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## REPORT – 2015/09/22/RCCS237(0) PARALLEL GASEOUS EMISSION MEASUREMENTS ON THE FLUE OF UNIT 6 AT MEDUPI POWER STATION

Herewith the report for the gaseous emission measurements carried out between the 12<sup>th</sup> and the 18<sup>th</sup> of September 2015. Tests were carried out on the flue of Unit 6.

We thank you for the opportunity to be of service and trust that your requirements have been interpreted correctly. If you have any queries, please contact us at the above numbers, we will gladly assist.

Yours faithfully  
Inthuu Measurements cc



CC Scheepers

# ***INTHUU MEASUREMENTS CC***

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## **REPORT**

**CUSTOMER** : MITSUBISHI HITACHI POWER SYSTEMS AFRICA (PTY) LTD

**OPERATING COMPANY** : MEDUPI POWER STATION

**LOCATION** : LEPHALALE IN LIMPOPO

**TYPE OF MEASUREMENT** : PARALLEL MEASUREMENTS OF COMBUSTION GASES

**TITLE** : GASEOUS EMISSION MEASUREMENTS FROM THE FLUE OF UNIT 6 AT MEDUPI POWER STATION

**ORDER No's.** : LETTER OF INTENT DATED 9 SEPTEMBER 2015

**REPORT No.** : 2015/09/22/RCCS237(0)

**REPORT DATE** : 03 OCTOBER 2015

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**Summary:**

Plant : Medupi Power Station  
 Operating times : 24 hours  
 Emission source : Power generation - fossil fuel boiler  
 Measured components : SO<sub>2</sub>, NO<sub>x</sub>, CO, O<sub>2</sub>  
 Date of measurement : 12th to the 18<sup>th</sup> of September 2015  
 Emission source No. : Unit 6 flue  
 Measurement results : The AMS passes the variability test

Unit	Measured component	Unit of measure	Mean value	Maximum	Limit value
6	SO <sub>2</sub>	[mg/Nm <sup>3</sup> (d)] at 10% O <sub>2</sub>			
	NO <sub>2</sub>	[mg/Nm <sup>3</sup> (d)] at 10% O <sub>2</sub>			
	CO	[mg/Nm <sup>3</sup> (d)] at 10% O <sub>2</sub>			
	O <sub>2</sub>	[% (d)]			

## GLOSSARY

Some of the following abbreviations were used in the text, figures and Tables:

AMS	Automated Measurement System
SRM	Standard Reference Method
CEM	Continuous Emission Monitor
ESP	Electrostatic Precipitator
FFP	Fabric Filter Plant
FGD	Flue Gas Desulphurization
MCR	Maximum Continuous Rating
°C	Degrees Celsius
Pa (g)	Gauge pressure in Pascal
kPa (abs)	Absolute pressure in kilo Pascal
% v/v	Percentage on a Volume-by-Volume basis
Am <sup>3</sup>	<b>Actual</b> Cubic Metres
Nm <sup>3</sup>	<b>Normal</b> Cubic Metres
Am <sup>3</sup> (w)	<b>Actual</b> Cubic Metres on a wet basis
Nm <sup>3</sup> (w)	<b>Normal</b> Cubic Metres on a wet basis
Am <sup>3</sup> (d)	<b>Actual</b> Cubic Metres on a dry basis
Nm <sup>3</sup> (d)	<b>Normal</b> Cubic Metres on a dry basis
ATPD	Actual Temperature and Pressure – Dry
NTPD	Normalised Temperature and Pressure - Dry
g/s	Grams per second
mg/s	Milligrams per second
dP	Differential pressure
AO	Analogue Output

- **'Actual'** refers to the measured temperature and pressure conditions of the gases in the duct.
- **'Normal' or 'Standard'** refers to the actual conditions being normalised to 0 °C and 101,325 kPa.

## **1 MEASUREMENT OBJECTIVE**

Unit 6 was put into commercial operation on the 23<sup>rd</sup> of August 2015. Units 1 to 5 at Medupi Power Station are still under construction. An Automated Measuring System (AMS) is installed on Unit 6 for the monitoring of gaseous emissions in compliance with the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004).

It was decided by Eskom not to perform the stratification measurements prior to the installation, but rather install the monitors and thereafter find the most representative point from where the parallel measurements would take place.

The Installation of the AMS was completed in [February 2015](#).. Eskom's R,T&D performed the stratification measurements and determined the most representative sampling point on the grid before the 11<sup>th</sup> of September 2015. From the stratification measurements, it would be determined whether the distribution of the gases in the measurement plane is homogeneous, allowing parallel measurements from a single point on the grid or whether a full grid measurement would be required.

Inthuu Measurements CC was contracted by Mitsubishi Hitachi Power Systems Africa (PTY) Ltd, to perform the parallel measurements for the gaseous as well as the particulate AMS. The scope of work included a reference measurement at the 150m level to verify that the measurements from the AMS is representative.

Eskom's R,T& D provided the position of the most representative sampling point to Inthuu Measurements on the day of setting up equipment. Eskom witnessed the preparations and the execution of the measurements. No comments were received and no procedural changes were proposed during the period of witnessing. R,T&D advised that a report will be issued in due course.

