Camden Power Station
Stack No. 1
Particulate Emission
Monitor Correlation

June2012
Report No. RSL171

P.O. Box 2459
Noordheuwel Ext 4
Krugersdorp 1756
Vat No. 4670254459

10 Chisel Street
Boltonia
Krugersdorp 1739

Tel: +27 (011) 660 9432
Tel: +27 (011) 954
6652Fax:+27(086) 689 4572
www.stacklabs.co.za

Camden Power Station
Ermelo
Piet Retief Road
2355

Attention: C Naicker
Email: Charlene.Chellan@eskom.co.za
Tel: 017 8278601
Mobile: 083 566 2531

Date	Order No.	Report No.	Enquiries
22nd August 2012	3070046757	RSL171	Tel: 011 954 6652 Cell: 082 458 7438 e-mail: pieter@stacklabs.co.za

Report No.: RSL171 2012/08/22
Camden Power Station Stack No. 1 Particulate Emission Monitors Correlation
June 2012

Sir

Herewith the finalised report for the particulate emission monitor correlation conducted on Stack No. 1 at Camden Power Station during June of 2012.

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

PH Pretorius

Stacklabs

ISO 9096, 12141 & 10155

Source Information

Source Location:	Eskom Camden Power Station Ermelo Piet Retief Road 2355 South Africa
Permit No.	TBA
Contact:	C Naicker
Title:	System Engineer
Telephone:	017 8278601
Listed Activity Category:	1.1 Solid Combustion Installation
Plant:	Stack No. 1 - Units/Boilers No. 1 & 2
Survey Date:	June2012
Pollutants:	Particulate Matter Limit 100 mg/Nm^3 dry 10% O_2
Measured Concentration:	29.9 to 54.4 mg/Nm^3 dry10% O_2
Compliance:	Yes – Boilers No. 1 & 2
Method:	ISO 9096, 12141& 10155
Purpose:	Regulatory & Environmental Management
Report No:	RSL171

Testing Laboratory

Laboratory:	Stacklabs 10 Chisel Street Boltonia Krugersdorp 1739
Contact:	Mr.PH Pretorius
Title:	Managing Member
Telephone:	(011) 954 6652
Facsimile:	086 689 4572
E Mail:	pieter@stacklabs.co.za

Report No. RSL171

Reference	SLOP019
Revision	0
Date	2012/05/25
Revision Date	No Revision

Title: Camden Power Station
Stack No. 1
Particulate Emission Monitor Correlations
June 2012

Compiled by	Functional representative	Authorised by
…………………	…………………...	……………………..
TV Byrne	P Buell	PH Pretorius
Site Supervisor	Quality Representative	Managing Member

Review and Certification

All work, activities and tasks performed for this report were carried out under my direction and supervision. All work was conducted in compliance with ISO 9096, 12141&10155

Name: TV Byrne Title: Site Supervisor

Sign:____________________________ Date:_______________________

I have reviewed the details, calculations, results, conclusions and all written material contained within this report, and hereby certify that the presented material is authentic and accurate.

Name: PH Pretorius Title: Managing Member

Sign:____________________________ Date:_______________________

Table of Contents

REPORT SUMMARY

In order to meet the requirements of the South African Air Quality Act No. 39 of 2004 (Reference 1), all Solid Fuel Combustion Installations (Category 1.1) such as Camden Power Station, are obligated to monitor several listed pollutants during operation. These pollutants include particulate matter, Sulphur Dioxide and Oxides of Nitrogen. The Act further specifies that all particulate monitoring programs are required to meet international standards such as ISO 10155 (Reference 2) and therewith ISO 9096 & 12141 (Reference 3 & 4). To this end, Camden Power Station scheduled new continuous particulate emission monitors correlations on two boilers. The risk areas included were Stack No. 1 serving Boilers No. 1 & 2. The pollutant considered was particulate matter (particulate emission monitors correlations).

Continuous particulate emission monitors generally operate on a principle of passing a light beam through a dust-laden gas stream. The dust concentration is then determined by measuring the degree of light attenuation resulting from the dust within the gas stream. However the degree of light attenuation is dependent on more than just the quantity of dust. Dust characteristics such as colour, size, shape and distribution of the dust within a duct, will all impact on the amount of light that is attenuated. In addition, these characteristics will change over time as the plant's electrostatic precipitator or bag filters performances change. In order to compensate for these characteristic changes and to facilitate the determination of mass emissions from the light attenuation, a correlation of light attenuation and measured mass emissions must be conducted at regular intervals. The correlation of the light attenuation and mass emission requires the determination of the actual mass emission emitted from a particular plant by means of isokinetic or Gravimetric dust sampling. This procedure must be conducted over a range of plant operating conditions representative of the plant's general operating conditions and is referred to as a particulate emission monitor correlation or a dynamic calibration.

