213	kg/m^3
DP meas. during calibration	8.05	Pa
Uncertainty of velocity meas. at calibration	2.1	%
Uncertainty of air density meas. at calibration	0.075	%
Uncertainty of DP meas. at calibration	3.88	%
Pitot coefficient, K	0.833	-
Expanded uncertainty (95%, k=2) as % of value	8.8	%
Expanded uncertainty (95%, k=2)	0.07	

Characteristics of pressure sensor used for Delta P		
Enter uncertainties as (95%,k=2) where relevant		
Repeatability of Delta P transducer	1	% of value
Range of Delta P transducer	2451	Pa
Resolution of Delta P transducer	1.96	Pa
Drift of Delta P transducer	0.1	% of range between calibrations
Lack of fit of measurement system	0.1	% of range
Unertainty in Delta P transducer	10.0	Pa
Enter uncertainties as (95%,k=2) where relevant		
Uncertainty in temperature readout system	1	°C
Uncertainty in atmospheric pressure transducer	170	Pa
Uncertainty in duct area measurement	0.8	%

Uncertainty in stack gas composition		
Enter uncertainties as (95%,k=2) where relevant		
Water vapour measurement	20	% relative
CO content measurement	6	% relative
CO_2 content measurement	10	% relative
O_2 content measurement	6	% relative

Duct dimensions	Circular		Rectangular	
Diameter	1.48	m	a	m
Area	1.7	m2	b	m
			Area	0.0 m2

All Pressures should be entered in Pascals, Pa

Measurement Point	Atmospheric Pressure, Pa	Stack Pressure, Pa	Static Pressure, Pa	meas1, Pa	meas2, Pa	meas3, Pa	meas4, Pa	meas5, Pa	Delta P, Pa	Stack Temperature, C	Water Vapour Content, %	Dry gas basis: CO, ppm	Dry gas basis: CO_2, %	Dry gas basis: N_2, %	Dry gas basis: O_2, %	dry molecular wt, g/mol	stack molecular wt, g/mol
1	103010	103284.68	274.7	60.8	60.8	60.8			60.77931502	14.5	1.68	140	6	83.7	10.3	29.37	29.18
2	103010	103284.68	274.7	70.6	70.6	70.6			71	14.6	1.68	140	6	83.7	10.3	29.37	29.18
3	103010	103284.68	274.7	58.8	58.8	58.8			59	15.0	1.68	140	6	83.7	10.3	29.37	29.18
4	103010	103284.68	274.7	60.8	60.8	60.8			61	15.1	1.68	140	6	83.7	10.3	29.37	29.18
5	103010	103284.68	274.7	58.8	58.8	58.8			59	15.1	1.68	140	6	83.7	10.3	29.37	29.18
6	103010	103284.68	274.7	65.7	65.7	65.7			66	15.0	1.68	140	6	83.7	10.3	29.37	29.18
7	103010	103284.68	274.7	46.1	46.1	46.1			46	15.0	1.68	140	6	83.7	10.3	29.37	29.18
8	103010	103284.68	274.7	50.0	50.0	50.0			50	15.0	1.68	140	6	83.7	10.3	29.37	29.18
9	103010	103284.68	274.7	52.9	52.9	52.9			53	14.9	1.68	140	6	83.7	10.3	29.37	29.18
10	103010	103284.68	274.7	58.8	58.8	58.8			59	14.8	1.68	140	6	83.7	10.3	29.37	29.18
11	103010	103284.68	274.7	63.7	63.7	63.7			64	14.7	1.68	140	6	83.7	10.3	29.37	29.18
12	103010	103284.68	274.7	71.6	71.6	71.6			72	14.6	1.68	140	6	83.7	10.3	29.37	29.18
Mean	**103010**	**103285**	**274.7**	**59.9**	**59.9**	**59.9**	**#DIV/0!**	**#DIV/0!**	**59.9**	**14.9**	**1.7**	**140.0**	**6.0**	**90.2**	**10.3**	**28.82**	**28.71**

$$\rho = \frac{molar\ mass\ .absolute\ pressure}{R.gas\ temperature}$$

Mean density	**1.239 kg/m3**

$$Velocity = K.\sqrt{\frac{2.\Delta_p}{\rho}}$$

Mean velocity	**8.17 m/sec**	
Standard uncertainty of velocity	**0.36 m/sec**	**4.5 % of value**
Expanded uncertainty in velocity	**0.73 m/sec**	**8.9 % of value**

	Circular duct	Rectangular duct
Flow rate	**50625 m^3/hour**	**0 m3/hour**
Volume flow rate expanded uncertainty	**4614 m^3/hour**	**#DIV/0! m3/hour**
Volume flow rate expanded uncertainty	**9.1 % of value**	**#DIV/0! % of value**

Developed for the STA by NPL, David Butterfield & Chris Dimopoulos

SCV 1E Uncertainty Calculations

Uncertainty calculation for gaseous measurement of O2 according to BS EN 14789:2017 - Horiba PG250 AS0246

v1.0 May-20

		Cal gas conc	15.30	**% vol**
Measured concentration	14.01	**% vol**	**Full Scale**	25.00	**% vol**

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% range		≤0.2 % vol
Standard deviation of repeatability at span level	0.0	% range		≤0.2 % vol
Deviation from linearity(lack of fit)	0.7	% range		≤0.3 % vol
Zero drift	0.1	% of span value		≤±5% span value
Span drift	0.2	% of span value		≤±5% span value
Influence of sample gas flow	0.2	% vol/10l/h		≤0.2 % vol
Influence of atmospheric pressure	0.2	% vol/3kPa		≤0.2 % vol
Influence of ambient temperature	-0.1	% vol/20K		≤0.5 % vol
Cross sensitivity	0.6	% vol		≤0.4 % vol
Influence of voltage	0.0	% vol/10V		≤0.2 % vol
Influence from vibration	0.0	% vol		≤0.2 % vol
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges			
	min	max	value at calib	
flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**	**Value of uncertainty quantity**			**% vol**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.00
Lack of fit			u_{fit}				0.10
Zero drift			u_{0dr}				0.01
Span drift			u_{sdr}				0.02
Influence of sample gas flow			u_{spres}				0.001
Influence of atmospheric pressure			u_{apres}				0.014
Influence of ambient temperature			u_{temp}				-0.014
Cross sensitivity			u_{interf}				0.32
Influence of voltage			u_{volt}				0.000
Influence from vibration			u_{vib}				0.00
Uncertainty of calibration gas			u_{cal}				0.07

Measurement uncertainty				
Combined uncertainty			0.35	% vol
Expanded uncertainty	k =	2	0.69	% vol
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.69**	**% vol**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**4.96**	**% value**

Uncertainty calculation for gaseous measurement of CO according to BS EN 15058:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	N/A	mg/m^3 (Corrected)	**Cal gas conc.**	193.69	mg.m^{-3}
Measured concentration	121.71	mg/m3 (101.3kPa, 273K)	**Range**	250.09	mg/m^3
Measured concentration	313.22	mg/m^3 (Corrected)			

Gas	CO	
Full Scale	200.0	ppm
Cal gas conc	154.9	ppm
Conversion	1.25	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	14.01	0.0	101.3	273.0
	Uncert	0.69	0.0	0.0	0.0
Factors		2.57	1.00	1.00	1.00
Uncertainty in factor		0.26	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**2.57**	uf	**0.26**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.1	% of range		≤±1% range
Standard deviation of repeatability at span level	0.2	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	1.6	% of range		≤±2 % range
Zero drift	0.1	% of span value		≤±5% span value
Span drift	1.4	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.1	% full scale/20K		≤±5% range
Cross sensitivity	2.9	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.3	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.41
Standard deviation of reproducibility			u_{rp}				0.00
Lack of fit			u_{flt}				2.32
Zero drift			u_{0dr}				0.14
Span drift			u_{sdr}				1.59
Influence of sample gas flow			u_{spres}				0.03
Influence of atmospheric pressure			u_{apres}				0.35
Influence of ambient temperature			u_{temp}				0.03
Cross sensitivity			u_{interf}				4.19
Influence of voltage			u_{volt}				0.00
Influence from vibration			u_{vib}				0.00
Uncertainty of calibration gas			u_{cal}				0.61
Uncertainty in std conditions correction factor (no O_2 factor)			u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)			u_{of}				31.11

Measurement uncertainty				
Combined uncertainty			5.11	mg/m^3
Expanded uncertainty	k =	2	10.23	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			10.23	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**67.56**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**67.56**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**21.57**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**N/A**	**% ELV**

Uncertainty calculation for gaseous measurement of NOx according to BS EN 14792:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	107	**mg/m^3 (Corrected)**	**Cal gas conc.**	163.1	**mg.m^{-3}**
Measured concentration	27.26	**mg/m3 (101.3kPa, 273K)**	**Range**	205.4	**mg/m^3**
Measured concentration	70.16	**mg/m^3 (Corrected)**			
NO/NO2 ratio	99		**Gas**	NOx	
			Full Scale	100	**ppm**
			Cal gas conc	79.4	**ppm**
			Conversion	2.05	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	14.01	0.0	101.3	273.0
	Uncert	0.69	0.0	0.0	0.0
Factors		2.57	1.00	1.00	1.00
Uncertainty in factor		0.26	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**2.57**	uf	**0.26**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% of range		≤±1% range
Standard deviation of repeatability at span level	0.3	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	-1.6	% of range		≤±2 % range
Zero drift	0.0	% of span value		≤±5% span value
Span drift	0.0	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.2	% full scale/20K		≤±5% range
Cross sensitivity	0.7	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Converter efficiency	95.4	%		≥95%
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.62
Standard deviation of reproducibility			u_{rp}				0.00
Lack of fit			u_{fit}				-1.84
Zero drift			u_{0dr}				0.00
Span drift			u_{sdr}				0.00
Influence of sample gas flow			u_{spres}				0.02
Influence of atmospheric pressure			u_{apres}				0.28
Influence of ambient temperature			u_{temp}				0.07
Cross sensitivity			u_{interf}				0.83
Influence of voltage			u_{volt}				0.00
Influence from vibration			u_{vib}				0.00
Converter efficiency			u_{conv}				0.72
Uncertainty of calibration gas			u_{cal}				0.14
Uncertainty in std conditions correction factor (no O_2 factor)			u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)			u_{of}				6.97

Measurement uncertainty				
Combined uncertainty			2.25	mg/m^3
Expanded uncertainty	k =	2	4.50	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			4.50	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**18.13**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**18.13**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**25.84**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**4.21**	**% ELV**

Uncertainty calculation for Velocity and Volume Flow Rate Measurement by Pitot tube EN ISO 16911-1

v1.3 Jan-16

Enter data in orange cells only

Constants

Gas constant	8.314	J/(K.mol)
Velocity meas. during calibration	3.086	m/s
Air density meas. during calibration	1.213	kg/m^3
DP meas. during calibration	8.05	Pa
Uncertainty of velocity meas. at calibration	2.1	%
Uncertainty of air density meas. at calibration	0.075	%
Uncertainty of DP meas. at calibration	3.88	%
Pitot coefficient, K	0.833	-
Expanded uncertainty (95%, k=2) as % of value	8.8	%
Expanded uncertainty (95%, k=2)	0.07	