## **2 PLANT DESCRIPTION AND MATERIALS HANDLED**

On completion, the power station will consist of six power generation units, each consisting of a steam driven turbine and a boiler supplying the steam. The boilers are specially designed to burn low grade coal, which contains high percentages of ash and sulphur. The boilers are equipped with low NOx burners.

Each unit is equipped with particulate matter abatement technology. Medupi uses Fabric filters (FFPs) to clean the boiler waste gases. Currently, no further emission abatement technology is implemented at Medupi Power Station. It is however planned to install Flue Gas Desulphurization (FGD) in the near future.

## **3 DESCRIPTION OF THE MEASUREMENT SITE**

The measuring site is located inside the multi-flue stack.

The stack consists of a concrete outer windshield with three flues inside the windshield. The height of the 220m tall stack is divided into 5 levels, level 5 being the "roof" of the stack. Each level is a complete platform of grating through which the three flues enter from the bottom. The flues are constructed of stainless steel with a refractory brick lining. The flues are supported from the top of the stack with a single expansion joint at 55m. The gaseous and the

particulate AMSs are positioned on the 150m level and measurements took place on the 180m level.

#### 4 MEASUREMENT AND ANALYTICAL METHODS AND APPARATUS

Compound	Method	Comment
Velocity	USEPA Method 2	
Combustion gases:	Horiba PG 250	Portable Gas Analyser
O <sub>2</sub>	Zirconium cell	The analyser calibration was verified before and after the tests using reference gases.
CO <sub>2</sub>	NDIR	
CO	NDIR	
SO <sub>2</sub>	NDIR	
NO <sub>x</sub>	Chemiluminescence	
Homogeneity		Performed by Eskom
Report format	BS EN 15259:2007	
Correlation function	Eskom prescribed format in accordance BS EN 14181: 2014	The spread sheet with areas provided for filling in SRM and AMS values
Variability test	Eskom prescribed format in accordance BS EN 14181: 2014	The spread sheet with areas provided for filling in SRM and AMS values

#### 5 PLANT OPERATING CONDITION DURING THE MEASUREMENTS

##### 5.1 PRODUCTION PLANT

Normal operating conditions were maintained on the unit for the duration of the parallel tests.

The tests were carried out at a condition which represents the normal state of power production. The coal which was burnt during the test period was the normal supply.

The economiser outlet oxygen levels were representative of normal running excess air levels. Air ingress may be expected at the air heaters and the FFPs, but no abnormal ingress air was noticed from the O<sub>2</sub> readings in the stack.

Additional operating data is tabulated in the Appendices.

##### 5.2 WASTE GAS CLEANING UNITS

Medupi Power Station employs a Fabric Filter Plant (FFP) for gas cleaning in terms of particulate matter. Currently, no further emission abatement technology is implemented at Medupi Power Station. It is however planned to install Flue Gas Desulphurization (FGD) in the future.

Boiler ashing and FFP de-dusting are continuous processes.

##### 5.3 AUTOMATED MEASURING SYSTEM

The sampling probe of the AMS protrudes into the inside diameter of the flue by a number of centimetres only.

The port provided for the reference measurement is positioned at an angle between 60° and 90° to the position of the AMS and its probe. Due to the short distance the AMS probe extends into the duct, it was impossible to position the SRM probe to a position close to the AMS probe.

It was requested that the functionality tests are carried out prior to the parallel tests. This request was not fulfilled and some work was done on the AMS during the QAL2 parallel tests.

A leak existed in the sampling line between the probe and the analyser cells. The wrong oxygen was recorded and because the AMS automatically normalises the concentrations, all the measured compounds were firstly diluted with ambient air and then normalised to 10% O<sub>2</sub>. Consequently, only the last 21 hours were available for the parallel measurements.

An effort was made to calculate the AMS measured O<sub>2</sub> as follows: One of the tests (where the leak on the AMS was repaired) was used to draw a correlation between the SRM and AMS O<sub>2</sub> readings. The correlation was implemented to calculate the AMS readings for O<sub>2</sub> during the period before the leak was repaired. The dilution factor was determined using the calculated O<sub>2</sub> and the incorrect reading of the AMS. When this dilution factor was applied to the SO<sub>2</sub> as measured by the AMS before the repair, the calculated matched the SO<sub>2</sub> of the AMS after the repair. The distribution also supports the correlation as given in the figures given in the appendices of this report. This increases the confidence in the methodology used to correct for the period before the leak was repaired.

## **6 PRESENTATION OF MEASUREMENT RESULTS AND DISCUSSION**

### **6.1 EVALUATION OF THE OPERATING CONDITIONS DURING THE MEASUREMENTS**

The stratification measurements were carried out by Eskom's R,T&D department. R,T&D performed the measurements and supplied Inthuu Measurements with the location of the most representative sampling point from where the QAL 2 parallel measurements were carried out.

### **6.2 MEASUREMENT RESULTS**

Parallel measurement information:

The correlation function was determined from the parallel measurements. The function yields the emission in ppm or in percentage at the AMS measured condition (for oxygen). It is the responsibility of the operating company to convert the AMS values (at actual measured conditions) to normalised conditions (given by the emissions license). This is done by using the AMS values for oxygen together with the formulas for each gas given in the Eskom Standard for Emission measurement and reporting.