Stacklabs, an environmental testing laboratory, was contracted by Camden Power Station to complete the required particulate emission monitor correlation. All the required site measurements were carried out from the 31st of May to the 4th of June 2012. The relevant results and correlation graphs for the particulate emission monitor correlation have been presented in this report and may be summarised as follows:

Unit No. 1 Particulate Emission Monitor Correlation Functions

	Particulate Emission Monitor Correlations				
	Date	Function	Correlation	**MME	Monitor
Stack No.		mg/Nm^3(d)=m*mA+c	Coefficient	mg/Nm^3(d)	Range SL
		As Tested			Output 1
1	31st May to 4th June 2012	7.5075*mA-29.3904	0.99	54.4	0 to 200
		As Tested			Output 2
1	31st May to 4th June 2012	15.0150*mA-59.4203	0.99	54.4	0 to 400

Unit No. 1 Air to Gas Flow Correlation Functions

	Air to Gas Flow Correlations				
	Date	Function	Correlation	**MME	Monitor
Stack No.		Nm^3(d) = m*kg/s+c	Coefficient	Nm^3(d)	Range
1	31st May to 4th June 2012	0.9036*kg/s+3.1717	0.99	419.6	n/a

All particulate emissions reported as mg/Nm^3 Dry corrected to 6% O_2
**MME: Maximum Measured Emission during correlation period

Monitoring Deviations

- The uniform distribution of sampling points along the sampling plane could not be achieved (see discussion 5.1).

Recommendations

It is recommended that:

- The particulate emissions from the Units/Boilers No. 1 & 2 at Camden Power Station reported to the authorities are according to the correlations presented in this report.
- The correlations are re-evaluated during the third quarter of 2013.

1. Monitoring Objective

The primary objective of the particulate emission monitor correlation presented in this report is to quantify the concentrations of all particulate matter released into the atmosphere during the operations of the first two Units/Boilers at Camden Power Station. The requirement for conducting this particulate emission monitor correlation is to demonstrate compliance with the requirements of the National Environmental Management: Air Quality Act (39/2004), Listed Activities and Associated Minimum Emission Standards in terms of Section 21, Category 1.1. The substance applicable under Category 1.1 is Particulate Matter which is capped at 100 mg/Nm^3 dry @ 6% O_2.

2. Plant Description & General Operating Procedure

2.1. The two units on which the particulate emission monitors correlation was conducted are designed for a maximum load of 200 MW. Each of these boilers has been retrofitted with pulse jet fabric filters that were designed for the following specifications.

Electrostatic Precipitator Design Data for Units under Test

Description	97% MCR
Number of FFPs in use	2
Gas Volume Flow Rate Worst Coal	415 m^3/s
Gas Temperature	138°C
Inlet Dust Burden	17.7 g/Nm^3
Outlet Dust Burden	30 g/Nm3
Carbon in Dust	n/a
Sulphur in Coal	n/a
Pressure Drop	n/a
Temperature Drop	n/a

During the correlations, the particulate emission measurements were conducted through purpose built ports situated on Stack No. 1.

2.2. The operating regime followed during the correlation periods included all significant activities that arise during normal production. The correlation included measurements at the following conditions:

Day No. 1	1. 92% boiler load @ normal conditions. 2. All ESP fields in service. 3. Test without soot blowing.
Day No. 2	1. 98% boiler load @ normal conditions. 2. All ESP fields in service. 3. Test without soot blowing
Day No. 3	1. 80% boiler load @ normal conditions. 2. All ESP fields in service. 3. Test without soot blowing.
Day No. 4	1. 75% boiler load @ normal conditions. 2. All ESP fields in service. 4. Test without soot blowing.
Day No. 5	3. 98% boiler load @ normal conditions. 4. All ESP fields in service. 5. Soot blowing to be conducted during tests

Perfect plant conditions could not always be maintained and as a result some measurements were conducted at conditions that deviated from those listed above.

All the measurements were conducted between morning and evening peak periods. For an indication of the plant parameters please see Appendix No. 1.

3. Methods & Procedures

The method selected for the determination of the particulate emission concentration on these Units/Boilers was in compliance with ISO 12141 Stationary source emissions - Determination of mass (Low) concentration of particulate material - Manual gravimetric method.

This method can be briefly described as follows:

A sharp-edged nozzle is positioned in the duct, facing into the moving gas stream and a sample flow of the gas is extracted isokinetically for a measured period of time. To allow for non-uniformity of the distribution of particulate concentration in the duct, samples are taken at a pre-selected number of stated positions in the duct cross-section. The particulate matter entrapped in the gas sample is separated by a filter medium, then dried and weighed. The particulate concentration is calculated from the weighed particulate mass and the gas sample volume. The particulate mass flow rate is calculated from the particulate concentration and the duct gas volumetric flow rate. The particulate mass flow rate can also be calculated from the weighed particulate matter, the sample time, the area of the sample plane and the nozzle opening.

The degree to which this sample represents the total gas flow depends on

- *Homogeneity of the gas velocity within the sampling plane;*
- *A sufficient number of sampling points in the sampling plane;*
- *Isokinetic withdrawal of the plane*

As stated above, the gas has to be sampled at more than one sampling point in the sampling plane, dependant on the sampling plane area. This plane is normally divided into equal areas, at the centres of which gas is withdrawn. To determine the particle concentration in the plane, the nozzle is moved from one sampling point to the other, extracting gas isokinetically at each point. Sampling periods should be equal for each sampling point, resulting in a composite sample. If equal sampling areas cannot be chosen, the sampling period shall be proportional to the sampling area. The sample is extracted through a sampling train, which principally consists of:

- *A sampling probe tube with entry nozzle;*
- *A particle separator;*
- *A gas metering system, in-stack or external;*
- *A suction system*

The particle separator and / or the gas metering system may be located either in the duct, or placed outside the duct.

