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Report Number R007300
Emission Testing Report
Santos Limited, Wilga Park



Document Information

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Aaron Davis
Client Manager

NATA Accredited Laboratory
No. 14601

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Table of Contents

1	Executive Summary	4
2	Results Summary	4
3	Results	5
3.1	GO2A	5
3.2	GO3B	6
3.3	GO4B	7
3.4	GO1A	8
3.5	GO3A	9
3.6	GO4A	10
3.7	GO5A	11
3.8	GO6A	12
4	Plant Operating Conditions	13
5	Test Methods.....	13
6	Quality Assurance/Quality Control Information	13
7	Definitions	14

1 EXECUTIVE SUMMARY

Ektimo was engaged by Santos Limited to perform sampling of air emissions as directed from gas-fired engines situated at Wilga Park, NSW.

Monitoring was performed as follows:

Location	Test Date	Test Parameters*
GO2A, GO3B & GO4B	19 March 2019	Nitrogen oxides (as NO ₂), oxygen
GO1A, GO3A, GO4A, GO5A & GO6A	20 March 2019	

* Flow rate, velocity, temperature and moisture were also determined.

All results are reported on a dry basis at STP.

Plant operating conditions have been noted in the report.

2 RESULTS SUMMARY

The following Results summary table shows that all analytes highlighted in green are below the Department planning limit DA 07_0023.


Location Description	Pollutant	Units	Department Planning limit	Detected values	Corrected to 3% O ₂
GO1A	Oxides of Nitrogen (as NO ₂)	mg/m ³	450	250	440
GO2A	Oxides of Nitrogen (as NO ₂)	mg/m ³	450	230	430
GO3A	Oxides of Nitrogen (as NO ₂)	mg/m ³	450	280	420
GO3B	Oxides of Nitrogen (as NO ₂)	mg/m ³	450	230	440
GO4A	Oxides of Nitrogen (as NO ₂)	mg/m ³	450	290	430
GO4B	Oxides of Nitrogen (as NO ₂)	mg/m ³	450	230	440
GO5A	Oxides of Nitrogen (as NO ₂)	mg/m ³	450	280	430
GO6A	Oxides of Nitrogen (as NO ₂)	mg/m ³	450	290	440

3 RESULTS

3.1 GO2A

Date	19/03/2019	Client	GHD Pty Ltd (NSW)
Report	R007300	Stack ID	G02A
Licence No.	DA 07_0023	Location	Wilga Park
Ektimo Staff	Aaron Davis / Scott Woods	State	NSW
Process Conditions	Engine operating at 2900kW		

Sampling Plane Details	
Sampling plane dimensions	600 mm
Sampling plane area	0.283 m ²
Sampling port size, number	4" Flange (x2)
Access & height of ports	Elevated work platform 10 m
Duct orientation & shape	Vertical Circular
Downstream disturbance	Exit 8 D
Upstream disturbance	Change in diameter 3 D
No. traverses & points sampled	2 12
Sample plane compliance to AS4323.1	Compliant but non-ideal



Comments
 The sampling plane is deemed to be non-ideal due to the following reasons:
 The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D


Stack Parameters		
Moisture content, %v/v	9.1	
Gas molecular weight, g/g mole	28.3 (wet)	29.4 (dry)
Gas density at STP, kg/m ³	1.26 (wet)	1.31 (dry)
Gas Flow Parameters		
Flow measurement time(s) (hhmm)	1220 & 1330	
Temperature, °C	385	
Temperature, K	658	
Velocity at sampling plane, m/s	37	
Volumetric flow rate, actual, m ³ /s	10	
Volumetric flow rate (wet STP), m ³ /s	4.2	
Volumetric flow rate (dry STP), m ³ /s	3.8	
Mass flow rate (wet basis), kg/hour	19000	
Velocity difference, %	<1	