The table below gives a summary of the correlation function constants for all the gases measured by the AMS and their statistical parameters obtained from the QAL2 procedures.

Unit 6 Stack

Station	Medupi			
Stack/Unit	6			
Parameter	O <sub>2</sub>	CO	SO <sub>2</sub>	NO <sub>2</sub>
Units	%	PPM	PPM	PPM
ELV (%)	21	100	3500	1200
ELV (mg/Nm <sup>3</sup> )				
Uncertainty (%)	0.1	0.2	0.2	0.2
No of Tests	15	13	15	15
<i>Kv value</i>	0.9761	0.9721	0.9761	0.9761
SRM Max	9.0	0.6	3265.6	480.5
SRM Min	7.3	-3.0	2623.5	409.0
Difference	1.7	3.6	642.0	71.6
15% of ELV	3.15	15	525	180
Method A	FALSE	FALSE	TRUE	FALSE
Method B	TRUE	TRUE	FALSE	TRUE
Method used	B	B	A	B
<u>Valid Calibration range</u>				
Minimum	0	0	0	0
Maximum	10.00	-0.05	3436.27	531.33
<u>Variability test</u>				
Standard deviation	0.09	1.82	126.80	34.73
The AMS Pass or fails the test	Pass	Pass	Pass	Pass
<u>Uncertainty data</u>				
<b>m</b>	<b>1.00</b>	<b>-0.20</b>	<b>0.99</b>	<b>0.97</b>
<b>C</b>	<b>0.02</b>	<b>-1.63</b>	<b>6.69</b>	<b>8.48</b>
Uncertainty (±)	0.75	9.92	348.61	119.52

The valid range gives the maximum reportable value ( $\hat{y}_{s,max}$  plus 10%) at normalized conditions.



Further comments to the notes:

The zero and span cycle check values were removed from all the tests where it occurred. When the cycle check values are removed, more than 95% of the readings are available and the tests could therefore be used in the correlation and the variability test calculations. The AMS showed CO values for tests 2 and 3 in excess of 10 ppm. The average CO measured by the SRM did not show a corresponding increase and was omitted from the calculations.

Detailed information is given in the Appendices:

**Appendix A** – Plant parameters

**Appendix B** – Test for homogeneity and the most representative sampling point

**Appendix C** – Calibration function

**Appendix D** – Monitor calibration certificates

**Appendix E** – Reference gas and equipment calibration certificates

**Appendix F** –

# **APPENDIX A**

## **Plant Parameters**

## **Unit 6**

Plant parameters will be made available as soon as it in a format which can be presented here.

# **APPENDIX B**

**Test for homogeneity  
Test for the most representative sampling point**

## **Homogeneity using SO<sub>2</sub> – Unit 6 stack**

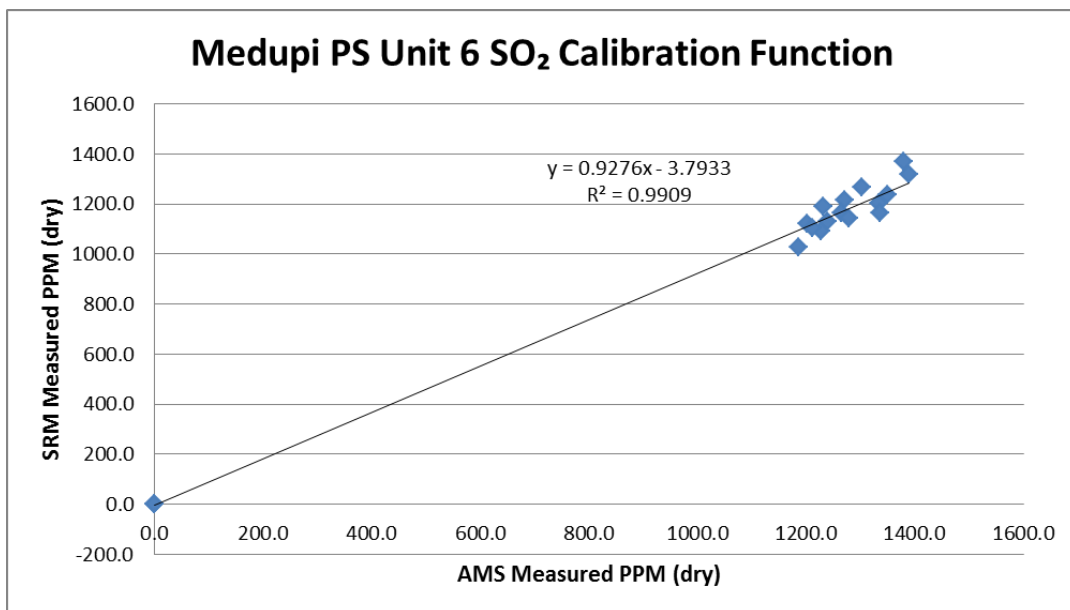
The test for homogeneity was performed by Eskom. If it is made available, it will be included in this report