It is necessary to avoid condensation of vapour in the sampling train during gas sampling, because it will interfere with particle separation, particulate condition and flow measurements. To this end, the probe tube, the particle separator and the gas flow-measuring device may be heated above the relevant dew point where necessary. The water vapour may intentionally be removed downstream of the particle separator, to make use of a dry gas meter for the measurement of sampled gas volume.

For isokinetic sampling, the gas velocity at the sampling point in the duct has to be measured, and the corresponding sample gas flow has to be calculated and adjusted.

Normally a Pitot static tube is used for the measurement of duct gas velocity. If the sample gas flow-measuring device is used within the duct, the relationship between the measured pressure drop and the pitot static tube differential pressure is simple, facilitating the adjustment to isokinetic conditions. If the gas meter device is situated outside the duct, the calculation of the isokinetic sample gas flow rate is more complicated. The calculation may also include the duct gas density under standard conditions (which may be derived from the dry gas composition and the moisture content), the temperature and static pressure of the gas in the duct and the gas meter device, and the water vapour content of the duct gas, if the sample gas flow is measured after water removal.

After sampling, the collected particulate matter is completely recovered, dried and weighed and the concentrations are determined.

All Stacklabs isokinetic sampling is carried out employing procedures and equipment that comply with the requirements of ISO 9096 12141 1992 (Reference 1). All Stacklabs sampling equipment is calibrated by SANAS accredited laboratories.

Camden Power Station personnel were responsible for the setting of the plant prior to the test period. Stacklabs was contracted to provide the service of particulate emission monitors correlation through isokinetic dust sampling only.

The broad outlines of filter weighing, pre-test preparations, sampling system integrity checks and sampling procedures are discussed in Appendix No 4.

4. Results

The summarised results of the particulate emission monitor correlation conducted at Camden Power Station have been presented in the following tables.

Unit No. 1

Monitor SN. 10058568
Range Output No. 1 Scattered Light Value 0 to 200

Correlation Test Co-ordinates

Monitor Output	Monitor Output	Dust Mass
mA	%CH	mg/Nm^3 (dry) @ 6% O_2
7.9	24.3	30.0
8.6	28.8	32.3
8.3	26.9	35.0
8.3	26.7	32.1
9.5	34.4	48.4
11.7	48.2	54.4
10.6	41.5	50.8
10.5	40.5	49.1
10.5	40.7	45.5
9.6	34.8	45.4
9.8	36.2	40.2
10.1	38.1	52.1
10.3	39.2	46.9
9.5	34.6	43.3

This correlation also includes three additional zero points

Unit No. 1 Particulate Emission Monitor Correlation Functions

	Particulate Emission Monitor Correlations				
	Date	Function	Correlation	**MME	Monitor
Stack No.		mg/Nm^3(d) = m*mA+c	Coefficient	mg/Nm^3(d)	Range SL
		As Tested			Output 1
1	31st May to 4th June 2012	7.5075*mA-29.3904	0.99	54.4	0 to 200
		As Tested			Output 2
1	31st May to 4th June 2012	15.0150*mA-59.4203	0.99	54.4	0 to 400

*Recommended range which includes the cap value of 200 mg/Nm^3 dry @ 6% O_2

Unit No. 1 Air to Gas Flow Correlation Functions

	Air to Gas Flow Correlations				
	Date	Function	Correlation	**MME	Monitor
Stack No.		$Nm^3(d) = m*kg/s+c$	Coefficient	$Nm^3(d)$	Range
1	31st May to 4th June 2012	0.9036*kg/s+3.1717	0.99	419.6	n/a

All particulate emissions reported as mg/Nm^3 Dry corrected to 6% O_2
**MME: Maximum Measured Emission during correlation period

Abbreviations

The following abbreviations were used in the text, tables and figures:

MCR	Maximum Continuous Rating
°C	Degrees Celsius
% v/v	Percentage on a Volume-by-Volume basis
Am3	Actual Cubic Metres
Nm3	Normal Cubic Metres
Sm3	Standard Cubic Meters
g/s	Grams per second
mg/s	Milligrams per second
Fo	Fields out
FFP	Fabric Filter Plant

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

For the detailed results of the Measurements, Boiler Parameters & Correlation Functions please see Appendixes No. 1 & 2.

5. Discussion

5.1. Unit No. 1& 2

A total of 12 isokinetic measurements were completed on Stack No. 1 from the 31st May to the 4th of June 2012. All 12 measurements were included in the final correlation. The derived correlations produced a correlation with a coefficient value of 0.99. The minimum and maximum emissions measured during the correlation were 29.96 & 54.40 mg/Nm^3 dry @ 6% O_2 respectively. The operating range on Output No. 1 was 0 to 200 scattered light while that of output No. 2 was 0 to 400 scattered light. The maximum operating ranges for the two outputs are 120.8 mg/Nm^3 dry @ 6% O_2 and 240.9 mg/Nm^3 dry @ 6% O_2 respectively (see Figures No. 1 & 2 of Appendix No. 2.

The total air flow to gas flow correlation for Units No. 1 & 2 have also been presented in Appendix No. 2. The maximum gas flow measured during the correlation period was 419.6 Nm^3/s Dry @ 6% O_2.