Gas Analyser Results	Sampling time	Average		
		1226 - 1325		
Combustion Gases		Corrected to		
		Concentration mg/m ³	3% O ₂ mg/m ³	Mass Rate g/min
Nitrogen oxides (as NO ₂)		230	430	52
Oxygen		Concentration % 11.6		

3.2 GO3B

Date	19/03/2019	Client	GHD Pty Ltd (NSW)
Report	R007300	Stack ID	G03B
Licence No.	DA 07_0023	Location	Wilga Park
Ektimo Staff	Aaron Davis / Scott Woods	State	NSW
Process Conditions	Engine operating at 2900kW		

Sampling Plane Details	
Sampling plane dimensions	600 mm
Sampling plane area	0.283 m ²
Sampling port size, number	4" Flange (x2)
Access & height of ports	Elevated work platform 10 m
Duct orientation & shape	Vertical Circular
Downstream disturbance	Exit 8 D
Upstream disturbance	Change in diameter 3 D
No. traverses & points sampled	2 12
Sample plane compliance to AS4323.1	Compliant but non-ideal



Comments
 The sampling plane is deemed to be non-ideal due to the following reasons:
 The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D


Stack Parameters		
Moisture content, %v/v	8.8	
Gas molecular weight, g/g mole	28.4 (wet)	29.4 (dry)
Gas density at STP, kg/m ³	1.27 (wet)	1.31 (dry)
% Oxygen correction & Factor	3 %	1.89
Gas Flow Parameters		
Flow measurement time(s) (hhmm)	1430 & 1540	
Temperature, °C	391	
Temperature, K	664	
Velocity at sampling plane, m/s	37	
Volumetric flow rate, actual, m ³ /s	10	
Volumetric flow rate (wet STP), m ³ /s	4.2	
Volumetric flow rate (dry STP), m ³ /s	3.8	
Mass flow rate (wet basis), kg/hour	19000	
Velocity difference, %	<1	

Gas Analyser Results	Sampling time	Average		
		1436 - 1535		
		Corrected to		
		Concentration	3% O ₂	Mass Rate
		mg/m ³	mg/m ³	g/min
Combustion Gases				
Nitrogen oxides (as NO ₂)		230	440	53
		Concentration		
		%		
Oxygen		11.4		

3.3 GO4B

Date	19/03/2019	Client	GHD Pty Ltd (NSW)
Report	R007300	Stack ID	G04B
Licence No.	DA 07_0023	Location	Wilga Park
Ektimo Staff	Aaron Davis / Scott Woods	State	NSW
Process Conditions	Engine operating at 2900kW		

Sampling Plane Details	
Sampling plane dimensions	600 mm
Sampling plane area	0.283 m ²
Sampling port size, number	4" Flange (x2)
Access & height of ports	Elevated work platform 10 m
Duct orientation & shape	Vertical Circular
Downstream disturbance	Exit 8 D
Upstream disturbance	Change in diameter 3 D
No. traverses & points sampled	2 12
Sample plane compliance to AS4323.1	Compliant but non-ideal



Comments
 The sampling plane is deemed to be non-ideal due to the following reasons:
 The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D


Stack Parameters		
Moisture content, %v/v	8.9	
Gas molecular weight, g/g mole	28.4 (wet)	29.4 (dry)
Gas density at STP, kg/m ³	1.26 (wet)	1.31 (dry)
% Oxygen correction & Factor	3 %	1.94
Gas Flow Parameters		
Flow measurement time(s) (hhmm)	1045 & 1155	
Temperature, °C	363	
Temperature, K	636	
Velocity at sampling plane, m/s	37	
Volumetric flow rate, actual, m ³ /s	10	
Volumetric flow rate (wet STP), m ³ /s	4.3	
Volumetric flow rate (dry STP), m ³ /s	3.9	
Mass flow rate (wet basis), kg/hour	20000	
Velocity difference, %	<1	