Characteristics of pressure sensor used for Delta P		
Enter uncertainties as (95%,k=2) where relevant		
Repeatability of Delta P transducer	1	% of value
Range of Delta P transducer	2451	Pa
Resolution of Delta P transducer	1.96	Pa
Drift of Delta P transducer	0.1	% of range between calibrations
Lack of fit of measurement system	0.1	% of range
Unertainty in Delta P transducer	10.0	Pa
Enter uncertainties as (95%,k=2) where relevant		
Uncertainty in temperature readout system	1	°C
Uncertainty in atmospheric pressure transducer	170	Pa
Uncertainty in duct area measurement	0.8	%

Uncertainty in stack gas composition		
Enter uncertainties as (95%,k=2) where relevant		
Water vapour measurement	20	% relative
CO content measurement	6	% relative
CO_2 content measurement	10	% relative
O_2 content measurement	6	% relative

Duct dimensions	Circular		Rectangular	
Diameter	1.48	m	a	m
Area	1.7	m2	b	m
			Area	0.0 m2

All Pressures should be entered in Pascals, Pa

Measurement Point	Atmospheric Pressure, Pa	Stack Pressure, Pa	Static Pressure, Pa	meas1, Pa	meas2, Pa	meas3, Pa	meas4, Pa	meas5, Pa	Delta P, Pa	Stack Temperature, C	Water Vapour Content, %	Dry gas basis: CO, ppm	Dry gas basis: CO_2, %	Dry gas basis: N_2, %	Dry gas basis: O_2, %	dry molecular wt, g/mol	stack molecular wt, g/mol
1	102510	102729.744	219.744	32.4	32.4	32.4			32.4	7.0	1.0	100	4.3	82.7	13.0	29.21	29.10
2	102510	102729.744	219.744	36.3	36.3	36.3			36.3	7.0	1.0	100	4.3	82.7	13.0	29.21	29.10
3	102510	102729.744	219.744	44.1	44.1	44.1			44.1	7.0	1.0	100	4.3	82.7	13.0	29.21	29.10
4	102510	102729.744	219.744	49.0	49.0	49.0			49.0	7.0	1.0	100	4.3	82.7	13.0	29.21	29.10
5	102510	102729.744	219.744	42.2	42.2	42.2			42.2	6.9	1.0	100	4.3	82.7	13.0	29.21	29.10
6	102510	102729.744	219.744	43.1	43.1	43.1			43.1	7.0	1.0	100	4.3	82.7	13.0	29.21	29.10
7	102510	102729.744	219.744	17.6	17.6	17.6			17.6	7.2	1.0	100	4.3	82.7	13.0	29.21	29.10
8	102510	102729.744	219.744	21.6	21.6	21.6			21.6	7.2	1.0	100	4.3	82.7	13.0	29.21	29.10
9	102510	102729.744	219.744	23.5	23.5	23.5			23.5	7.0	1.0	100	4.3	82.7	13.0	29.21	29.10
10	102510	102729.744	219.744	29.4	29.4	29.4			29.4	7.0	1.0	100	4.3	82.7	13.0	29.21	29.10
11	102510	102729.744	219.744	35.3	35.3	35.3			35.3	7.0	1.0	100	4.3	82.7	13.0	29.21	29.10
12	102510	102729.744	219.744	40.2	40.2	40.2			40.2	7.1	1.0	100	4.3	82.7	13.0	29.21	29.10
Mean	**102510**	**102642**	**219.7**	**34.6**	**34.6**	**34.6**	**#DIV/0!**	**#DIV/0!**	**34.6**	**7.0**	**1.0**	**100.0**	**4.3**	**89.6**	**13.0**	**28.72**	**28.66**

$$\rho = \frac{molar\ mass\ .absolute\ pressure}{R.gas\ temperature}$$

Mean density	**1.263 kg/m3**

$$Velocity = K.\sqrt{\frac{2.\Delta_p}{\rho}}$$

Mean velocity	**6.10 m/sec**	
Standard uncertainty of velocity	**0.29 m/sec**	**4.7 % of value**
Expanded uncertainty in velocity	**0.57 m/sec**	**9.4 % of value**

	Circular duct		Rectangular duct	
Flow rate	**37762**	**m^3/hour**	**0**	**m3/hour**
Volume flow rate expanded uncertainty	**3605**	**m^3/hour**	**#DIV/0!**	**m3/hour**
Volume flow rate expanded uncertainty	**9.5**	**% of value**	**#DIV/0!**	**% of value**

Developed for the STA by NPL, David Butterfield & Chris Dimopoulos

SCV 1F Uncertainty Calculations

Uncertainty calculation for gaseous measurement of O2 according to BS EN 14789:2017 - Horiba PG250 AS0246

v1.0 May-20

		Cal gas conc	15.30	**% vol**
Measured concentration	13.07	**% vol**	**Full Scale**	25.00	**% vol**

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% range		≤0.2 % vol
Standard deviation of repeatability at span level	0.0	% range		≤0.2 % vol
Deviation from linearity(lack of fit)	0.7	% range		≤0.3 % vol
Zero drift	0.1	% of span value		≤±5% span value
Span drift	0.2	% of span value		≤±5% span value
Influence of sample gas flow	0.2	% vol/10l/h		≤0.2 % vol
Influence of atmospheric pressure	0.2	% vol/3kPa		≤0.2 % vol
Influence of ambient temperature	-0.1	% vol/20K		≤0.5 % vol
Cross sensitivity	0.6	% vol		≤0.4 % vol
Influence of voltage	0.0	% vol/10V		≤0.2 % vol
Influence from vibration	0.0	% vol		≤0.2 % vol
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges			
	min	max	value at calib	
flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**				**% vol**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.00
Lack of fit			u_{fit}				0.10
Zero drift			u_{0dr}				0.01
Span drift			u_{sdr}				0.02
Influence of sample gas flow			u_{spres}				0.001
Influence of atmospheric pressure			u_{apres}				0.014
Influence of ambient temperature			u_{temp}				-0.014
Cross sensitivity			u_{interf}				0.32
Influence of voltage			u_{volt}				0.000
Influence from vibration			u_{vib}				0.00
Uncertainty of calibration gas			u_{cal}				0.07

Measurement uncertainty				
Combined uncertainty			0.35	% vol
Expanded uncertainty	k =	2	0.69	% vol
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.69**	**% vol**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**5.30**	**% value**

Uncertainty calculation for gaseous measurement of CO according to BS EN 15058:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	N/A	mg/m^3 (Corrected)	**Cal gas conc.**	193.69	mg.m^{-3}
Measured concentration	110.48	mg/m3 (101.3kPa, 273K)	**Range**	250.09	mg/m^3
Measured concentration	250.84	mg/m^3 (Corrected)			

Gas	CO	
Full Scale	200.0	ppm
Cal gas conc	154.9	ppm
Conversion	1.25	

Correction for reference conditions

		O2, %	Moisture, %	Pressure, KPa	Temperature, K
	ref	3.00	0.0	101.3	273.0
	measured	13.07	0.0	101.3	273.0
	Uncert	0.69	0.0	0.0	0.0
Factors		2.27	1.00	1.00	1.00
Uncertainty in factor		0.20	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**2.27**	uf	**0.20**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.1	% of range		≤±1% range
Standard deviation of repeatability at span level	0.2	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	1.6	% of range		≤±2 % range
Zero drift	0.1	% of span value		≤±5% span value
Span drift	1.4	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.1	% full scale/20K		≤±5% range
Cross sensitivity	2.9	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.3	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic		**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero		u_{r0}				0.00
Standard deviation of repeatability at span level		u_{rs}				0.41
Standard deviation of reproducibility		u_{rp}				0.00
Lack of fit		u_{flt}				2.32
Zero drift		u_{0dr}				0.14
Span drift		u_{sdr}				1.59
Influence of sample gas flow		u_{spres}				0.03
Influence of atmospheric pressure		u_{apres}				0.35
Influence of ambient temperature		u_{temp}				0.03
Cross sensitivity		u_{interf}				4.19
Influence of voltage		u_{volt}				0.00
Influence from vibration		u_{vib}				0.00
Uncertainty of calibration gas		u_{cal}				0.55
Uncertainty in std conditions correction factor (no O_2 factor)		u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)		u_{of}				21.93

Measurement uncertainty				
Combined uncertainty			5.11	mg/m^3
Expanded uncertainty	k =	2	10.21	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			10.21	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**49.61**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**49.61**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**19.78**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**N/A**	**% ELV**

Uncertainty calculation for gaseous measurement of NOx according to BS EN 14792:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	107	**mg/m^3 (Corrected)**	**Cal gas conc.**	163.1	**mg.m^{-3}**
Measured concentration	31.91	**mg/m3 (101.3kPa, 273K)**	**Range**	205.4	**mg/m^3**
Measured concentration	72.45	**mg/m^3 (Corrected)**			
NO/NO2 ratio	99		**Gas**	NOx	
			Full Scale	100	**ppm**
			Cal gas conc	79.4	**ppm**
			Conversion	2.05	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	13.07	0.0	101.3	273.0
	Uncert	0.69	0.0	0.0	0.0
Factors		2.27	1.00	1.00	1.00
Uncertainty in factor		0.20	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**2.27**	uf	**0.20**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% of range		≤±1% range
Standard deviation of repeatability at span level	0.3	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	-1.6	% of range		≤±2 % range
Zero drift	0.0	% of span value		≤±5% span value
Span drift	0.0	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.2	% full scale/20K		≤±5% range
Cross sensitivity	0.7	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Converter efficiency	95.4	%		≥95%
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.62
Standard deviation of reproducibility			u_{rp}				0.00
Lack of fit			u_{fit}				-1.84
Zero drift			u_{0dr}				0.00
Span drift			u_{sdr}				0.00
Influence of sample gas flow			u_{spres}				0.02
Influence of atmospheric pressure			u_{apres}				0.28
Influence of ambient temperature			u_{temp}				0.07
Cross sensitivity			u_{interf}				0.83
Influence of voltage			u_{volt}				0.00
Influence from vibration			u_{vib}				0.00
Converter efficiency			u_{conv}				0.84
Uncertainty of calibration gas			u_{cal}				0.16
Uncertainty in std conditions correction factor (no O_2 factor)			u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)			u_{of}				6.33

Measurement uncertainty				
Combined uncertainty			2.30	mg/m^3
Expanded uncertainty	k =	2	4.59	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			4.59	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**16.40**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**16.40**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**22.64**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**4.29**	**% ELV**

Uncertainty calculation for Velocity and Volume Flow Rate Measurement by Pitot tube EN ISO 16911-1

v1.3 Jan-16

Enter data in orange cells only

Constants

Gas constant	8.314	J/(K.mol)
Velocity meas. during calibration	3.086	m/s
Air density meas. during calibration	1.213	kg/m^3
DP meas. during calibration	8.05	Pa
Uncertainty of velocity meas. at calibration	2.1	%
Uncertainty of air density meas. at calibration	0.075	%
Uncertainty of DP meas. at calibration	3.88	%
Pitot coefficient, K	0.833	-
Expanded uncertainty (95%, k=2) as % of value	8.8	%
Expanded uncertainty (95%, k=2)	0.07	