A further point to note pertains to the physical structure of the stack and the access to the sampling positions. Camden Power Station has recently installed new rack and pinion lifts on all four stacks which substantially improve the accessibility to the sampling level but unfortunately the new installation obscures one sampling port on each stack leaving only three ports available per stack for measurement. The loss of the sampling port therefore leads to an unmeasured quarter in each stack of which the significance cannot be determined without the opportunity of actually measuring the conditions within this quarter. Theoretically, the long straight segment of stack before the measurement levels should result in uniformly distributed gas and particulate flow profiles however deviations from this theory have been measured in at Camden. It is recommended that the air to gas flow data be closely monitor the over the next 18 months in order to determine the necessity for new sampling ports.

6. Monitoring Deviations

The ISO standards have the following requirements that could not be met:

6.1. The uniform distribution of sampling points along the sampling plane could not be achieved (see discussion 5.1).

7. Recommendations

It is recommended that:

7.1. The particulate emissions from Units/Boilers No. 1 & 2, reported to the authorities, are according to the correlations presented in this report.

7.2. The correlations are re-evaluated during the third quarter of 2013.

7.3. The air to gas flow data be closely monitor the over the next 18 months in order to determine the necessity for new sampling ports.

8. Acknowledgement

The author expresses sincere appreciation for the co-operation and assistance of the ESKOM Camden personnel during the correlation.

9. References

9.1. South African Air Quality Act No. 39 of 2004
9.2. ESKOM Standard for emission monitoring and Reporting GST36-742
9.3. ISO 9096 Stationary source emission – Manual Determination of mass concentration of particulate matter.
9.4. ISO 12141 Stationary source emission – Determination of concentration of particulate matter (dust) at low concentrations – Manual gravimetric method.
9.5. ISO 10155 Stationary source emissions – Automated monitoring of mass concentrations of particles – Performance characteristics, test methods and specifications

10. Distribution

10.1. C Naicker	Camden Power Station
10.2. E Patel	Eskom

Appendix No. 1

Detailed Measurement Results
&
Boiler Parameters

Table No. 1 Measurements No. 1 to 7 Results

Station		Camden	Camden	Camden	Camden	Camden	Camden	Camden
Unit No.		1 & 2	1 & 2	1 & 2	1 & 2	1 & 2	1 & 2	1 & 2
Location		Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1
Test No.		1	2	3	4	5	6	7
Date	yyyy/mm/dd	2012/05/31	2012/05/31	2012/06/01	2012/06/01	2012/06/01	2012/06/02	2012/06/02
Start Time	00H00	11H04	14H02	10H06	13H18	15H37	09H13	11H23
End Time	00H00	13H12	15H50	11H56	15H06	17H17	10H53	13H30
Boiler Load	MW	377.0	355.1	393	392	391	325	323
Gas Temperature	°C	143	149	152	150	151	144	141
Barometric pressure	kPa (g)	83.7	83.5	83.4	83.1	83.1	83.7	83.3
Duct pressure	Pa	-156.3	-156.8	-139.0	-140.9	-156.8	-140.6	-162.7
Duct pressure	kPa (abs)	83.5	83.3	83.3	83.0	82.9	83.6	83.1
Moisture	%v/v	7.9	8.2	7.2	7.7	5.4	7.0	6.2
Oxygen	%	7.6	7.6	7.1	6.9	6.7	7.8	7.4
Nozzle diameter	mm	5.5	8.0	8.0	8.0	8.0	8.0	8.0
Sample Time	min	91	90	90	90	90	90	90
Thimbles used		CR1	CR2	CR03	CR04	CR5	CR6	CR7
Average Face velocity 30x100	m/s	0.029	0.060	0.065	0.058	0.059	0.057	0.054
Total Dust Mass	g	0.01568	0.03410	0.04213	0.03500	0.05463	0.05555	0.05183
Velocity	m/s	8.7	8.6	9.4	9.1	8.8	8.7	8.1
Gas Volume Flow	Am^3/s	851.0	842.0	919.5	889.4	857.7	855.4	792.3
Gas Volume Flow	Nm^3/s	460.3	447.4	486.0	470.5	452.4	461.7	428.8
Gas Volume Flow Dry	Nm^3/s	424.0	410.7	451.2	434.1	427.8	429.6	402.1
Gas Volume Flow Dry @ 6% O_2	Nm^3/s	377.9	366.9	419.6	408.2	406.5	376.8	364.3
Dust Concentration Corrected for 6% O_2	mg/Am^3 (wet)	14.9	15.7	17.2	15.7	24.1	27.3	25.8
Dust Concentration Corrected for 6% O_2	mg/Nm^3 (wet)	27.6	29.6	32.5	29.6	45.7	50.6	47.6
Dust Concentration Corrected for 6% O_2	mg/Am^3 (dry)	16.2	17.1	18.5	17.0	25.5	29.4	27.5
Dust Concentration Corrected for 6% O_2	mg/Nm^3 (dry)	30.0	32.3	35.0	32.1	48.4	54.4	50.8
Outlet Dust Flowrate	g/s	11.3	11.8	14.7	13.1	19.7	20.5	18.5
Stack Diameter	m	11.2	11.2	11.2	11.2	11.2	11.2	11.2
Duct Area	m^2	97.82	97.82	97.82	97.82	97.82	97.82	97.82
Monitor Signal Output No. 1 Average	mA	7.9	8.6	8.3	8.3	9.5	11.7	10.6
Monitor Signal Output No. 2 Average	mA	5.9	6.3	6.1	6.1	6.8	7.9	7.3
Isokineticity	%	104.3	103.8	103.4	96.3	100.3	97.6	100.7