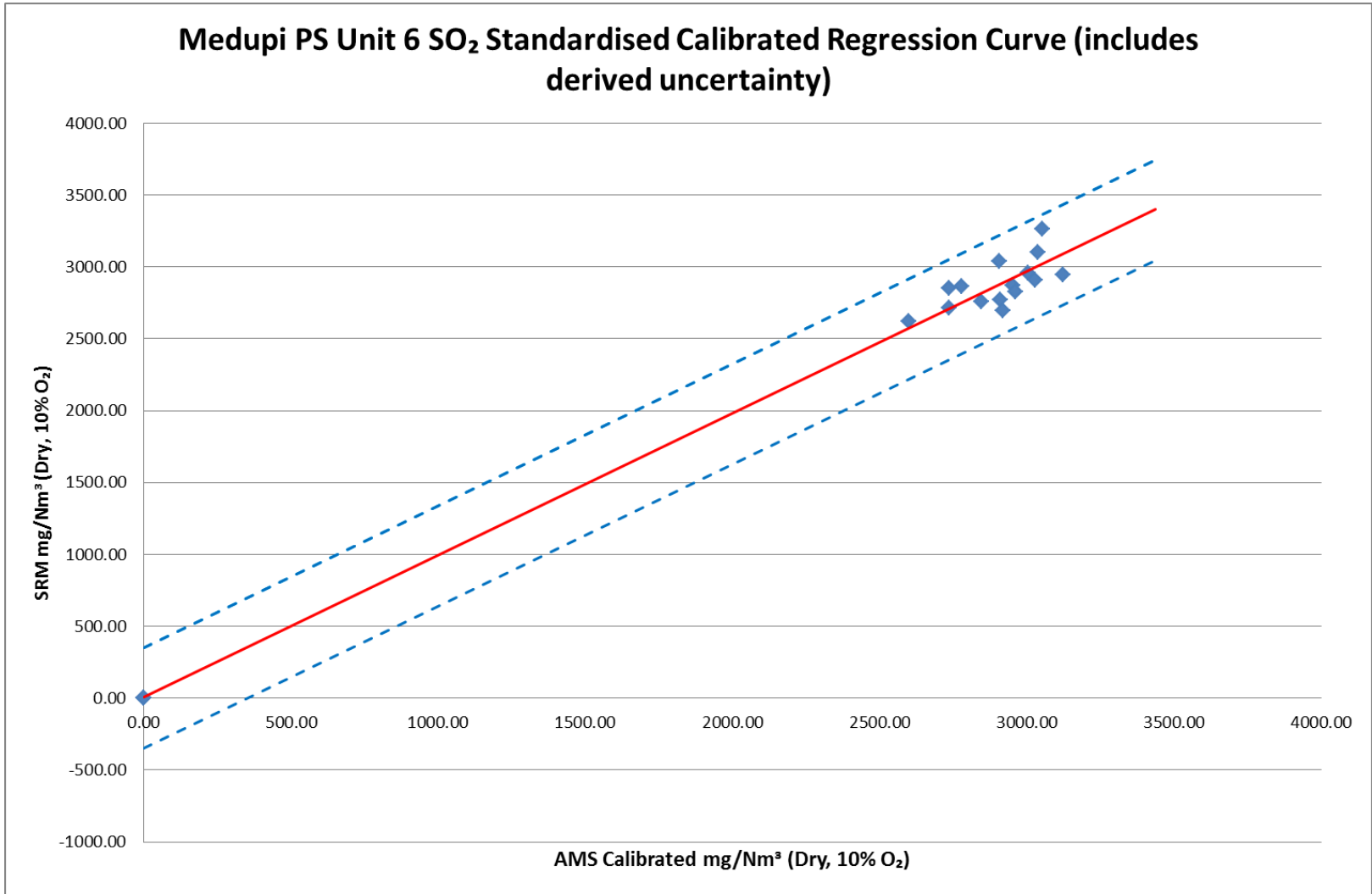
# **APPENDIX C**

## **Calibration Function**

# Unit 6 SO<sub>2</sub>

Medupi PS Unit 6 SO <sub>2</sub> Calibration Function		
Sample Number	AMS ppm (dry)	SRM ppm (dry)
1	1202.1	1123.0
2	1270.5	1216.4
3	1264.5	1165.1
4	1231.3	1190.9
5	1302.8	1265.1
6	1350.9	1235.9
7	1379.8	1370.3
8	1390.3	1317.1
9	1334.8	1203.3
10	1239.4	1130.8
11	1186.1	1026.2
12	1278.4	1142.5
13	1227.4	1091.1
14	1212.3	1104.1
15	1336.1	1166.4
	0	0
	0	0
	0	0