Characteristics of pressure sensor used for Delta P		
Enter uncertainties as (95%,k=2) where relevant		
Repeatability of Delta P transducer	1	% of value
Range of Delta P transducer	2451	Pa
Resolution of Delta P transducer	1.96	Pa
Drift of Delta P transducer	0.1	% of range between calibrations
Lack of fit of measurement system	0.1	% of range
Unertainty in Delta P transducer	10.0	Pa
Enter uncertainties as (95%,k=2) where relevant		
Uncertainty in temperature readout system	1	°C
Uncertainty in atmospheric pressure transducer	170	Pa
Uncertainty in duct area measurement	0.8	%

Uncertainty in stack gas composition		
Enter uncertainties as (95%,k=2) where relevant		
Water vapour measurement	20	% relative
CO content measurement	6	% relative
CO_2 content measurement	10	% relative
O_2 content measurement	6	% relative

Duct dimensions	Circular		Rectangular	
Diameter	1.48	m	a	m
Area	1.7	m2	b	m
			Area	0.0 m2

All Pressures should be entered in Pascals, Pa

Measurement Point	Atmospheric Pressure, Pa	Stack Pressure, Pa	Static Pressure, Pa	meas1, Pa	meas2, Pa	meas3, Pa	meas4, Pa	meas5, Pa	Delta P, Pa	Stack Temperature, C	Water Vapour Content, %	Dry gas basis: CO, ppm	Dry gas basis: CO_2, %	Dry gas basis: N_2, %	Dry gas basis: O_2, %	dry molecular wt, g/mol	stack molecular wt, g/mol
1	102510	102682.656	172.656	34.3	34.3	34.3			34.31090364	9.7	1.2	100	4.3	82.5	13.2	29.22	29.08
2	102510	102682.656	172.656	46.1	46.1	46.1			46	9.8	1.2	100	4.3	82.5	13.2	29.22	29.08
3	102510	102682.656	172.656	41.2	41.2	41.2			41	10.2	1.2	100	4.3	82.5	13.2	29.22	29.08
4	102510	102682.656	172.656	35.3	35.3	35.3			35	10.7	1.2	100	4.3	82.5	13.2	29.22	29.08
5	102510	102682.656	172.656	34.3	34.3	34.3			34	10.8	1.2	100	4.3	82.5	13.2	29.22	29.08
6	102510	102682.656	172.656	52.0	52.0	52.0			52	10.7	1.2	100	4.3	82.5	13.2	29.22	29.08
7	102510	102682.656	172.656	26.5	26.5	26.5			26	10.0	1.2	100	4.3	82.5	13.2	29.22	29.08
8	102510	102682.656	172.656	31.4	31.4	31.4			31	10.0	1.2	100	4.3	82.5	13.2	29.22	29.08
9	102510	102682.656	172.656	31.4	31.4	31.4			31	10.0	1.2	100	4.3	82.5	13.2	29.22	29.08
10	102510	102682.656	172.656	50.0	50.0	50.0			50	10.0	1.2	100	4.3	82.5	13.2	29.22	29.08
11	102510	102682.656	172.656	53.9	53.9	53.9			54	9.9	1.2	100	4.3	82.5	13.2	29.22	29.08
12	102510	102682.656	172.656	72.5	72.5	72.5			73	9.8	1.2	100	4.3	82.5	13.2	29.22	29.08
Mean	**102510**	**102683**	**172.7**	**42.4**	**42.4**	**42.4**	**#DIV/0!**	**#DIV/0!**	**42.4**	**10.1**	**1.2**	**100.0**	**4.3**	**89.5**	**13.2**	**28.73**	**28.65**

$$\rho = \frac{molar\ mass\ .absolute\ pressure}{R.gas\ temperature}$$

Mean density	**1.250 kg/m3**

$$Velocity = K.\sqrt{\frac{2.\Delta_p}{\rho}}$$

Mean velocity	**6.79 m/sec**	
Standard uncertainty of velocity	**0.31 m/sec**	**4.6 % of value**
Expanded uncertainty in velocity	**0.62 m/sec**	**9.1 % of value**

	Circular duct		Rectangular duct	
Flow rate	**42066**	**m^3/hour**	**0**	**m3/hour**
Volume flow rate expanded uncertainty	**3910**	**m^3/hour**	**#DIV/0!**	**m3/hour**
Volume flow rate expanded uncertainty	**9.3**	**% of value**	**#DIV/0!**	**% of value**

Developed for the STA by NPL, David Butterfield & Chris Dimopoulos

SCV 1G Uncertainty Calculations

Uncertainty calculation for gaseous measurement of O2 according to BS EN 14789:2017 - Horiba PG250 AS0246

v1.0 May-20

		Cal gas conc	15.30	**% vol**
Measured concentration	10.93	**% vol**	**Full Scale**	25.00	**% vol**

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% range		≤0.2 % vol
Standard deviation of repeatability at span level	0.0	% range		≤0.2 % vol
Deviation from linearity(lack of fit)	0.7	% range		≤0.3 % vol
Zero drift	0.1	% of span value		≤±5% span value
Span drift	0.2	% of span value		≤±5% span value
Influence of sample gas flow	0.2	% vol/10l/h		≤0.2 % vol
Influence of atmospheric pressure	0.2	% vol/3kPa		≤0.2 % vol
Influence of ambient temperature	-0.1	% vol/20K		≤0.5 % vol
Cross sensitivity	0.6	% vol		≤0.4 % vol
Influence of voltage	0.0	% vol/10V		≤0.2 % vol
Influence from vibration	0.0	% vol		≤0.2 % vol
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges			
	min	max	value at calib	
flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**				**% vol**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.00
Lack of fit			u_{fit}				0.10
Zero drift			u_{0dr}				0.01
Span drift			u_{sdr}				0.02
Influence of sample gas flow			u_{spres}				0.001
Influence of atmospheric pressure			u_{apres}				0.014
Influence of ambient temperature			u_{temp}				-0.014
Cross sensitivity			u_{interf}				0.32
Influence of voltage			u_{volt}				0.000
Influence from vibration			u_{vib}				0.00
Uncertainty of calibration gas			u_{cal}				0.05

Measurement uncertainty				
Combined uncertainty			0.34	% vol
Expanded uncertainty	k =	2	0.69	% vol
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.69**	**% vol**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**6.31**	**% value**

Uncertainty calculation for gaseous measurement of CO according to BS EN 15058:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	N/A	mg/m^3 (Corrected)	**Cal gas conc.**	193.69	mg.m^{-3}
Measured concentration	388.31	mg/m3 (101.3kPa, 273K)	**Range**	250.09	mg/m^3
Measured concentration	693.90	mg/m^3 (Corrected)			

Gas	CO	
Full Scale	200.0	ppm
Cal gas conc	154.9	ppm
Conversion	1.25	

Correction for reference conditions

		O2, %	Moisture, %	Pressure, KPa	Temperature, K
	ref	3.00	0.0	101.3	273.0
	measured	10.93	0.0	101.3	273.0
	Uncert	0.69	0.0	0.0	0.0
Factors		1.79	1.00	1.00	1.00
Uncertainty in factor		0.12	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.79**	uf	**0.12**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.1	% of range		≤±1% range
Standard deviation of repeatability at span level	0.2	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	1.6	% of range		≤±2 % range
Zero drift	0.1	% of span value		≤±5% span value
Span drift	1.4	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.1	% full scale/20K		≤±5% range
Cross sensitivity	2.9	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.3	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic		**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero		u_{r0}				0.00
Standard deviation of repeatability at span level		u_{rs}				0.41
Standard deviation of reproducibility		u_{rp}				0.00
Lack of fit		u_{fit}				2.32
Zero drift		u_{0dr}				0.14
Span drift		u_{sdr}				1.59
Influence of sample gas flow		u_{spres}				0.03
Influence of atmospheric pressure		u_{apres}				0.35
Influence of ambient temperature		u_{temp}				0.03
Cross sensitivity		u_{interf}				4.19
Influence of voltage		u_{volt}				0.00
Influence from vibration		u_{vib}				0.00
Uncertainty of calibration gas		u_{cal}				1.94
Uncertainty in std conditions correction factor (no O_2 factor)		u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)		u_{of}				47.48

Measurement uncertainty				
Combined uncertainty			5.44	mg/m^3
Expanded uncertainty	k =	2	10.87	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			10.87	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**96.93**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**96.93**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**13.97**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**N/A**	**% ELV**

Uncertainty calculation for gaseous measurement of NOx according to BS EN 14792:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	107	**mg/m^3 (Corrected)**	**Cal gas conc.**	163.1	**mg.m^{-3}**
Measured concentration	27.54	**mg/m3 (101.3kPa, 273K)**	**Range**	205.4	**mg/m^3**
Measured concentration	49.21	**mg/m^3 (Corrected)**			
NO/NO2 ratio	99				

Gas	NOx	
Full Scale	100	**ppm**
Cal gas conc	79.4	**ppm**
Conversion	2.05	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	10.93	0.0	101.3	273.0
	Uncert	0.69	0.0	0.0	0.0
Factors		1.79	1.00	1.00	1.00
Uncertainty in factor		0.12	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.79**	uf	**0.12**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% of range		≤±1% range
Standard deviation of repeatability at span level	0.3	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	-1.6	% of range		≤±2 % range
Zero drift	0.0	% of span value		≤±5% span value
Span drift	0.0	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.2	% full scale/20K		≤±5% range
Cross sensitivity	0.7	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Converter efficiency	95.4	%		≥95%
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.62
Standard deviation of reproducibility			u_{rp}				0.00
Lack of fit			u_{fit}				-1.84
Zero drift			u_{0dr}				0.00
Span drift			u_{sdr}				0.00
Influence of sample gas flow			u_{spres}				0.02
Influence of atmospheric pressure			u_{apres}				0.28
Influence of ambient temperature			u_{temp}				0.07
Cross sensitivity			u_{interf}				0.83
Influence of voltage			u_{volt}				0.00
Influence from vibration			u_{vib}				0.00
Converter efficiency			u_{conv}				0.72
Uncertainty of calibration gas			u_{cal}				0.14
Uncertainty in std conditions correction factor (no O_2 factor)			u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)			u_{of}				3.37

Measurement uncertainty				
Combined uncertainty			2.25	mg/m^3
Expanded uncertainty	k =	2	4.51	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			4.51	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**10.50**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**10.50**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**21.34**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**4.21**	**% ELV**

Uncertainty calculation for Velocity and Volume Flow Rate Measurement by Pitot tube EN ISO 16911-1

v1.3 Jan-16

Enter data in orange cells only

Constants

Gas constant	8.314	J/(K.mol)
Velocity meas. during calibration	3.086	m/s
Air density meas. during calibration	1.213	kg/m^3
DP meas. during calibration	8.05	Pa
Uncertainty of velocity meas. at calibration	2.1	%
Uncertainty of air density meas. at calibration	0.075	%
Uncertainty of DP meas. at calibration	3.88	%
Pitot coefficient, K	0.833	-
Expanded uncertainty (95%, k=2) as % of value	8.8	%
Expanded uncertainty (95%, k=2)	0.07	