Table No. 2 Measurements No. 8 to 14 Results

Station		Camden	Camden	Camden	Camden	Camden	Camden	Camden
Unit No.		1 & 2	1 & 2	1 & 2	1 & 2	1 & 2	1 & 2	1 & 2
Location		Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1
Test No.		8	9	10	11	12	13	14
Date	yyyy/mm/dd	2012/06/02	2012/06/03	2012/06/03	2012/06/03	2012/06/04	2012/06/04	2012/06/04
Start Time	00H00	14H11	09H09	11H22	13H36	09H19	12H11	14H15
End Time	00H00	15H52	10H50	13H06	15H18	11H00	13H52	15H56
Boiler Load	MW	323	297	301	303	392	392	392
Gas Temperature	°C	142	142	136	139	147	149	145
Barometric pressure	kPa (g)	83.2	83.6	83.6	83.6	83.7	83.5	83.4
Duct pressure	Pa	-162.4	-155.9	-170.0	-174.7	-154.9	-162.8	-162.0
Duct pressure	kPa (abs)	83.0	83.5	83.4	83.4	83.5	83.3	83.2
Moisture	%v/v	6.4	7.9	7.1	8.5	6.1	7.5	5.8
Oxygen	%	7.6	8.3	8.0	7.8	6.9	6.7	6.7
Nozzle diameter	mm	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Sample Time	min	90	90	90	90	90	90	90
Thimbles used		CR8	CR9	CR10	CR11	CR12	CR13	CR14
Average Face velocity 30x100	m/s	0.053	0.054	0.055	0.053	0.056	0.057	0.059
Total Dust Mass	g	0.04824	0.04213	0.04454	0.03781	0.05629	0.05128	0.05033
Velocity	m/s	8.2	8.3	7.9	7.6	8.8	8.8	8.8
Gas Volume Flow	Am^3/s	802.1	808.8	774.5	747.7	861.4	856.6	858.9
Gas Volume Flow	Nm^3/s	432.7	438.6	426.2	407.8	462.3	456.3	460.5
Gas Volume Flow Dry	Nm^3/s	405.1	404.0	395.7	373.1	434.1	421.8	433.9
Gas Volume Flow Dry @ 6% O_2	Nm^3/s	363.0	342.4	342.2	327.2	408.4	402.9	414.0
Dust Concentration Corrected for 6% O_2	mg/Am^3 (wet)	24.8	22.7	23.2	20.1	26.2	23.1	21.9
Dust Concentration Corrected for 6% O_2	mg/Nm^3 (wet)	45.9	41.9	42.2	36.8	48.9	43.4	40.8
Dust Concentration Corrected for 6% O_2	mg/Am^3 (dry)	26.5	24.7	25.0	21.9	28.0	25.0	23.2
Dust Concentration Corrected for 6% O_2	mg/Nm^3 (dry)	49.1	45.5	45.4	40.2	52.1	46.9	43.3
Outlet Dust Flowrate	g/s	17.8	15.6	15.5	13.2	21.3	18.9	17.9
Stack Diameter	m	11.2	11.2	11.2	11.2	11.2	11.2	11.2
Duct Area	m^2	97.82	97.82	97.82	97.82	97.82	97.82	97.82
Monitor Signal Output No. 1 Average	mA	10.5	10.5	9.6	9.8	10.1	10.3	9.5
Monitor Signal Output No. 2 Average	mA	7.2	7.3	6.8	6.9	7.0	7.1	6.8
Isokineticity	%	97.2	97.5	103.4	103.6	95.3	97.8	101.4

Table No. 3
Unit No. 1
Measurements No. 1 to 7
Plant Parameters

Station		Camden	Camden	Camden	Camden	Camden	Camden	Camden
Unit No.		1	1	1	1	1	1	1
Location		Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1
Test No.		1	2	3	4	5	6	7
Date	yyyy/mm/dd	2012/05/31	2012/05/31	2012/06/01	2012/06/01	2012/06/01	2012/06/02	2012/06/02
Start Time	00H00	11H04	14H02	10H06	13H18	15H37	09H13	11H23
End Time	00H00	13H12	15H50	11H56	15H06	17H17	10H53	13H30
Generator Load	MW	188.7	180.2	196.9	196.6	194.8	164.5	162.9
Total Coal Flow	kg/s	26.6	25.2	28.4	28.2	28.0	23.4	22.8
Total Air Flow	kg/s	220.2	213.6	227.0	225.0	223.0	200.2	196.2
LH FFP Inlet Temperature	°C	162.1	159.1	158.3	159.6	163.5	153.7	152.4
RH FFP Inlet Temperature	°C	156.0	154.2	157.2	160.3	161.1	146.2	147.6
LH Average O2	%	3.3	3.4	3.2	3.2	3.2	3.5	3.6
RH Average O2	%	3.8	4.0	3.3	3.3	3.3	4.7	4.4
LH FD Fan Motor Amps	A	155.8	150.3	159.1	161.3	157.7	141.7	139.5
RH FD Fan Motor Amps	A	164.0	158.4	167.5	169.5	166.4	149.7	147.3