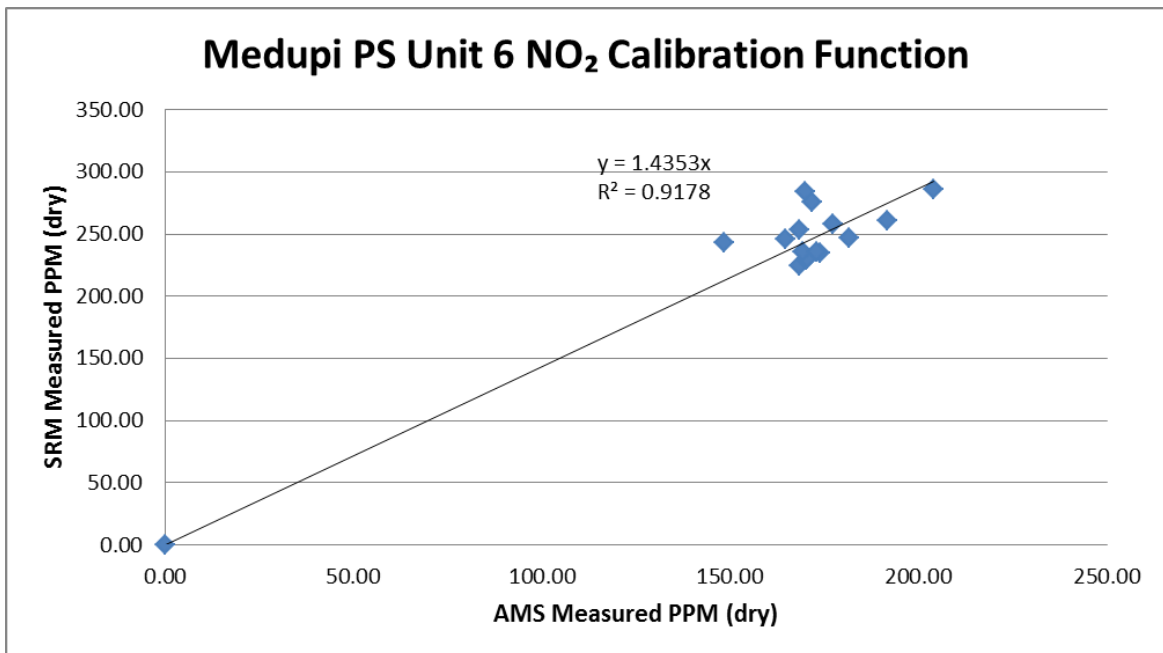


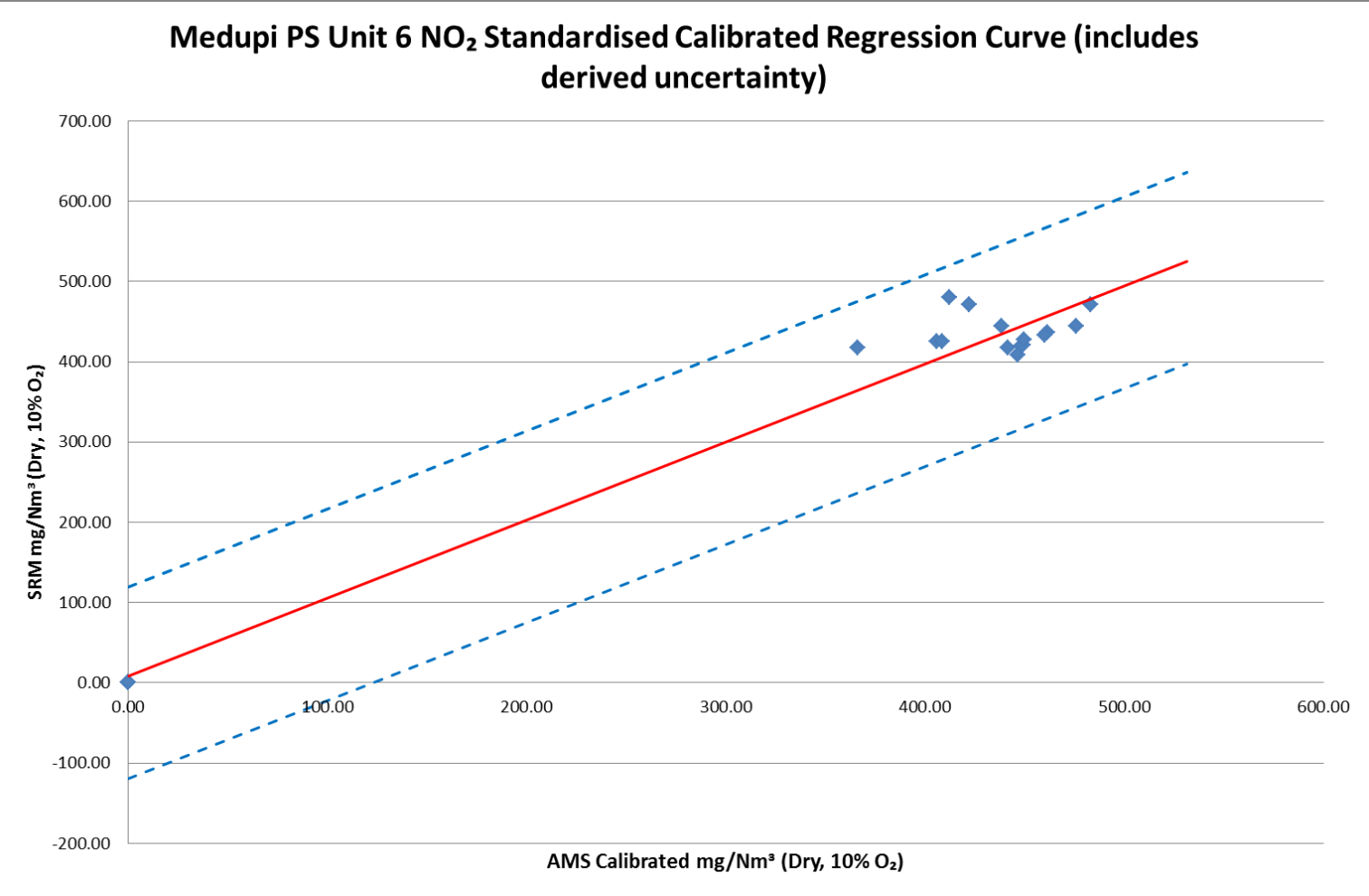




# Unit 6 NO<sub>2</sub>

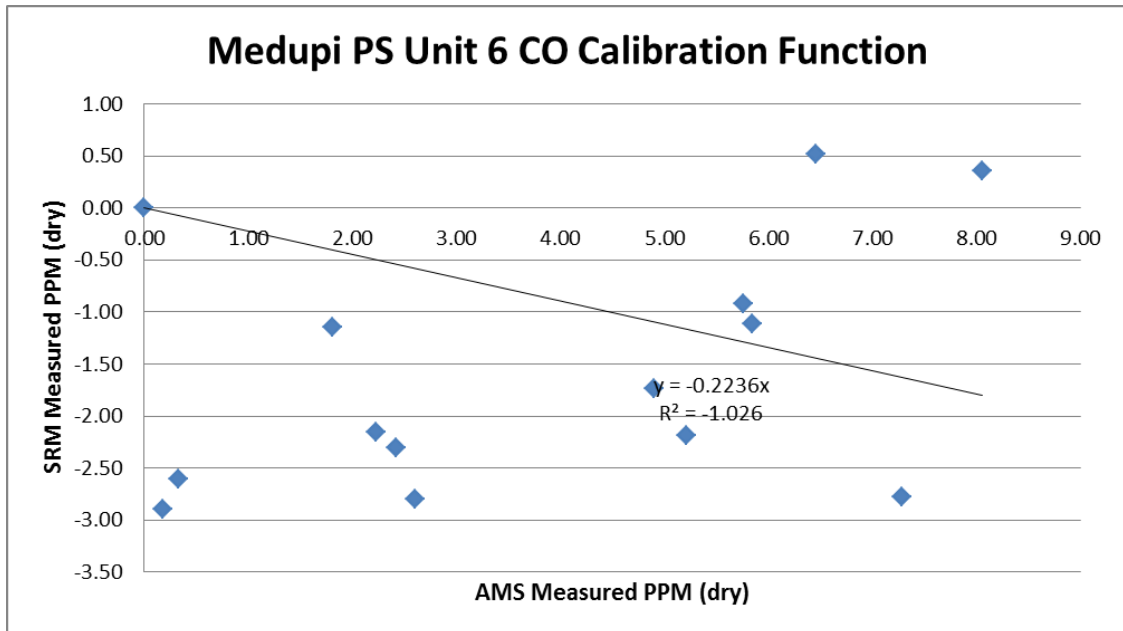
Medupi PS Unit 6 NO <sub>2</sub> Calibration Function		
Sample Number	AMS ppm (wet)	SRM ppm (wet)
1	168.40	253.53
2	181.65	247.11
3	191.77	260.74
4	148.23	242.84
5	164.71	246.14
6	177.39	258.31
7	171.63	275.21
8	169.74	284.23
9	203.87	286.15
10	168.46	224.00
11	173.91	235.08
12	170.34	229.44
13	170.51	230.33
14	169.42	235.89
15	173.07	235.55
	0	0