Characteristics of pressure sensor used for Delta P		
Enter uncertainties as (95%,k=2) where relevant		
Repeatability of Delta P transducer	1	% of value
Range of Delta P transducer	2451	Pa
Resolution of Delta P transducer	1.96	Pa
Drift of Delta P transducer	0.1	% of range between calibrations
Lack of fit of measurement system	0.1	% of range
Unertainty in Delta P transducer	10.0	Pa
Enter uncertainties as (95%,k=2) where relevant		
Uncertainty in temperature readout system	1	°C
Uncertainty in atmospheric pressure transducer	170	Pa
Uncertainty in duct area measurement	0.8	%

Uncertainty in stack gas composition		
Enter uncertainties as (95%,k=2) where relevant		
Water vapour measurement	20	% relative
CO content measurement	6	% relative
CO_2 content measurement	10	% relative
O_2 content measurement	6	% relative

Duct dimensions	Circular			Rectangular		
	Diameter	1.48	m	a		m
	Area	1.7	m2	b		m
				Area	0.0	m2

All Pressures should be entered in Pascals, Pa

Measurement Point	Atmospheric Pressure, Pa	Stack Pressure, Pa	Static Pressure, Pa	meas1, Pa	meas2, Pa	meas3, Pa	meas4, Pa	meas5, Pa	Delta P, Pa	Stack Temperature, C	Water Vapour Content, %	Dry gas basis: CO, ppm	Dry gas basis: CO_2, %	Dry gas basis: N_2, %	Dry gas basis: O_2, %	dry molecular wt, g/mol	stack molecular wt, g/mol
1	102510	102729.744	219.744	40.2	40.2	40.2			40.2	11.5	11.4	233	5.7	83.5	10.8	29.34	28.05
2	102510	102729.744	219.744	49.0	49.0	49.0			49.0	11.7	11.4	233	5.7	83.5	10.8	29.34	28.05
3	102510	102729.744	219.744	53.9	53.9	53.9			53.9	11.7	11.4	233	5.7	83.5	10.8	29.34	28.05
4	102510	102729.744	219.744	54.9	54.9	54.9			54.9	11.7	11.4	233	5.7	83.5	10.8	29.34	28.05
5	102510	102729.744	219.744	55.9	55.9	55.9			55.9	11.6	11.4	233	5.7	83.5	10.8	29.34	28.05
6	102510	102729.744	219.744	57.8	57.8	57.8			57.8	11.6	11.4	233	5.7	83.5	10.8	29.34	28.05
7	102510	102729.744	219.744	44.1	44.1	44.1			44.1	11.4	11.4	233	5.7	83.5	10.8	29.34	28.05
8	102510	102729.744	219.744	45.1	45.1	45.1			45.1	11.7	11.4	233	5.7	83.5	10.8	29.34	28.05
9	102510	102729.744	219.744	53.9	53.9	53.9			53.9	11.7	11.4	233	5.7	83.5	10.8	29.34	28.05
10	102510	102729.744	219.744	68.6	68.6	68.6			68.6	11.7	11.4	233	5.7	83.5	10.8	29.34	28.05
11	102510	102729.744	219.744	65.7	65.7	65.7			65.7	11.6	11.4	233	5.7	83.5	10.8	29.34	28.05
12	102510	102729.744	219.744	53.9	53.9	53.9			53.9	11.6	11.4	233	5.7	83.5	10.8	29.34	28.05
Mean	**102510**	**102730**	**219.7**	**53.6**	**53.6**	**53.6**	**#DIV/0!**	**#DIV/0!**	**53.6**	**11.6**	**11.4**	**233.0**	**5.7**	**90.1**	**10.8**	**28.81**	**28.03**

$$\rho = \frac{molar\ mass\ .absolute\ pressure}{R.gas\ temperature}$$

Mean density	**1.217**	**kg/m3**

$$Velocity = K.\sqrt{\frac{2.\Delta_p}{\rho}}$$

Mean velocity	**7.80**	**m/sec**		
Standard uncertainty of velocity	**0.35**	**m/sec**	**4.5**	**% of value**
Expanded uncertainty in velocity	**0.70**	**m/sec**	**9.0**	**% of value**

	Circular duct		Rectangular duct	
Flow rate	**48283**	**m^3/hour**	**0**	**m3/hour**
Volume flow rate expanded uncertainty	**4420**	**m^3/hour**	**#DIV/0!**	**m3/hour**
Volume flow rate expanded uncertainty	**9.2**	**% of value**	**#DIV/0!**	**% of value**

Developed for the STA by NPL, David Butterfield & Chris Dimopoulos

SCV 1H Uncertainty Calculations

Uncertainty calculation for gaseous measurement of O2 according to BS EN 14789:2017 - Horiba PG250 AS0246

v1.0 May-20

		Cal gas conc	15.30	**% vol**
Measured concentration	10.12	**% vol**	**Full Scale**	25.00	**% vol**

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% range		≤0.2 % vol
Standard deviation of repeatability at span level	0.0	% range		≤0.2 % vol
Deviation from linearity(lack of fit)	0.7	% range		≤0.3 % vol
Zero drift	0.1	% of span value		≤±5% span value
Span drift	0.2	% of span value		≤±5% span value
Influence of sample gas flow	0.2	% vol/10l/h		≤0.2 % vol
Influence of atmospheric pressure	0.2	% vol/3kPa		≤0.2 % vol
Influence of ambient temperature	-0.1	% vol/20K		≤0.5 % vol
Cross sensitivity	0.6	% vol		≤0.4 % vol
Influence of voltage	0.0	% vol/10V		≤0.2 % vol
Influence from vibration	0.0	% vol		≤0.2 % vol
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges			
	min	max	value at calib	
flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**				**% vol**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.00
Lack of fit			u_{fit}				0.10
Zero drift			u_{0dr}				0.01
Span drift			u_{sdr}				0.02
Influence of sample gas flow			u_{spres}				0.001
Influence of atmospheric pressure			u_{apres}				0.014
Influence of ambient temperature			u_{temp}				-0.014
Cross sensitivity			u_{interf}				0.32
Influence of voltage			u_{volt}				0.000
Influence from vibration			u_{vib}				0.00
Uncertainty of calibration gas			u_{cal}				0.05

Measurement uncertainty				
Combined uncertainty			0.34	% vol
Expanded uncertainty	k =	2	0.69	% vol
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.69**	**% vol**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**6.80**	**% value**

Uncertainty calculation for gaseous measurement of CO according to BS EN 15058:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	N/A	mg/m^3 (Corrected)	**Cal gas conc.**	193.69	mg.m^{-3}
Measured concentration	97.98	mg/m3 (101.3kPa, 273K)	**Range**	250.09	mg/m^3
Measured concentration	162.02	mg/m^3 (Corrected)			

Gas	CO	
Full Scale	200.0	ppm
Cal gas conc	154.9	ppm
Conversion	1.25	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	10.12	0.0	101.3	273.0
	Uncert	0.69	0.0	0.0	0.0
Factors		1.65	1.00	1.00	1.00
Uncertainty in factor		0.10	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.65**	uf	**0.10**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.1	% of range		≤±1% range
Standard deviation of repeatability at span level	0.2	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	1.6	% of range		≤±2 % range
Zero drift	0.1	% of span value		≤±5% span value
Span drift	1.4	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.1	% full scale/20K		≤±5% range
Cross sensitivity	2.9	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.3	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic		**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero		u_{r0}				0.00
Standard deviation of repeatability at span level		u_{rs}				0.41
Standard deviation of reproducibility		u_{rp}				0.00
Lack of fit		u_{flt}				2.32
Zero drift		u_{0dr}				0.14
Span drift		u_{sdr}				1.59
Influence of sample gas flow		u_{spres}				0.03
Influence of atmospheric pressure		u_{apres}				0.35
Influence of ambient temperature		u_{temp}				0.03
Cross sensitivity		u_{interf}				4.19
Influence of voltage		u_{volt}				0.00
Influence from vibration		u_{vib}				0.00
Uncertainty of calibration gas		u_{cal}				0.49
Uncertainty in std conditions correction factor (no O_2 factor)		u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)		u_{of}				10.24

Measurement uncertainty				
Combined uncertainty			5.10	mg/m^3
Expanded uncertainty	k =	2	10.20	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			10.20	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**26.53**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**26.53**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**16.38**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**N/A**	**% ELV**

Uncertainty calculation for gaseous measurement of NOx according to BS EN 14792:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	107	**mg/m^3 (Corrected)**	**Cal gas conc.**	163.1	**mg.m^{-3}**
Measured concentration	29.93	**mg/m3 (101.3kPa, 273K)**	**Range**	205.4	**mg/m^3**
Measured concentration	49.50	**mg/m^3 (Corrected)**			
NO/NO2 ratio	99		**Gas**	NOx	
			Full Scale	100	**ppm**
			Cal gas conc	79.4	**ppm**
			Conversion	2.05	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	10.12	0.0	101.3	273.0
	Uncert	0.69	0.0	0.0	0.0
Factors		1.65	1.00	1.00	1.00
Uncertainty in factor		0.10	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.65**	uf	**0.10**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% of range		≤±1% range
Standard deviation of repeatability at span level	0.3	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	-1.6	% of range		≤±2 % range
Zero drift	0.0	% of span value		≤±5% span value
Span drift	0.0	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.2	% full scale/20K		≤±5% range
Cross sensitivity	0.7	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Converter efficiency	95.4	%		≥95%
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.62
Standard deviation of reproducibility			u_{rp}				0.00
Lack of fit			u_{flt}				-1.84
Zero drift			u_{0dr}				0.00
Span drift			u_{sdr}				0.00
Influence of sample gas flow			u_{spres}				0.02
Influence of atmospheric pressure			u_{apres}				0.28
Influence of ambient temperature			u_{temp}				0.07
Cross sensitivity			u_{interf}				0.83
Influence of voltage			u_{volt}				0.00
Influence from vibration			u_{vib}				0.00
Converter efficiency			u_{conv}				0.79
Uncertainty of calibration gas			u_{cal}				0.15
Uncertainty in std conditions correction factor (no O_2 factor)			u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)			u_{of}				3.13

Measurement uncertainty				
Combined uncertainty			2.28	mg/m^3
Expanded uncertainty	k =	2	4.55	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			4.55	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**9.79**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**9.79**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**19.78**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**4.25**	**% ELV**

Uncertainty calculation for Velocity and Volume Flow Rate Measurement by Pitot tube EN ISO 16911-1

v1.3 Jan-16

Enter data in orange cells only

Constants

Gas constant	8.314	J/(K.mol)
Velocity meas. during calibration	3.086	m/s
Air density meas. during calibration	1.213	kg/m^3
DP meas. during calibration	8.05	Pa
Uncertainty of velocity meas. at calibration	2.1	%
Uncertainty of air density meas. at calibration	0.075	%
Uncertainty of DP meas. at calibration	3.88	%
Pitot coefficient, K	0.833	-
Expanded uncertainty (95%, k=2) as % of value	8.8	%
Expanded uncertainty (95%, k=2)	0.07	