Table No. 4
Unit No. 1
Measurements No. 8 to 14
Plant Parameters

Station		Camden	Camden	Camden	Camden	Camden	Camden	Camden
Unit No.		1	1	1	1	1	1	1
Location		Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1
Test No.		8	9	10	11	12	13	14
Date	yyyy/mm/dd	2012/06/02	2012/06/03	2012/06/03	2012/06/03	2012/06/04	2012/06/04	2012/06/04
Start Time	00H00	14H11	09H09	11H22	13H36	09H19	12H11	14H15
End Time	00H00	15H52	10H50	13H06	15H18	11H00	13H52	15H56
Generator Load	MW	163.0	145.0	148.1	150.1	196.0	196.0	196.0
Total Coal Flow	kg/s	22.8	20.6	21.1	21.3	27.3	27.4	27.6
Total Air Flow	kg/s	195.5	174.2	182.1	175.5	226.5	228.3	229.4
LH FFP Inlet Temperature	°C	154.0	148.3	150.8	151.6	160.5	162.3	163.6
RH FFP Inlet Temperature	°C	150.0	145.1	144.9	149.7	151.4	154.1	154.9
LH Average O2	%	3.6	4.2	4.0	4.1	3.1	3.1	3.0
RH Average O2	%	4.5	4.9	5.1	4.8	3.5	3.4	3.4
LH FD Fan Motor Amps	A	139.9	133.5	137.5	137.1	154.4	154.1	154.2
RH FD Fan Motor Amps	A	147.5	141.0	145.0	144.3	163.0	162.5	162.8

Table No. 5
Unit No. 2
Measurements No. 1 to 7
Plant Parameters

Station		Camden	Camden	Camden	Camden	Camden	Camden	Camden
Unit No.		2	2	2	2	2	2	2
Location		Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1
Test No.		1	2	3	4	5	6	7
Date	yyyy/mm/dd	2012/05/31	2012/05/31	2012/06/01	2012/06/01	2012/06/01	2012/06/02	2012/06/02
Start Time	00H00	11H04	14H02	10H06	13H18	15H37	09H13	11H23
End Time	00H00	13H12	15H50	11H56	15H06	17H17	10H53	13H30
Generator Load	MW	188.4	174.9	195.7	195.6	195.9	160.5	160.4
Total Coal Flow	kg/s	24.3	22.1	25.6	25.4	25.3	20.7	20.4
Total Air Flow	kg/s	214.1	202.2	220.9	219.0	221.4	193.4	192.9
LH FFP Inlet Temperature	°C	163.8	162.4	160.0	162.9	162.7	153.1	153.8
RH FFP Inlet Temperature	°C	153.9	154.6	150.2	152.6	151.8	145.9	147.5
LH Average O2	%	3.2	3.4	3.1	3.1	3.1	3.6	3.6
RH Average O2	%	4.6	5.1	3.7	3.8	3.7	5.5	5.1
LH FD Fan Motor Amps	A	152.6	146.6	154.7	154.7	154.0	139.4	137.9
RH FD Fan Motor Amps	A	152.5	146.7	154.8	154.5	153.9	140.2	138.6

Table No. 6
Unit No. 2
Measurements No. 8 to 14
Plant Parameters

Station		Camden	Camden	Camden	Camden	Camden	Camden	Camden
Unit No.		2	2	2	2	2	2	2
Location		Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1	Stack No. 1
Test No.		8	9	10	11	12	13	14
Date	yyyy/mm/dd	2012/06/02	2012/06/03	2012/06/03	2012/06/03	2012/06/04	2012/06/04	2012/06/04
Start Time	00H00	14H11	09H09	11H22	13H36	09H19	12H11	14H15
End Time	00H00	15H52	10H50	13H06	15H18	11H00	13H52	15H56
Generator Load	MW	159.9	152.1	153.3	152.4	196.0	196.0	196.1
Total Coal Flow	kg/s	20.4	20.2	19.9	19.8	24.7	24.7	24.6
Total Air Flow	kg/s	192.9	182.5	182.5	182.6	233.5	233.1	235.1
LH FFP Inlet Temperature	°C	155.5	149.4	146.8	148.6	160.2	162.5	163.3
RH FFP Inlet Temperature	°C	148.7	144.3	142.8	144.4	150.3	151.7	152.5
LH Average O2	%	3.6	3.8	3.8	3.8	2.9	2.9	2.9
RH Average O2	%	5.2	5.0	5.1	5.1	4.7	4.6	4.7
LH FD Fan Motor Amps	A	138.3	134.1	134.0	133.3	158.8	158.9	159.5
RH FD Fan Motor Amps	A	138.4	135.3	133.7	133.7	158.3	157.9	158.7