Gas Analyser Results	Sampling time	Average		
		1050 - 1149		
Combustion Gases	Nitrogen oxides (as NO ₂)	Corrected to		
		Concentration mg/m ³	3% O ₂ mg/m ³	Mass Rate g/min
		230	440	54
Oxygen		Concentration %		
		11.7		

3.4 G01A

Date	20/03/2019	Client	GHD Pty Ltd (NSW)
Report	R007300	Stack ID	G01A
Licence No.	DA 07_0023	Location	Wilga Park
Ektimo Staff	Aaron Davis / Scott Woods	State	NSW
Process Conditions	Engine operating at 3040kW		

Sampling Plane Details			
Sampling plane dimensions		600 mm	
Sampling plane area		0.283 m ²	
Sampling port size, number		4" Flange (x2)	
Access & height of ports		Elevated work platform	10 m
Duct orientation & shape		Vertical	Circular
Downstream disturbance		Exit	8 D
Upstream disturbance		Change in diameter	3 D
No. traverses & points sampled			2 12
Sample plane compliance to AS4323.1		Compliant but non-ideal	



Comments
 The sampling plane is deemed to be non-ideal due to the following reasons:
 The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D


Stack Parameters			
Moisture content, %v/v		9.1	
Gas molecular weight, g/g mole		28.4 (wet)	29.4 (dry)
Gas density at STP, kg/m ³		1.27 (wet)	1.31 (dry)
% Oxygen correction & Factor		3 %	1.76
Gas Flow Parameters			
Flow measurement time(s) (hhmm)		1455 & 1605	
Temperature, °C		391	
Temperature, K		664	
Velocity at sampling plane, m/s		34	
Volumetric flow rate, actual, m ³ /s		9.5	
Volumetric flow rate (wet STP), m ³ /s		3.8	
Volumetric flow rate (dry STP), m ³ /s		3.4	
Mass flow rate (wet basis), kg/hour		17000	
Velocity difference, %		<1	

Gas Analyser Results	Sampling time	Average		
		1500 - 1559		
		Corrected to		
		Concentration	3% O ₂	Mass Rate
		mg/m ³	mg/m ³	g/min
Combustion Gases				
Nitrogen oxides (as NO ₂)		250	440	51
		Concentration		
		%		
Oxygen		10.8		

3.5 GO3A

Date	20/03/2019	Client	Santos Limited
Report	R007300	Stack ID	G03A
Licence No.	DA 07_0023	Location	Wilga Park
Ektimo Staff	Aaron Davis / Scott Woods	State	NSW
Process Conditions	Engine operating at 1000kW		

Sampling Plane Details	
Sampling plane dimensions	320 mm
Sampling plane area	0.0804 m ²
Sampling port size, number	Sampled at exit
Access & height of ports	Elevated work platform 4 m
Duct orientation & shape	Vertical Circular
Downstream disturbance	Exit 0 D
Upstream disturbance	Exit 0 D
No. traverses & points sampled	2 8
Sample plane compliance to AS4323.1	Non-compliant



Comments
 The sampling plane is deemed to be non-compliant due to the following reasons:
 The downstream disturbance is <1D from the sampling plane
 The upstream disturbance is <2D from the sampling plane
 The stack or duct does not have the required number of access holes (ports)

Stack Parameters		
Moisture content, %v/v	8.5	
Gas molecular weight, g/g mole	28.5 (wet)	29.5 (dry)
Gas density at STP, kg/m ³	1.27 (wet)	1.32 (dry)
% Oxygen correction & Factor	3 %	1.50
Gas Flow Parameters		
Flow measurement time(s) (hhmm)	0950 & 1055	
Temperature, °C	540	
Temperature, K	813	
Velocity at sampling plane, m/s	42	
Volumetric flow rate, actual, m ³ /s	3.4	
Volumetric flow rate (wet STP), m ³ /s	1.1	
Volumetric flow rate (dry STP), m ³ /s	1	
Mass flow rate (wet basis), kg/hour	5100	
Velocity difference, %	<1	