Characteristics of pressure sensor used for Delta P		
Enter uncertainties as (95%,k=2) where relevant		
Repeatability of Delta P transducer	1	% of value
Range of Delta P transducer	2451	Pa
Resolution of Delta P transducer	1.96	Pa
Drift of Delta P transducer	0.1	% of range between calibrations
Lack of fit of measurement system	0.1	% of range
Unertainty in Delta P transducer	10.0	Pa
Enter uncertainties as (95%,k=2) where relevant		
Uncertainty in temperature readout system	1	°C
Uncertainty in atmospheric pressure transducer	170	Pa
Uncertainty in duct area measurement	0.8	%

Uncertainty in stack gas composition		
Enter uncertainties as (95%,k=2) where relevant		
Water vapour measurement	20	% relative
CO content measurement	6	% relative
CO_2 content measurement	10	% relative
O_2 content measurement	6	% relative

Duct dimensions	Circular		Rectangular	
Diameter	1.48	m	a	m
Area	1.7	m2	b	m
			Area	0.0 m2

All Pressures should be entered in Pascals, Pa

Measurement Point	Atmospheric Pressure, Pa	Stack Pressure, Pa	Static Pressure, Pa	meas1, Pa	meas2, Pa	meas3, Pa	meas4, Pa	meas5, Pa	Delta P, Pa	Stack Temperature, C	Water Vapour Content, %	Dry gas basis: CO, ppm	Dry gas basis: CO_2, %	Dry gas basis: N_2, %	Dry gas basis: O_2, %	dry molecular wt, g/mol	stack molecular wt, g/mol
1	102510	102776.832	266.832	37.3	37.3	37.3			37.3	12.4	1.5	80	6.2	83.6	10.2	29.40	29.23
2	102510	102776.832	266.832	53.9	53.9	53.9			53.9	12.7	1.5	80	6.2	83.6	10.2	29.40	29.23
3	102510	102776.832	266.832	65.7	65.7	65.7			65.7	12.7	1.5	80	6.2	83.6	10.2	29.40	29.23
4	102510	102776.832	266.832	66.7	66.7	66.7			66.7	12.8	1.5	80	6.2	83.6	10.2	29.40	29.23
5	102510	102776.832	266.832	59.8	59.8	59.8			59.8	12.9	1.5	80	6.2	83.6	10.2	29.40	29.23
6	102510	102776.832	266.832	66.7	66.7	66.7			66.7	12.8	1.5	80	6.2	83.6	10.2	29.40	29.23
7	102510	102776.832	266.832	44.1	44.1	44.1			44.1	12.9	1.5	80	6.2	83.6	10.2	29.40	29.23
8	102510	102776.832	266.832	55.9	55.9	55.9			55.9	13.0	1.5	80	6.2	83.6	10.2	29.40	29.23
9	102510	102776.832	266.832	66.7	66.7	66.7			66.7	13.1	1.5	80	6.2	83.6	10.2	29.40	29.23
10	102510	102776.832	266.832	66.7	66.7	66.7			66.7	13.0	1.5	80	6.2	83.6	10.2	29.40	29.23
11	102510	102776.832	266.832	66.7	66.7	66.7			66.7	13.0	1.5	80	6.2	83.6	10.2	29.40	29.23
12	102510	102776.832	266.832	73.5	73.5	73.5			73.5	12.7	1.5	80	6.2	83.6	10.2	29.40	29.23
Mean	**102510**	**102777**	**266.8**	**60.3**	**60.3**	**60.3**	**#DIV/0!**	**#DIV/0!**	**60.3**	**12.8**	**1.5**	**80.0**	**6.2**	**90.2**	**10.2**	**28.84**	**28.74**

$$\rho = \frac{molar\ mass\ .absolute\ pressure}{R.gas\ temperature}$$

Mean density	**1.243**	**kg/m3**

$$Velocity = K.\sqrt{\frac{2.\Delta_p}{\rho}}$$

Mean velocity	**8.17**	**m/sec**		
Standard uncertainty of velocity	**0.36**	**m/sec**	**4.5**	**% of value**
Expanded uncertainty in velocity	**0.73**	**m/sec**	**8.9**	**% of value**

	Circular duct		Rectangular duct	
Flow rate	**50609**	**m^3/hour**	**0**	**m3/hour**
Volume flow rate expanded uncertainty	**4614**	**m^3/hour**	**#DIV/0!**	**m3/hour**
Volume flow rate expanded uncertainty	**9.1**	**% of value**	**#DIV/0!**	**% of value**

Developed for the STA by NPL, David Butterfield & Chris Dimopoulos

SCV 2A Uncertainty Calculations

Uncertainty calculation for gaseous measurement of O2 according to BS EN 14789:2017 - Horiba PG250 AS0246

v1.0 May-20

		Cal gas conc	15.30	**% vol**
Measured concentration	10.43	**% vol**	**Full Scale**	25.00	**% vol**

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% range		≤0.2 % vol
Standard deviation of repeatability at span level	0.0	% range		≤0.2 % vol
Deviation from linearity(lack of fit)	0.7	% range		≤0.3 % vol
Zero drift	0.3	% of span value		≤±5% span value
Span drift	0.5	% of span value		≤±5% span value
Influence of sample gas flow	0.2	% vol/10l/h		≤0.2 % vol
Influence of atmospheric pressure	0.2	% vol/3kPa		≤0.2 % vol
Influence of ambient temperature	-0.1	% vol/20K		≤0.5 % vol
Cross sensitivity	0.6	% vol		≤0.4 % vol
Influence of voltage	0.0	% vol/10V		≤0.2 % vol
Influence from vibration	0.0	% vol		≤0.2 % vol
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges			
	min	max	value at calib	
flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**				**% vol**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.00
Lack of fit			u_{fit}				0.10
Zero drift			u_{0dr}				0.02
Span drift			u_{sdr}				0.05
Influence of sample gas flow			u_{spres}				0.001
Influence of atmospheric pressure			u_{apres}				0.014
Influence of ambient temperature			u_{temp}				-0.014
Cross sensitivity			u_{interf}				0.32
Influence of voltage			u_{volt}				0.000
Influence from vibration			u_{vib}				0.00
Uncertainty of calibration gas			u_{cal}				0.05

Measurement uncertainty				
Combined uncertainty			0.35	% vol
Expanded uncertainty	k =	2	0.70	% vol
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.70**	**% vol**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**6.67**	**% value**

Uncertainty calculation for gaseous measurement of CO according to BS EN 15058:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	N/A	mg/m^3 (Corrected)	**Cal gas conc.**	193.69	mg.m^{-3}
Measured concentration	157.16	mg/m3 (101.3kPa, 273K)	**Range**	250.09	mg/m^3
Measured concentration	267.64	mg/m^3 (Corrected)			

Gas	CO	
Full Scale	200.0	ppm
Cal gas conc	154.9	ppm
Conversion	1.25	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	10.43	0.0	101.3	273.0
	Uncert	0.70	0.0	0.0	0.0
Factors		1.70	1.00	1.00	1.00
Uncertainty in factor		0.11	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.70**	uf	**0.11**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.1	% of range		≤±1% range
Standard deviation of repeatability at span level	0.2	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	1.6	% of range		≤±2 % range
Zero drift	0.0	% of span value		≤±5% span value
Span drift	0.0	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.1	% full scale/20K		≤±5% range
Cross sensitivity	2.9	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.3	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic		**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero		u_{r0}				0.00
Standard deviation of repeatability at span level		u_{rs}				0.41
Standard deviation of reproducibility		u_{rp}				0.00
Lack of fit		u_{fit}				2.32
Zero drift		u_{0dr}				0.00
Span drift		u_{sdr}				0.00
Influence of sample gas flow		u_{spres}				0.03
Influence of atmospheric pressure		u_{apres}				0.35
Influence of ambient temperature		u_{temp}				0.03
Cross sensitivity		u_{interf}				4.19
Influence of voltage		u_{volt}				0.00
Influence from vibration		u_{vib}				0.00
Uncertainty of calibration gas		u_{cal}				0.79
Uncertainty in std conditions correction factor (no O_2 factor)		u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)		u_{of}				17.60

Measurement uncertainty				
Combined uncertainty			4.88	mg/m^3
Expanded uncertainty	k =	2	9.77	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			9.77	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**38.94**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**38.94**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**14.55**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**N/A**	**% ELV**

Uncertainty calculation for gaseous measurement of NOx according to BS EN 14792:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	107	**mg/m^3 (Corrected)**	**Cal gas conc.**	163.1	**mg.m^{-3}**
Measured concentration	29.64	**mg/m3 (101.3kPa, 273K)**	**Range**	205.4	**mg/m^3**
Measured concentration	50.47	**mg/m^3 (Corrected)**			
NO/NO2 ratio	99				

Gas	NOx	
Full Scale	100	**ppm**
Cal gas conc	79.4	**ppm**
Conversion	2.05	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	10.43	0.0	101.3	273.0
	Uncert	0.70	0.0	0.0	0.0
Factors		1.70	1.00	1.00	1.00
Uncertainty in factor		0.11	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.70**	uf	**0.11**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% of range		≤±1% range
Standard deviation of repeatability at span level	0.3	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	-1.6	% of range		≤±2 % range
Zero drift	0.0	% of span value		≤±5% span value
Span drift	0.0	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.2	% full scale/20K		≤±5% range
Cross sensitivity	0.7	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Converter efficiency	95.4	%		≥95%
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.62
Standard deviation of reproducibility			u_{rp}				0.00
Lack of fit			u_{fit}				-1.84
Zero drift			u_{0dr}				0.00
Span drift			u_{sdr}				0.00
Influence of sample gas flow			u_{spres}				0.02
Influence of atmospheric pressure			u_{apres}				0.28
Influence of ambient temperature			u_{temp}				0.07
Cross sensitivity			u_{interf}				0.83
Influence of voltage			u_{volt}				0.00
Influence from vibration			u_{vib}				0.00
Converter efficiency			u_{conv}				0.78
Uncertainty of calibration gas			u_{cal}				0.15
Uncertainty in std conditions correction factor (no O_2 factor)			u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)			u_{of}				3.32

Measurement uncertainty				
Combined uncertainty			2.27	mg/m^3
Expanded uncertainty	k =	2	4.55	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			4.55	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**10.20**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**10.20**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**20.21**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**4.25**	**% ELV**

Uncertainty calculation for Velocity and Volume Flow Rate Measurement by Pitot tube EN ISO 16911-1

v1.3 Jan-16

Enter data in orange cells only

Constants

Gas constant	8.314	J/(K.mol)
Velocity meas. during calibration	3.086	m/s
Air density meas. during calibration	1.213	kg/m^3
DP meas. during calibration	8.05	Pa
Uncertainty of velocity meas. at calibration	2.1	%
Uncertainty of air density meas. at calibration	0.075	%
Uncertainty of DP meas. at calibration	3.88	%
Pitot coefficient, K	0.833	-
Expanded uncertainty (95%, k=2) as % of value	8.8	%
Expanded uncertainty (95%, k=2)	0.07	