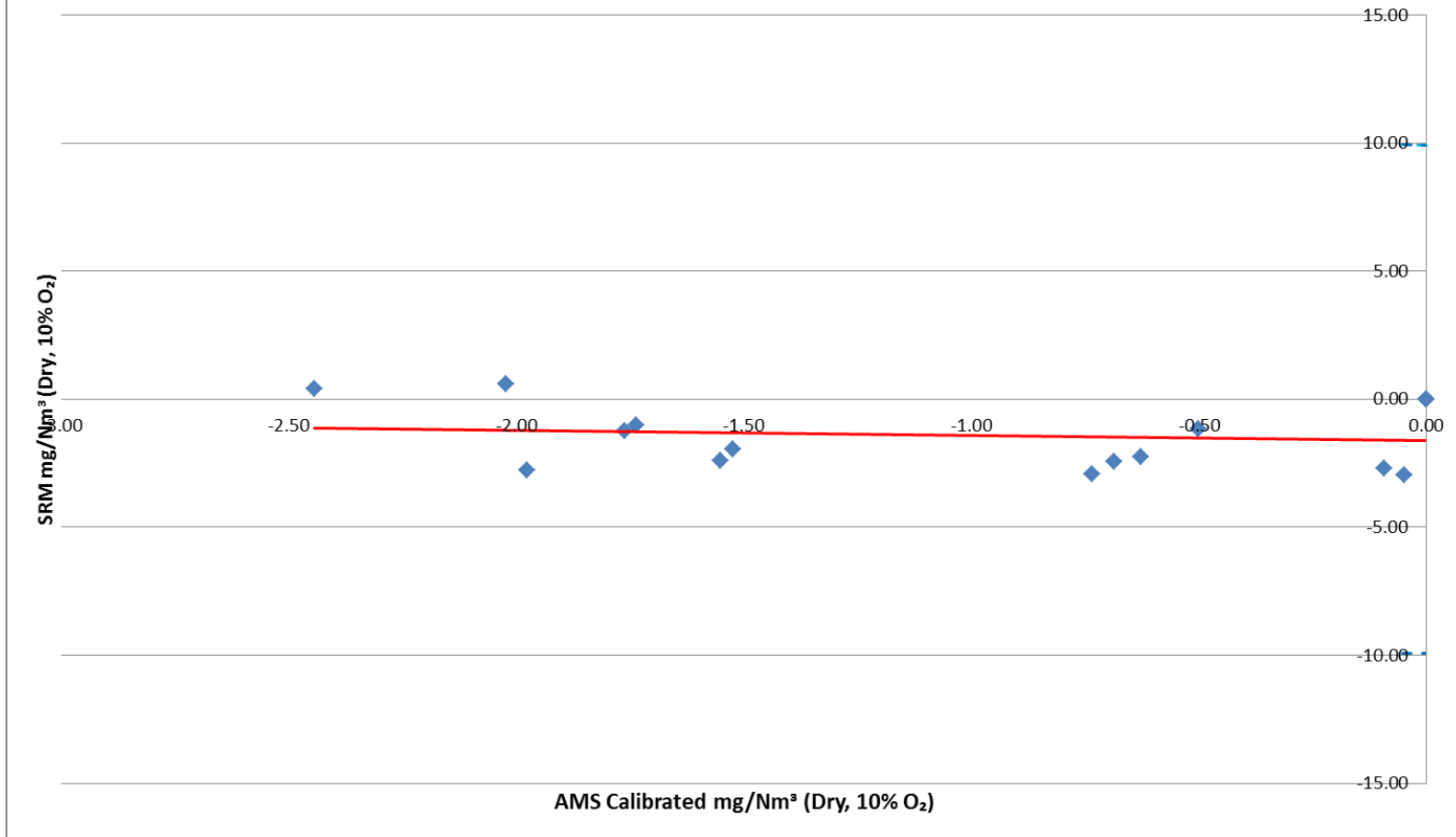


# Unit 6 CO

Medupi PS Unit 6 CO Calibration Function		
Sample Number	AMS ppm (dry)	SRM ppm (dry)
1	1.81	-1.14
2		
3		
4	2.22	-2.15
5	2.42	-2.31
6	2.60	-2.80
7	0.33	-2.60
8	0.18	-2.89
9	7.28	-2.78
10	8.05	0.35
11	6.45	0.51
12	5.76	-0.92
13	5.84	-1.11
14	4.90	-1.73
15	5.21	-2.19
	0.00	0.00