Gas Analyser Results	Sampling time	Average		
		0953 - 1052		
Combustion Gases		Corrected to		
		Concentration mg/m ³	3% O ₂ mg/m ³	Mass Rate g/min
Nitrogen oxides (as NO ₂)		280	420	17
Oxygen		Concentration %		
		9		

3.6 G04A

Date	20/03/2019	Client	Santos Limited
Report	R007300	Stack ID	G04A
Licence No.	DA 07_0023	Location	Wilga Park
Ektimo Staff	Aaron Davis / Scott Woods	State	NSW
Process Conditions	Engine operating at 1000kW		

Sampling Plane Details	
Sampling plane dimensions	320 mm
Sampling plane area	0.0804 m ²
Sampling port size, number	Sampled at exit
Access & height of ports	Elevated work platform 4 m
Duct orientation & shape	Vertical Circular
Downstream disturbance	Exit 0 D
Upstream disturbance	Exit 0 D
No. traverses & points sampled	2 8
Sample plane compliance to AS4323.1	Non-compliant



Comments
 The sampling plane is deemed to be non-compliant due to the following reasons:
 The downstream disturbance is <1D from the sampling plane
 The upstream disturbance is <2D from the sampling plane
 The stack or duct does not have the required number of access holes (ports)

Stack Parameters		
Moisture content, %v/v	8.5	
Gas molecular weight, g/g mole	28.6 (wet)	29.6 (dry)
Gas density at STP, kg/m ³	1.28 (wet)	1.32 (dry)
% Oxygen correction & Factor	3 %	1.51
Gas Flow Parameters		
Flow measurement time(s) (hhmm)	0945 & 1050	
Temperature, °C	520	
Temperature, K	793	
Velocity at sampling plane, m/s	38	
Volumetric flow rate, actual, m ³ /s	3.1	
Volumetric flow rate (wet STP), m ³ /s	1	
Volumetric flow rate (dry STP), m ³ /s	0.95	
Mass flow rate (wet basis), kg/hour	4800	
Velocity difference, %	<1	

Gas Analyser Results	Sampling time	Average		
		0949 - 1048		
Combustion Gases		Corrected to		
		Concentration mg/m ³	3% O ₂ mg/m ³	Mass Rate g/min
Nitrogen oxides (as NO ₂)		290	430	16
Oxygen		Concentration %	9	

3.7 G05A

Date	20/03/2019	Client	Santos Limited
Report	R007300	Stack ID	G05A
Licence No.	DA 07_0023	Location	Wilga Park
Ektimo Staff	Aaron Davis / Scott Woods	State	NSW
Process Conditions	Engine operating at 800kW		

Sampling Plane Details	
Sampling plane dimensions	320 mm
Sampling plane area	0.0804 m ²
Sampling port size, number	Sampled at exit
Access & height of ports	Elevated work platform 4 m
Duct orientation & shape	Vertical Circular
Downstream disturbance	Exit 0 D
Upstream disturbance	Exit 0 D
No. traverses & points sampled	2 8
Sample plane compliance to AS4323.1	Non-compliant



Comments
 The sampling plane is deemed to be non-compliant due to the following reasons:
 The downstream disturbance is <1D from the sampling plane
 The upstream disturbance is <2D from the sampling plane
 The stack or duct does not have the required number of access holes (ports)


Stack Parameters		
Moisture content, %v/v	8.6	
Gas molecular weight, g/g mole	28.5 (wet)	29.5 (dry)
Gas density at STP, kg/m ³	1.27 (wet)	1.32 (dry)
% Oxygen correction & Factor	3 %	1.53
Gas Flow Parameters		
Flow measurement time(s) (hhmm)	1300 & 1420	
Temperature, °C	505	
Temperature, K	778	
Velocity at sampling plane, m/s	40	
Volumetric flow rate, actual, m ³ /s	3.2	
Volumetric flow rate (wet STP), m ³ /s	1.1	
Volumetric flow rate (dry STP), m ³ /s	1	
Mass flow rate (wet basis), kg/hour	5000	
Velocity difference, %	<1	