Appendix No. 2

Particulate Emission Monitor Correlations
&
Air to Gas Flow Correlations

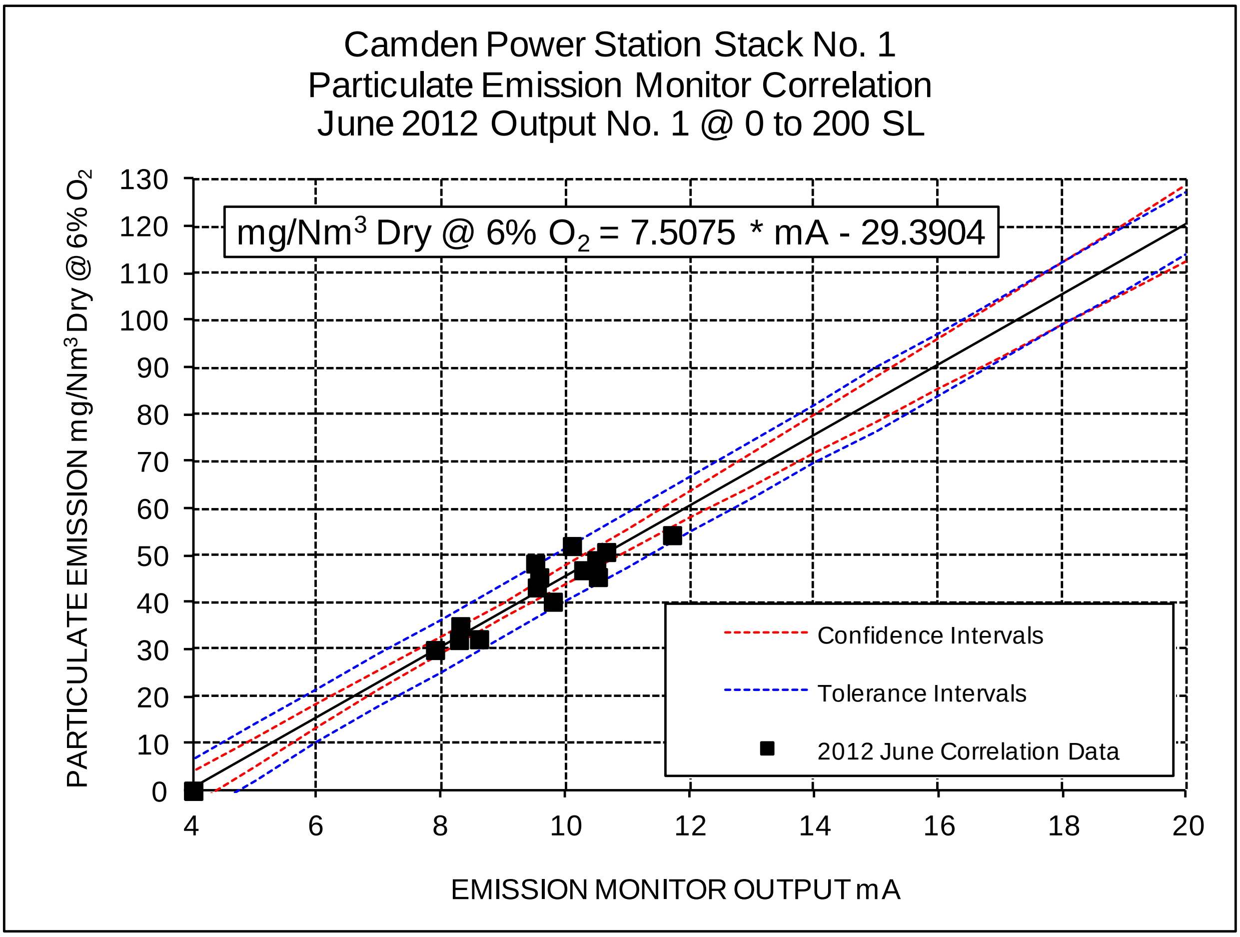
Camden Power Station Stack No. 1

Particulate Emission Monitor Correlation

Plant: Camden PS
Location: Stack No. 1
Monitor information:
Make of Monitor: Sick
Model: SP100
Serial Number: 10058568
Monitor setting: Output 1 (0 – 200 SL)

Dates:
Calibration date: n/a
Correlation dates: 31st May to 4 June 2012
Correlation Coefficient: 0.99

Operational data:
Operating Range: 0 – 120.8 [mg/Nm^3 dry @ 6% O_2]
Limits of validity: [as an hourly average]
Lower limit: 29.9 [mg/Nm^3 dry @ 6% O_2]
Upper limit: 54.4 [mg/Nm^3 dry @ 6% O_2]
Linear function:
E = 7.5075 * x – 29.3904
where: E = [mg/Nm^3 dry @ 6% O_2]
x = Monitor output [mA]
Quartz Filters



This correlation was produced as described in the German VDI guide with reference to the zero point hypotheses.