Characteristics of pressure sensor used for Delta P		
Enter uncertainties as (95%,k=2) where relevant		
Repeatability of Delta P transducer	1	% of value
Range of Delta P transducer	2451	Pa
Resolution of Delta P transducer	1.96	Pa
Drift of Delta P transducer	0.1	% of range between calibrations
Lack of fit of measurement system	0.1	% of range
Unertainty in Delta P transducer	10.0	Pa
Enter uncertainties as (95%,k=2) where relevant		
Uncertainty in temperature readout system	1	°C
Uncertainty in atmospheric pressure transducer	170	Pa
Uncertainty in duct area measurement	0.8	%

Uncertainty in stack gas composition		
Enter uncertainties as (95%,k=2) where relevant		
Water vapour measurement	20	% relative
CO content measurement	6	% relative
CO_2 content measurement	10	% relative
O_2 content measurement	6	% relative

Duct dimensions	Circular			Rectangular		
	Diameter	1.48	m	a		m
	Area	1.7	m2	b		m
				Area	0.0	m2

All Pressures should be entered in Pascals, Pa

Measurement Point	Atmospheric Pressure, Pa	Stack Pressure, Pa	Static Pressure, Pa	meas1, Pa	meas2, Pa	meas3, Pa	meas4, Pa	meas5, Pa	Delta P, Pa	Stack Temperature, C	Water Vapour Content, %	Dry gas basis: CO, ppm	Dry gas basis: CO_2, %	Dry gas basis: N_2, %	Dry gas basis: O_2, %	dry molecular wt, g/mol	stack molecular wt, g/mol
1	102340	102580.345	240.345	38.2	38.2	38.2			38.2	12.2	1.4	126	6	83.6	10.4	29.38	29.22
2	102340	102580.345	240.345	50.0	50.0	50.0			50.0	12.2	1.4	126	6	83.6	10.4	29.38	29.22
3	102340	102580.345	240.345	56.9	56.9	56.9			56.9	12.3	1.4	126	6	83.6	10.4	29.38	29.22
4	102340	102580.345	240.345	68.6	68.6	68.6			68.6	12.3	1.4	126	6	83.6	10.4	29.38	29.22
5	102340	102580.345	240.345	68.6	68.6	68.6			68.6	12.2	1.4	126	6	83.6	10.4	29.38	29.22
6	102340	102580.345	240.345	66.7	66.7	66.7			66.7	12.0	1.4	126	6	83.6	10.4	29.38	29.22
7	102340	102580.345	240.345	39.2	39.2	39.2			39.2	12.2	1.4	126	6	83.6	10.4	29.38	29.22
8	102340	102580.345	240.345	49.0	49.0	49.0			49.0	12.2	1.4	126	6	83.6	10.4	29.38	29.22
9	102340	102580.345	240.345	56.9	56.9	56.9			56.9	12.3	1.4	126	6	83.6	10.4	29.38	29.22
10	102340	102580.345	240.345	70.6	70.6	70.6			70.6	12.3	1.4	126	6	83.6	10.4	29.38	29.22
11	102340	102580.345	240.345	76.5	76.5	76.5			76.5	12.1	1.4	126	6	83.6	10.4	29.38	29.22
12	102340	102580.345	240.345	70.6	70.6	70.6			70.6	12.0	1.4	126	6	83.6	10.4	29.38	29.22
Mean	**102340**	**102484**	**240.3**	**59.3**	**59.3**	**59.3**	**#DIV/0!**	**#DIV/0!**	**59.3**	**12.2**	**1.4**	**126.0**	**6.0**	**90.2**	**10.4**	**28.83**	**28.73**

$$\rho = \frac{molar\ mass\ .absolute\ pressure}{R.gas\ temperature}$$

Mean density	**1.242 kg/m3**

$$Velocity = K.\sqrt{\frac{2.\Delta_p}{\rho}}$$

Mean velocity	**8.09 m/sec**	
Standard uncertainty of velocity	**0.36 m/sec**	**4.5 % of value**
Expanded uncertainty in velocity	**0.72 m/sec**	**8.9 % of value**

	Circular duct	Rectangular duct
Flow rate	**50128 m^3/hour**	**0 m3/hour**
Volume flow rate expanded uncertainty	**4574 m^3/hour**	**#DIV/0! m3/hour**
Volume flow rate expanded uncertainty	**9.1 % of value**	**#DIV/0! % of value**

Developed for the STA by NPL, David Butterfield & Chris Dimopoulos

SCV 2D Uncertainty Calculations

Uncertainty calculation for gaseous measurement of O2 according to BS EN 14789:2017 - Horiba PG250 AS0246

v1.0 May-20

		Cal gas conc	15.30	**% vol**
Measured concentration	10.52	**% vol**	**Full Scale**	25.00	**% vol**

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% range		≤0.2 % vol
Standard deviation of repeatability at span level	0.0	% range		≤0.2 % vol
Deviation from linearity(lack of fit)	0.7	% range		≤0.3 % vol
Zero drift	0.3	% of span value		≤±5% span value
Span drift	0.5	% of span value		≤±5% span value
Influence of sample gas flow	0.2	% vol/10l/h		≤0.2 % vol
Influence of atmospheric pressure	0.2	% vol/3kPa		≤0.2 % vol
Influence of ambient temperature	-0.1	% vol/20K		≤0.5 % vol
Cross sensitivity	0.6	% vol		≤0.4 % vol
Influence of voltage	0.0	% vol/10V		≤0.2 % vol
Influence from vibration	0.0	% vol		≤0.2 % vol
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges			
	min	max	value at calib	
flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**				**% vol**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.00
Lack of fit			u_{fit}				0.10
Zero drift			u_{0dr}				0.02
Span drift			u_{sdr}				0.05
Influence of sample gas flow			u_{spres}				0.001
Influence of atmospheric pressure			u_{apres}				0.014
Influence of ambient temperature			u_{temp}				-0.014
Cross sensitivity			u_{interf}				0.32
Influence of voltage			u_{volt}				0.000
Influence from vibration			u_{vib}				0.00
Uncertainty of calibration gas			u_{cal}				0.05

Measurement uncertainty				
Combined uncertainty			0.35	% vol
Expanded uncertainty	k =	2	0.70	% vol
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.70**	**% vol**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**6.61**	**% value**

Uncertainty calculation for gaseous measurement of CO according to BS EN 15058:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	N/A	mg/m^3 (Corrected)	**Cal gas conc.**	193.69	mg.m^{-3}
Measured concentration	254.67	mg/m3 (101.3kPa, 273K)	**Range**	250.09	mg/m^3
Measured concentration	437.46	mg/m^3 (Corrected)			

Gas	CO	
Full Scale	200.0	ppm
Cal gas conc	154.9	ppm
Conversion	1.25	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	10.52	0.0	101.3	273.0
	Uncert	0.70	0.0	0.0	0.0
Factors		1.72	1.00	1.00	1.00
Uncertainty in factor		0.11	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.72**	uf	**0.11**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.1	% of range		≤±1% range
Standard deviation of repeatability at span level	0.2	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	1.6	% of range		≤±2 % range
Zero drift	0.0	% of span value		≤±5% span value
Span drift	0.0	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.1	% full scale/20K		≤±5% range
Cross sensitivity	2.9	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.3	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic		**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero		u_{r0}				0.00
Standard deviation of repeatability at span level		u_{rs}				0.41
Standard deviation of reproducibility		u_{rp}				0.00
Lack of fit		u_{fit}				2.32
Zero drift		u_{0dr}				0.00
Span drift		u_{sdr}				0.00
Influence of sample gas flow		u_{spres}				0.03
Influence of atmospheric pressure		u_{apres}				0.35
Influence of ambient temperature		u_{temp}				0.03
Cross sensitivity		u_{interf}				4.19
Influence of voltage		u_{volt}				0.00
Influence from vibration		u_{vib}				0.00
Uncertainty of calibration gas		u_{cal}				1.27
Uncertainty in std conditions correction factor (no O_2 factor)		u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)		u_{of}				29.03

Measurement uncertainty				
Combined uncertainty			4.98	mg/m^3
Expanded uncertainty	k =	2	9.97	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			9.97	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**60.53**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**60.53**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**13.84**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**N/A**	**% ELV**

Uncertainty calculation for gaseous measurement of NOx according to BS EN 14792:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	107	**mg/m^3 (Corrected)**	**Cal gas conc.**	163.1	**mg.m^{-3}**
Measured concentration	30.64	**mg/m3 (101.3kPa, 273K)**	**Range**	205.4	**mg/m^3**
Measured concentration	52.63	**mg/m^3 (Corrected)**			
NO/NO2 ratio	99				

Gas	NOx	
Full Scale	100	**ppm**
Cal gas conc	79.4	**ppm**
Conversion	2.05	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	10.52	0.0	101.3	273.0
	Uncert	0.70	0.0	0.0	0.0
Factors		1.72	1.00	1.00	1.00
Uncertainty in factor		0.11	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.72**	uf	**0.11**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% of range		≤±1% range
Standard deviation of repeatability at span level	0.3	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	-1.6	% of range		≤±2 % range
Zero drift	0.0	% of span value		≤±5% span value
Span drift	0.0	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.2	% full scale/20K		≤±5% range
Cross sensitivity	0.7	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Converter efficiency	95.4	%		≥95%
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.62
Standard deviation of reproducibility			u_{rp}				0.00
Lack of fit			u_{fit}				-1.84
Zero drift			u_{0dr}				0.00
Span drift			u_{sdr}				0.00
Influence of sample gas flow			u_{spres}				0.02
Influence of atmospheric pressure			u_{apres}				0.28
Influence of ambient temperature			u_{temp}				0.07
Cross sensitivity			u_{interf}				0.83
Influence of voltage			u_{volt}				0.00
Influence from vibration			u_{vib}				0.00
Converter efficiency			u_{conv}				0.81
Uncertainty of calibration gas			u_{cal}				0.15
Uncertainty in std conditions correction factor (no O_2 factor)			u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)			u_{of}				3.49

Measurement uncertainty				
Combined uncertainty			2.28	mg/m^3
Expanded uncertainty	k =	2	4.57	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			4.57	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**10.50**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**10.50**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**19.96**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**4.27**	**% ELV**

Uncertainty calculation for Velocity and Volume Flow Rate Measurement by Pitot tube EN ISO 16911-1

v1.3 Jan-16

Enter data in orange cells only

Constants

Gas constant	8.314	J/(K.mol)
Velocity meas. during calibration	3.086	m/s
Air density meas. during calibration	1.213	kg/m^3
DP meas. during calibration	8.05	Pa
Uncertainty of velocity meas. at calibration	2.1	%
Uncertainty of air density meas. at calibration	0.075	%
Uncertainty of DP meas. at calibration	3.88	%
Pitot coefficient, K	0.833	-
Expanded uncertainty (95%, k=2) as % of value	8.8	%
Expanded uncertainty (95%, k=2)	0.07	