Gas Analyser Results	Sampling time	Average		
		1304 - 1403		
Combustion Gases		Corrected to		
		Concentration mg/m ³	3% O ₂ mg/m ³	Mass Rate g/min
Nitrogen oxides (as NO ₂)		280	430	17
Oxygen		Concentration %		
		9.2		

3.8 G06A

Date	20/03/2019	Client	Santos Limited
Report	R007300	Stack ID	G06A
Licence No.	DA 07_0023	Location	Wilga Park
Ektimo Staff	Aaron Davis / Scott Woods	State	NSW
Process Conditions	Engine operating at 1000kW		

Sampling Plane Details	
Sampling plane dimensions	320 mm
Sampling plane area	0.0804 m ²
Sampling port size, number	Sampled at exit
Access & height of ports	Elevated work platform 4 m
Duct orientation & shape	Vertical Circular
Downstream disturbance	Exit 0 D
Upstream disturbance	Exit 0 D
No. traverses & points sampled	2 8
Sample plane compliance to AS4323.1	Non-compliant



Comments
 The sampling plane is deemed to be non-compliant due to the following reasons:
 The downstream disturbance is <1D from the sampling plane
 The upstream disturbance is <2D from the sampling plane
 The stack or duct does not have the required number of access holes (ports)

Stack Parameters		
Moisture content, %v/v	8.7	
Gas molecular weight, g/g mole	28.5 (wet)	29.5 (dry)
Gas density at STP, kg/m ³	1.27 (wet)	1.32 (dry)
% Oxygen correction & Factor	3 %	1.54
Gas Flow Parameters		
Flow measurement time(s) (hhmm)	1145 & 1300	
Temperature, °C	511	
Temperature, K	784	
Velocity at sampling plane, m/s	42	
Volumetric flow rate, actual, m ³ /s	3.4	
Volumetric flow rate (wet STP), m ³ /s	1.1	
Volumetric flow rate (dry STP), m ³ /s	1	
Mass flow rate (wet basis), kg/hour	5200	
Velocity difference, %	<1	

Gas Analyser Results	Sampling time	Average		
		1149 - 1258		
Combustion Gases		Corrected to		
		Concentration mg/m ³	3% O ₂ mg/m ³	Mass Rate g/min
Nitrogen oxides (as NO ₂)		290	440	18
Oxygen		Concentration %		
		9.3		

4 PLANT OPERATING CONDITIONS

Unless otherwise stated, the plant operating conditions were normal at the time of testing. See Santos Limited's records for complete process conditions.

5 TEST METHODS

All sampling and analysis was performed by Ektimo unless otherwise specified. Specific details of the methods are available upon request.

Parameter	Sampling Method	Analysis Method	Uncertainty*	NATA Accredited	
				Sampling	Analysis
Sample plane criteria	NSW TM-1	NA	-	✓	NA
Flow rate, temperature and velocity	NSW TM-2	NA	8%, 2%, 7%	✓	NA
Moisture content	NSW TM-22	NSW TM-22	19%	✓	✓
Molecular weight / Dry gas density	NSW TM-23	NSW TM-23	not specified	✓	✓
Nitrogen oxides (NO _x)	NSW TM-11	NSW TM-11	12%	✓	✓
Oxygen	NSW TM-25	NSW TM-25	13%	✓	✓

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* Uncertainty values cited in this table are calculated at the 95% confidence level (coverage factor = 2)

6 QUALITY ASSURANCE/QUALITY CONTROL INFORMATION

Ektimo is accredited by the National Association of Testing Authorities (NATA) for the sampling and analysis of air pollutants from industrial sources. Unless otherwise stated test methods used are accredited with the National Association of Testing Authorities. For full details, search for Ektimo at NATA's website www.nata.com.au.