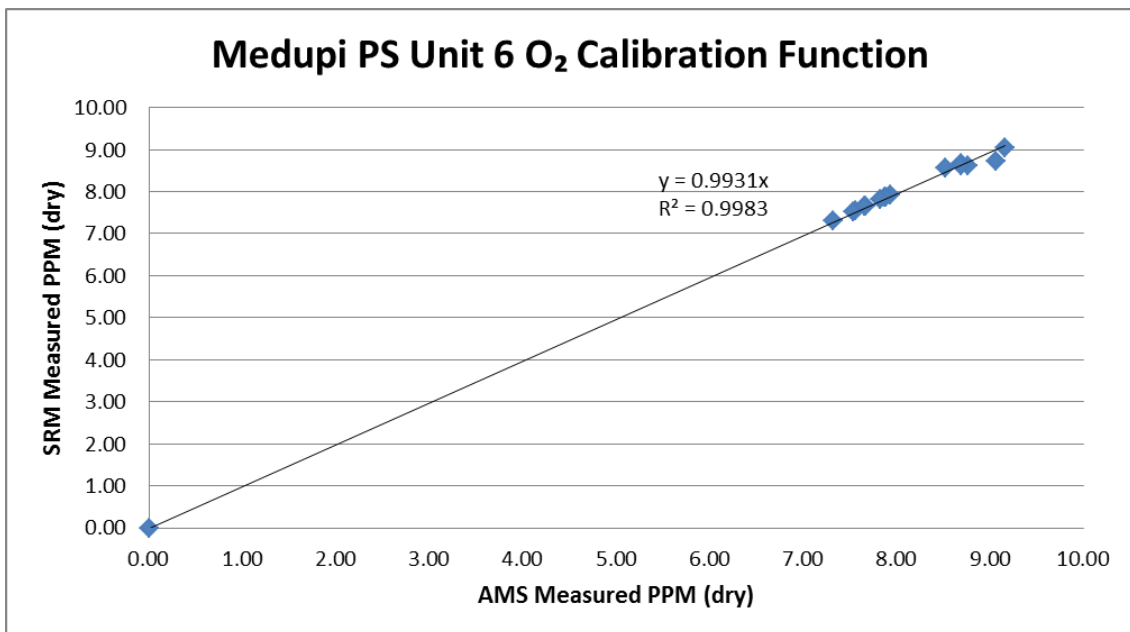


### Medupi PS Unit 6 CO Standardised Calibrated Regression Curve (includes derived uncertainty)

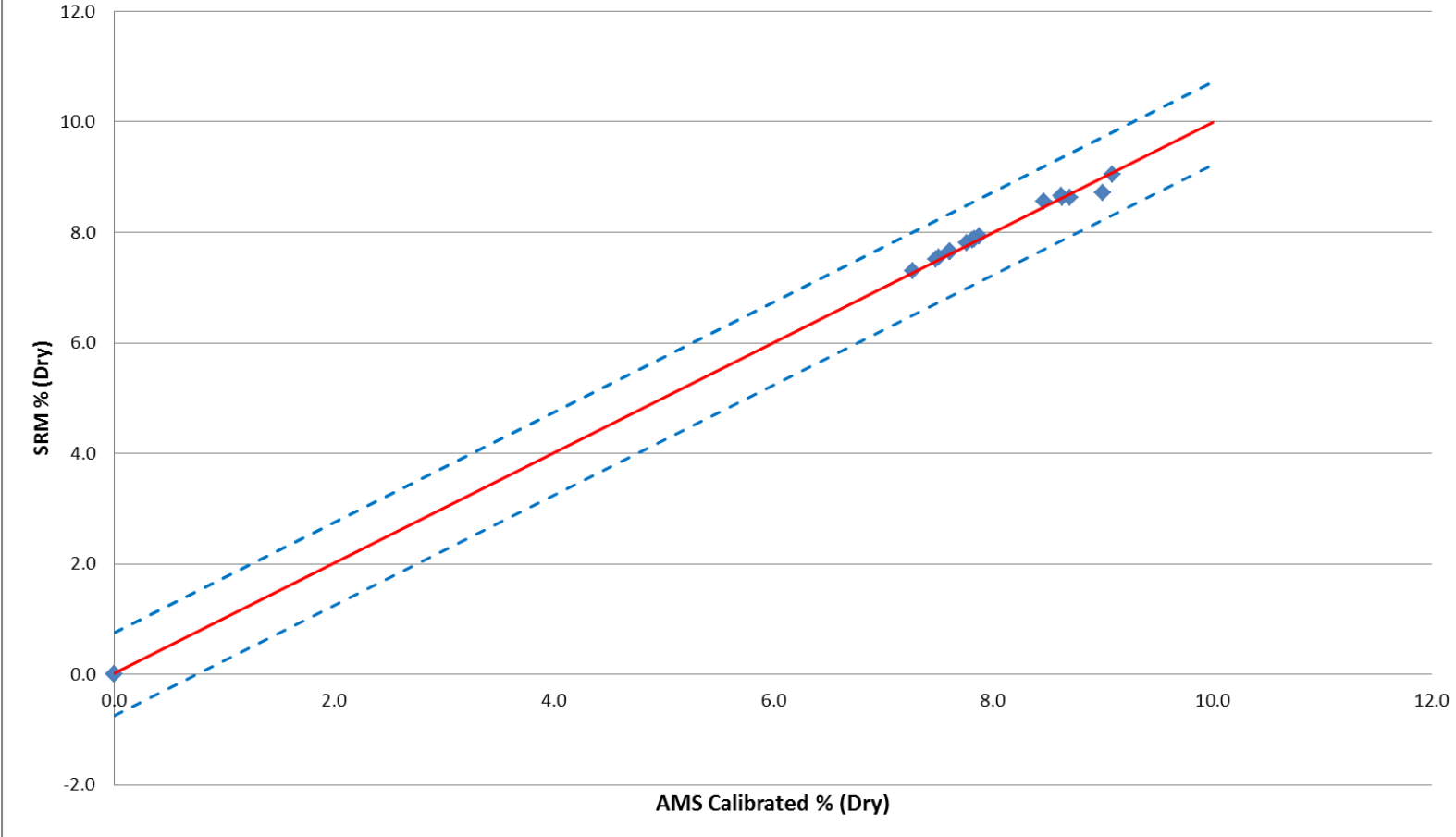


# Unit 6 O<sub>2</sub>

Medupi PS Unit 6 O <sub>2</sub> Calibration Function		
Sample Number	AMS % (wet)	SRM % (wet)
1	7.56	7.54
2	7.66	7.65
3	7.53	7.52
4	7.87	7.86
5	7.94	7.92
6	7.89	7.87
7	7.82	7.81
8	7.66	7.64
9	7.32	7.30
10	8.76	8.63
11	9.15	9.04
12	8.69	8.66
13	8.69	8.63
14	9.06	8.71
15	8.53	8.56
	0	0



**Medupi PS Unit 6 O<sub>2</sub> Standardised Calibrated Regression Curve (includes derived uncertainty)**



# **APPENDIX D**

## **Monitor Calibration certificates**

This was not available at the time of writing the report

# **APPENDIX E**

## **Equipment Calibration Certificates**

Reference gases  
Reference equipment











































## 7 REVISIONS

Revision No.	Date	Description
0	2015/08/03	Original document giving correlation functions in terms of ppm at actual O <sub>2</sub> .

## 8 DISTRIBUTION LIST

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