Characteristics of pressure sensor used for Delta P		
Enter uncertainties as (95%,k=2) where relevant		
Repeatability of Delta P transducer	1	% of value
Range of Delta P transducer	2451	Pa
Resolution of Delta P transducer	1.96	Pa
Drift of Delta P transducer	0.1	% of range between calibrations
Lack of fit of measurement system	0.1	% of range
Unertainty in Delta P transducer	10.0	Pa
Enter uncertainties as (95%,k=2) where relevant		
Uncertainty in temperature readout system	1	°C
Uncertainty in atmospheric pressure transducer	170	Pa
Uncertainty in duct area measurement	0.8	%

Uncertainty in stack gas composition		
Enter uncertainties as (95%,k=2) where relevant		
Water vapour measurement	20	% relative
CO content measurement	6	% relative
CO_2 content measurement	10	% relative
O_2 content measurement	6	% relative

Duct dimensions	Circular		Rectangular	
Diameter	1.48	m	a	m
Area	1.7	m2	b	m
			Area	0.0 m2

All Pressures should be entered in Pascals, Pa

Measurement Point	Atmospheric Pressure, Pa	Stack Pressure, Pa	Static Pressure, Pa	meas1, Pa	meas2, Pa	meas3, Pa	meas4, Pa	meas5, Pa	Delta P, Pa	Stack Temperature, C	Water Vapour Content, %	Dry gas basis: CO, ppm	Dry gas basis: CO_2, %	Dry gas basis: N_2, %	Dry gas basis: O_2, %	dry molecular wt, g/mol	stack molecular wt, g/mol
1	102340	102546.991	206.991	35.3	35.3	35.3			35.3	10.7	1.3	238	5.4	83.0	11.6	29.33	29.18
2	102340	102546.991	206.991	47.1	47.1	47.1			47.1	10.7	1.3	238	5.4	83.0	11.6	29.33	29.18
3	102340	102546.991	206.991	49.0	49.0	49.0			49.0	10.7	1.3	238	5.4	83.0	11.6	29.33	29.18
4	102340	102546.991	206.991	40.2	40.2	40.2			40.2	10.7	1.3	238	5.4	83.0	11.6	29.33	29.18
5	102340	102546.991	206.991	46.1	46.1	46.1			46.1	10.9	1.3	238	5.4	83.0	11.6	29.33	29.18
6	102340	102546.991	206.991	39.2	39.2	39.2			39.2	11.2	1.3	238	5.4	83.0	11.6	29.33	29.18
7	102340	102546.991	206.991								1.3	238	5.4	83.0	11.6	29.33	29.18
8	102340	102546.991	206.991								1.3	238	5.4	83.0	11.6	29.33	29.18
9	102340	102546.991	206.991								1.3	238	5.4	83.0	11.6	29.33	29.18
10	102340	102546.991	206.991								1.3	238	5.4	83.0	11.6	29.33	29.18
11	102340	102546.991	206.991								1.3	238	5.4	83.0	11.6	29.33	29.18
12	102340	102546.991	206.991								1.3	238	5.4	83.0	11.6	29.33	29.18
Mean	**102340**	**102547**	**207.0**	**42.8**	**42.8**	**42.8**	**#DIV/0!**	**#DIV/0!**	**42.8**	**10.8**	**1.3**	**238.0**	**5.4**	**89.8**	**11.6**	**28.80**	**28.71**

$$\rho = \frac{molar\ mass\ .absolute\ pressure}{R.gas\ temperature}$$

Mean density	**1.248**	**kg/m3**

$$Velocity = K.\sqrt{\frac{2.\Delta_p}{\rho}}$$

Mean velocity	**6.89**	**m/sec**		
Standard uncertainty of velocity	**0.31**	**m/sec**	**4.5**	**% of value**
Expanded uncertainty in velocity	**0.62**	**m/sec**	**9.1**	**% of value**

	Circular duct		Rectangular duct	
Flow rate	**42665**	**m^3/hour**	**0**	**m3/hour**
Volume flow rate expanded uncertainty	**3945**	**m^3/hour**	**#DIV/0!**	**m3/hour**
Volume flow rate expanded uncertainty	**9.2**	**% of value**	**#DIV/0!**	**% of value**

Developed for the STA by NPL, David Butterfield & Chris Dimopoulos

SCV 2E Uncertainty Calculations

Uncertainty calculation for gaseous measurement of O2 according to BS EN 14789:2017 - Horiba PG250 AS0246

v1.0 May-20

		Cal gas conc	15.30	**% vol**
Measured concentration	10.21	**% vol**	**Full Scale**	25.00	**% vol**

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% range		≤0.2 % vol
Standard deviation of repeatability at span level	0.0	% range		≤0.2 % vol
Deviation from linearity(lack of fit)	0.7	% range		≤0.3 % vol
Zero drift	0.3	% of span value		≤±5% span value
Span drift	0.5	% of span value		≤±5% span value
Influence of sample gas flow	0.2	% vol/10l/h		≤0.2 % vol
Influence of atmospheric pressure	0.2	% vol/3kPa		≤0.2 % vol
Influence of ambient temperature	-0.1	% vol/20K		≤0.5 % vol
Cross sensitivity	0.6	% vol		≤0.4 % vol
Influence of voltage	0.0	% vol/10V		≤0.2 % vol
Influence from vibration	0.0	% vol		≤0.2 % vol
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges			
	min	max	value at calib	
flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**				**% vol**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.00
Lack of fit			u_{fit}				0.10
Zero drift			u_{0dr}				0.02
Span drift			u_{sdr}				0.05
Influence of sample gas flow			u_{spres}				0.001
Influence of atmospheric pressure			u_{apres}				0.014
Influence of ambient temperature			u_{temp}				-0.014
Cross sensitivity			u_{interf}				0.32
Influence of voltage			u_{volt}				0.000
Influence from vibration			u_{vib}				0.00
Uncertainty of calibration gas			u_{cal}				0.05

Measurement uncertainty				
Combined uncertainty			0.35	% vol
Expanded uncertainty	k =	2	0.69	% vol
Expanded uncertainty	**expressed with a level of confidence of 95%**		**0.69**	**% vol**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**6.81**	**% value**

Uncertainty calculation for gaseous measurement of CO according to BS EN 15058:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	N/A	mg/m^3 (Corrected)	**Cal gas conc.**	193.69	mg.m^{-3}
Measured concentration	134.29	mg/m3 (101.3kPa, 273K)	**Range**	250.09	mg/m^3
Measured concentration	224.06	mg/m^3 (Corrected)			

Gas	CO	
Full Scale	200.0	ppm
Cal gas conc	154.9	ppm
Conversion	1.25	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	10.21	0.0	101.3	273.0
	Uncert	0.69	0.0	0.0	0.0
Factors		1.67	1.00	1.00	1.00
Uncertainty in factor		0.11	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.67**	uf	**0.11**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.1	% of range		≤±1% range
Standard deviation of repeatability at span level	0.2	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	1.6	% of range		≤±2 % range
Zero drift	0.0	% of span value		≤±5% span value
Span drift	0.0	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.1	% full scale/20K		≤±5% range
Cross sensitivity	2.9	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.3	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic		**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero		u_{r0}				0.00
Standard deviation of repeatability at span level		u_{rs}				0.41
Standard deviation of reproducibility		u_{rp}				0.00
Lack of fit		u_{flt}				2.32
Zero drift		u_{0dr}				0.00
Span drift		u_{sdr}				0.00
Influence of sample gas flow		u_{spres}				0.03
Influence of atmospheric pressure		u_{apres}				0.35
Influence of ambient temperature		u_{temp}				0.03
Cross sensitivity		u_{interf}				4.19
Influence of voltage		u_{volt}				0.00
Influence from vibration		u_{vib}				0.00
Uncertainty of calibration gas		u_{cal}				0.67
Uncertainty in std conditions correction factor (no O_2 factor)		u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)		u_{of}				14.43

Measurement uncertainty				
Combined uncertainty			4.87	mg/m^3
Expanded uncertainty	k =	2	9.73	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			9.73	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**33.12**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**33.12**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**14.78**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**N/A**	**% ELV**

Uncertainty calculation for gaseous measurement of NOx according to BS EN 14792:2017 - Horiba PG250 AS0246

v1.0 May-20

Emission Limit Value	107	**mg/m^3 (Corrected)**	**Cal gas conc.**	163.1	**mg.m^{-3}**
Measured concentration	33.37	**mg/m3 (101.3kPa, 273K)**	**Range**	205.4	**mg/m^3**
Measured concentration	55.68	**mg/m^3 (Corrected)**			
NO/NO2 ratio	99		**Gas**	NOx	
			Full Scale	100	**ppm**
			Cal gas conc	79.4	**ppm**
			Conversion	2.05	

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	3.00	0.0	101.3	273.0
	measured	10.21	0.0	101.3	273.0
	Uncert	0.69	0.0	0.0	0.0
Factors		1.67	1.00	1.00	1.00
Uncertainty in factor		0.11	0.00	0.00	0.00
Correction Factor (no O_2 factor)		**1.00**		**0.00**	
Correction Factor (inl. O_2 factor)		**1.67**	uf	**0.11**	

Performance characteristics	**Value**			**specification**
Standard deviation of repeatability at zero	0.0	% of range		≤±1% range
Standard deviation of repeatability at span level	0.3	% of range		≤±2% range
Standard deviation of reproducibility	0.0	% full scale		≤±3.3% range
Deviation from linearity(lack of fit)	-1.6	% of range		≤±2 % range
Zero drift	0.0	% of span value		≤±5% span value
Span drift	0.0	% of span value		≤±5% span value
Influence of sample gas flow	2.0	% full scale/10l		≤±2% range
Influence of atmospheric pressure	2.0	% full scale /3kPa		≤±2% range
Influence of ambient temperature	0.2	% full scale/20K		≤±5% range
Cross sensitivity	0.7	% full scale		≤4% range
Influence of voltage	0.0	% full scale/10V		≤±2% range/10V
Influence from vibration	0.0	% full scale		≤±2% range
Converter efficiency	95.4	%		≥95%
Uncertainty of calibration gas	1.0	% value		≤± 2% of value

	ranges min	max	value at calib	
Flow	0.30	0.5	0.4	l/min
pressure	103.0	103.5	103.1	kPa
Temp	277	284	277	K
Voltage	105	115	110	V

Performance characteristic			**Uncertainty**	**Value of uncertainty quantity**			**mg/m3**
Standard deviation of repeatability at zero			u_{r0}				0.00
Standard deviation of repeatability at span level			u_{rs}				0.62
Standard deviation of reproducibility			u_{rp}				0.00
Lack of fit			u_{fit}				-1.84
Zero drift			u_{0dr}				0.00
Span drift			u_{sdr}				0.00
Influence of sample gas flow			u_{spres}				0.02
Influence of atmospheric pressure			u_{apres}				0.28
Influence of ambient temperature			u_{temp}				0.07
Cross sensitivity			u_{interf}				0.83
Influence of voltage			u_{volt}				0.00
Influence from vibration			u_{vib}				0.00
Converter efficiency			u_{conv}				0.88
Uncertainty of calibration gas			u_{cal}				0.17
Uncertainty in std conditions correction factor (no O_2 factor)			u_f				0.00
Uncertainty in std conditions correction factor (including O_2 factor)			u_{of}				3.59