Ektimo is accredited by NATA (National Association of Testing Authorities) to ISO/IEC 17025 - Testing. ISO/IEC 17025 - Testing requires that a laboratory have adequate equipment to perform the testing, as well as laboratory personnel with the competence to perform the testing. This quality assurance system is administered and maintained by the Quality Director.

NATA is a member of APLAC (Asia Pacific Laboratory Accreditation Co-operation) and of ILAC (International Laboratory Accreditation Co-operation). Through the mutual recognition arrangements with both of these organisations, NATA accreditation is recognised worldwide.

7 DEFINITIONS

The following symbols and abbreviations may be used in this test report:

% v/v	Volume to volume ratio, dry or wet basis
~	Approximately
<	Less than
>	Greater than
≥	Greater than or equal to
APHA	American public health association, Standard Methods for the Examination of Water and Waste Water
AS	Australian Standard
BSP	British standard pipe
CARB	Californian Air Resources Board
CEM	Continuous Emission Monitoring
CEMS	Continuous Emission Monitoring System
CTM	Conditional test method
D	Duct diameter or equivalent duct diameter for rectangular ducts
D ₅₀	'Cut size' of a cyclone defined as the particle diameter at which the cyclone achieves a 50% collection efficiency ie. half of the particles are retained by the cyclone and half are not and pass through it to the next stage. The D ₅₀ method simplifies the capture efficiency distribution by assuming that a given cyclone stage captures all of the particles with a diameter equal to or greater than the D ₅₀ of that cyclone and less than the D ₅₀ of the preceding cyclone.
DECC	Department of Environment & Climate Change (NSW)
Disturbance	A flow obstruction or instability in the direction of the flow which may impede accurate flow determination. This includes centrifugal fans, axial fans, partially closed or closed dampers, louvres, bends, connections, junctions, direction changes or changes in pipe diameter.
DWER	Department of Water and Environmental Regulation (WA)
DEHP	Department of Environment and Heritage Protection (QLD)
EPA	Environment Protection Authority
FTIR	Fourier Transform Infra-red
ISC	Intersociety committee, Methods of Air Sampling and Analysis
ISO	International Organisation for Standardisation
Lower Bound	Defines values reported below detection as equal to zero.
Medium Bound	Defines values reported below detection are equal to half the detection limit.
NA	Not applicable
NATA	National Association of Testing Authorities
NIOSH	National Institute of Occupational Safety and Health
NT	Not tested or results not required
OM	Other approved method
OU	The number of odour units per unit of volume. The numerical value of the odour concentration is equal to the number of dilutions to arrive at the odour threshold (50% panel response).
PM ₁₀	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 10 microns (µm).
PM _{2.5}	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 2.5 microns (µm).
PSA	Particle size analysis
RATA	Relative Accuracy Test Audit
Semi-quantified VOCs	Unknown VOCs (those not matching a standard compound), are identified by matching the mass spectrum of the chromatographic peak to the NIST Standard Reference Database (version 14.0), with a match quality exceeding 70%. An estimated concentration will be determined by matching the integrated area of the peak with the nearest suitable compound in the analytical calibration standard mixture.
STP	Standard temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
TM	Test Method
TOC	The sum of all compounds of carbon which contain at least one carbon to carbon bond, plus methane and its derivatives.
USEPA	United States Environmental Protection Agency
VDI	Verein Deutscher Ingenieure (Association of German Engineers)
Vic EPA	Victorian Environment Protection Authority
VOC	Any chemical compound based on carbon with a vapour pressure of at least 0.010 kPa at 25°C or having a corresponding volatility under the particular conditions of use. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonate salts.
XRD	X-ray Diffractometry
Upper Bound	Defines values reported below detection are equal to the detection limit.