Measurement uncertainty				
Combined uncertainty			2.31	mg/m^3
Expanded uncertainty	k =	2	4.62	mg/m^3
Uncertainty corrected to std conditions (no O_2 factor)			4.62	mg/m^3
Uncertainty corrected to std conditions (including O_2 factor)			**10.53**	**mg/m3**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**10.53**	**mg.m^{-3}**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**18.91**	**% value**
Expanded uncertainty	**expressed with a level of confidence of 95%**		**4.32**	**% ELV**

Uncertainty calculation for Velocity and Volume Flow Rate Measurement by Pitot tube EN ISO 16911-1

v1.3 Jan-16

Enter data in orange cells only

Constants

Gas constant	8.314	J/(K.mol)
Velocity meas. during calibration	3.086	m/s
Air density meas. during calibration	1.213	kg/m^3
DP meas. during calibration	8.05	Pa
Uncertainty of velocity meas. at calibration	2.1	%
Uncertainty of air density meas. at calibration	0.075	%
Uncertainty of DP meas. at calibration	3.88	%
Pitot coefficient, K	0.833	-
Expanded uncertainty (95%, k=2) as % of value	8.8	%
Expanded uncertainty (95%, k=2)	0.07	

Characteristics of pressure sensor used for Delta P		
Enter uncertainties as (95%,k=2) where relevant		
Repeatability of Delta P transducer	1	% of value
Range of Delta P transducer	2451	Pa
Resolution of Delta P transducer	1.96	Pa
Drift of Delta P transducer	0.1	% of range between calibrations
Lack of fit of measurement system	0.1	% of range
Unertainty in Delta P transducer	10.0	Pa
Enter uncertainties as (95%,k=2) where relevant		
Uncertainty in temperature readout system	1	°C
Uncertainty in atmospheric pressure transducer	170	Pa
Uncertainty in duct area measurement	0.8	%

Uncertainty in stack gas composition		
Enter uncertainties as (95%,k=2) where relevant		
Water vapour measurement	20	% relative
CO content measurement	6	% relative
CO_2 content measurement	10	% relative
O_2 content measurement	6	% relative

Duct dimensions	Circular		Rectangular	
Diameter	1.48	m	a	m
Area	1.7	m2	b	m
			Area	0.0 m2

All Pressures should be entered in Pascals, Pa

Measurement Point	Atmospheric Pressure, Pa	Stack Pressure, Pa	Static Pressure, Pa	meas1, Pa	meas2, Pa	meas3, Pa	meas4, Pa	meas5, Pa	Delta P, Pa	Stack Temperature, C	Water Vapour Content, %	Dry gas basis: CO, ppm	Dry gas basis: CO_2, %	Dry gas basis: N_2, %	Dry gas basis: O_2, %	dry molecular wt, g/mol	stack molecular wt, g/mol
1	102340	102597.022	257.022	49.0	49.0	49.0			49.0	15.6	1.7	160	6.3	84.0	9.7	29.40	29.20
2	102340	102597.022	257.022	59.8	59.8	59.8			59.8	15.8	1.7	160	6.3	84.0	9.7	29.40	29.20
3	102340	102597.022	257.022	63.7	63.7	63.7			63.7	15.4	1.7	160	6.3	84.0	9.7	29.40	29.20
4	102340	102597.022	257.022	55.9	55.9	55.9			55.9	15.0	1.7	160	6.3	84.0	9.7	29.40	29.20
5	102340	102597.022	257.022	49.0	49.0	49.0			49.0	14.8	1.7	160	6.3	84.0	9.7	29.40	29.20
6	102340	102597.022	257.022	50.0	50.0	50.0			50.0	14.2	1.7	160	6.3	84.0	9.7	29.40	29.20
7	102340	102597.022	257.022	48.0	48.0	48.0			48.0	15.2	1.7	160	6.3	84.0	9.7	29.40	29.20
8	102340	102597.022	257.022	47.1	47.1	47.1			47.1	15.4	1.7	160	6.3	84.0	9.7	29.40	29.20
9	102340	102597.022	257.022	54.9	54.9	54.9			54.9	15.7	1.7	160	6.3	84.0	9.7	29.40	29.20
10	102340	102597.022	257.022	65.7	65.7	65.7			65.7	15.9	1.7	160	6.3	84.0	9.7	29.40	29.20
11	102340	102597.022	257.022	67.6	67.6	67.6			67.6	16.1	1.7	160	6.3	84.0	9.7	29.40	29.20
12	102340	102597.022	257.022	69.6	69.6	69.6			69.6	15.4	1.7	160	6.3	84.0	9.7	29.40	29.20
Mean	**102340**	**102597**	**257.0**	**56.7**	**56.7**	**56.7**	**#DIV/0!**	**#DIV/0!**	**56.7**	**15.4**	**1.7**	**160.0**	**6.3**	**90.4**	**9.7**	**28.84**	**28.72**

$$\rho = \frac{molar\ mass\ .absolute\ pressure}{R.gas\ temperature}$$

Mean density	**1.229 kg/m3**

$$Velocity = K.\sqrt{\frac{2.\Delta_p}{\rho}}$$

Mean velocity	**7.98 m/sec**	
Standard uncertainty of velocity	**0.36 m/sec**	**4.5 % of value**
Expanded uncertainty in velocity	**0.71 m/sec**	**8.9 % of value**

	Circular duct		Rectangular duct	
Flow rate	**49431**	**m^3/hour**	**0**	**m3/hour**
Volume flow rate expanded uncertainty	**4512**	**m^3/hour**	**#DIV/0!**	**m3/hour**
Volume flow rate expanded uncertainty	**9.1**	**% of value**	**#DIV/0!**	**% of value**

Developed for the STA by NPL, David Butterfield & Chris Dimopoulos

2.2.7 - Calculations Used in Reporting Results

Nozzle Selection

For isokinetic sampling, the pressure difference of the orifice meter must equal the pressure difference of the Pitot tube pressure multiplied by the K-factor. Where:

$$K = \text{Constant} \times C_p^2 \times D_n^4 \times DH_@ \times \left(\frac{M_d}{M_s}\right)\left(\frac{1-B_{wm}}{1-B_{ws}}\right)^2\left(\frac{T_m+273}{T_s+273}\right)\left(\frac{P_s}{P_m}\right)$$

$$DH = K \times Dp$$

Where:-

Constant: is a constant dependent on the units used to measure the nozzle (8.038×10^{-5} for mm)
D_n the nozzle diameter mm
$DH_@$ a constant dependent on the sampler control box orifice and gas meter
B_{ws} the percent water vapour in the emission as a fraction i.e.12% = 0.12
B_{wm} the percentage water vapour in the air around the meter box often assumed to be zero
C_p Pitot tube coefficient dependent on the Pitot tube type
T_m the meter temperature in ^oC
T_s the stack temperature in ^oC
P_s the stack pressure
P_m the meter pressure
M_d dry gas molecular weight
M_s apparent stack gas molecular weight
DH pressure drop across the orifice (mm water)
DP differential Pitot pressure (mm water)

From this the correct nozzle size can be determined.

$$D_n = \sqrt{\left(\frac{\text{Constant}.Q_m.P_m}{(T_m+273)C_p}\right)\left(\frac{1-B_{wm}}{1-B_{ws}}\right)\sqrt{\frac{(T_s+273)M_s}{(P_s.(\Delta P)_{avg})}}}$$

Where the Constant = 0.6071 Metric

Qm = Orifice flow rate normally 21.2 actual $lmin^{-1}$

$$= K_m\sqrt{\frac{(T_m+273)\Delta H}{P_m M_m}}$$

Where Km =Orifice meter coefficient

$$Km = Qm\sqrt{\frac{P_m M_m}{\Delta H(T_m+273)}} = Const\sqrt{\frac{1}{\Delta H_@}}$$

Where Const = 183.7 metric

Moisture Determination Calculations

These calculations are based at 273K and 101.325kPa

To calculate moisture the following equation is used:

$$B_{ws} = \frac{0.001245 \times W_I \times 100}{(0.001245 \times W_I) + 0.359V_m \left(\frac{P_b + \frac{\Delta H_{avg}}{13.6}}{(T_m + 273)} \right)}$$

Particulate Concentration C_s in stack Gases
At 273K and 101.325kPa and dry gas

$$C_s = \frac{W_t}{V_m} \times \frac{T_m + 273}{273} \times \frac{760}{\left(P_b + \frac{\Delta H_{avg}}{13.6} \right)} \times 1000 \qquad mg/Nm^3$$

Oxygen Concentration Correction C_{oxy} to Particulate concentration

$$C_{oxy} = C \times \frac{(20.9 - \%O_2 ref)}{(20.9 - \%O_2 Meas)} \qquad mg/Nm^3$$

Dry Molecular Weight of gases

$M_D = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%CO + \%N)$

Stack Molecular Weight of gases

$$M_s = 0.18(B_{ws}) + \frac{M_d}{100}(100 - B_{ws})$$

Stack Gas Velocity

$$(V_s)_{avg} = 34.96 \times C_p \times \sqrt{(\Delta P)_{avg}} \sqrt{\frac{T_s + 273}{P_s M_s}} \qquad m/s$$

Mass Emission Rate M_R

$$M_R = \frac{C_m \times (V_s)_{avg} \times A \times 3600}{10^6} \qquad kg/hr$$

IsoKinicity

$$I = \frac{2.12 \times 10^{8} \times Vm \times Y \times \left(P_b + \left(\frac{\Delta H_{avg}}{13.6} \right) \right) \left(\frac{273 + T_s}{273 + T_m} \right)}{\Theta P_s \pi D_n^{2} (Vs)avg \left(100 - B_{ws}\right)} \%$$

W_I = the weight change of the impingers during sampling in g
V_m = volume of dry gas sample in litres at temperature of the meter box
B_{ws} = the percent water vapour in the emission
Q = length of time sampling in minutes
Y = Gas Meter Calibration correction factor
Vs = Velocity of stack gas m/s
C_M = measured concentration of particulate matter (mg/m^3)
T_m = average temperature at dry gas meter (^oC)
P_b = atmospheric pressure (mmHg)
$\%O_{2ref}$ = % oxygen at standard temperature & pressure
$\%O_{2Meas}$ = % oxygen measured on site
C_P = Pitot tube coefficient
DP = mean differential Pitot pressure drop (mm H_2O)
DH = mean orifice pressure drop (mm H_2O)
D_s = diameter of stack (m)
D_n = Nozzle diameter (mm)
T_s = stack temperature (^oC)
M_d = molecular weight of dry stack gas
B_W = moisture fraction
P_s = stack pressure (mmHg)
A = duct c.s.a. (m^2)
M_s = molecular weight of wet stack gas
M_d = molecular weight of dry stack gas
W_t = total weight of particulate matter (g)