FIGURE 1

Prepared by: Stacklabs report No. RSL171

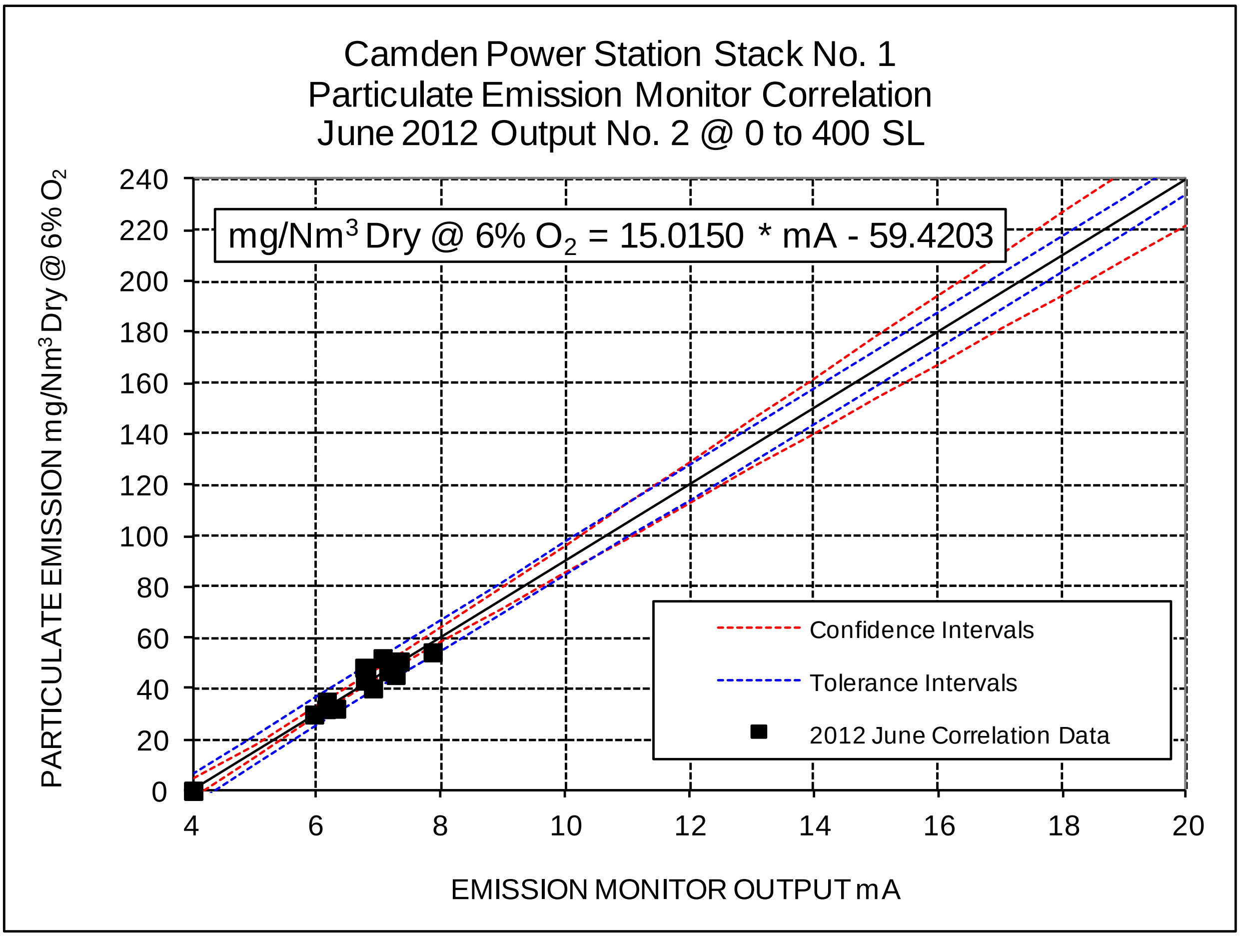
ISO 9096, 12141 & 10155
ISO 9096:2003(E)

Camden Power Station Stack no. 1
Particulate Emission Monitor Correlation

Plant: Camden PS
Location: Stack No. 1
Monitor information:
Make of Monitor: Sick
Model: SP100
Serial Number: 10058568
Monitor setting: Output 2 (0 – 400 SL)

Dates:
Calibration date: n/a
Correlation dates: 31st May to 4 June 2012
Correlation Coefficient: 0.99

Operational data:
Operating Range: 0 – 240.9 [mg/Nm^3 dry @ 6% O_2]
Limits of validity: [as an hourly average]
Lower limit: 29.9 [mg/Nm^3 dry @ 6% O_2]
Upper limit: 54.4 [mg/Nm^3 dry @ 6% O_2]
Linear function:
E = 15.0150 * x – 59.4203
where: E = [mg/Nm^{3}dry@ 6% O_2]
x = Monitor output [mA]
Quartz Filters



This correlation was produced as described in the German VDI guide with reference to the zero point hypotheses.

FIGURE 2

Prepared by: Stacklabs report No. RSL171

ISO 9096, 12141 & 10155
ISO 9096:2003(E)

Camden Power Station Stack No. 1

Air Flow to Gas flow Correlation

Plant: Camden PS
Location: Stack No. 1
Monitor information:
Make of Monitor: N/A
Model: N/A
Serial Number: N/A
Monitor setting: N/A
Dates:
Calibration date: N/A
Correlation dates: 31st May to 4 June 2012
Correlation Coefficient: 0.99

Operational data:
Operating Range: 340 to 550 Nm^3/s Dry 6% O_2
Limits of validity : [as an hourly average]
Lower limit: 327.2 Nm^3/s Dry 6% O_2
Upper limit: 419.6 Nm^3/s Dry 6% O_2
Linear function:
$E = 0.9036 * x - 3.1717$
where: E = [Nm^3/s Dry 6% O_2]
x = Total Air Flow [kg/s]

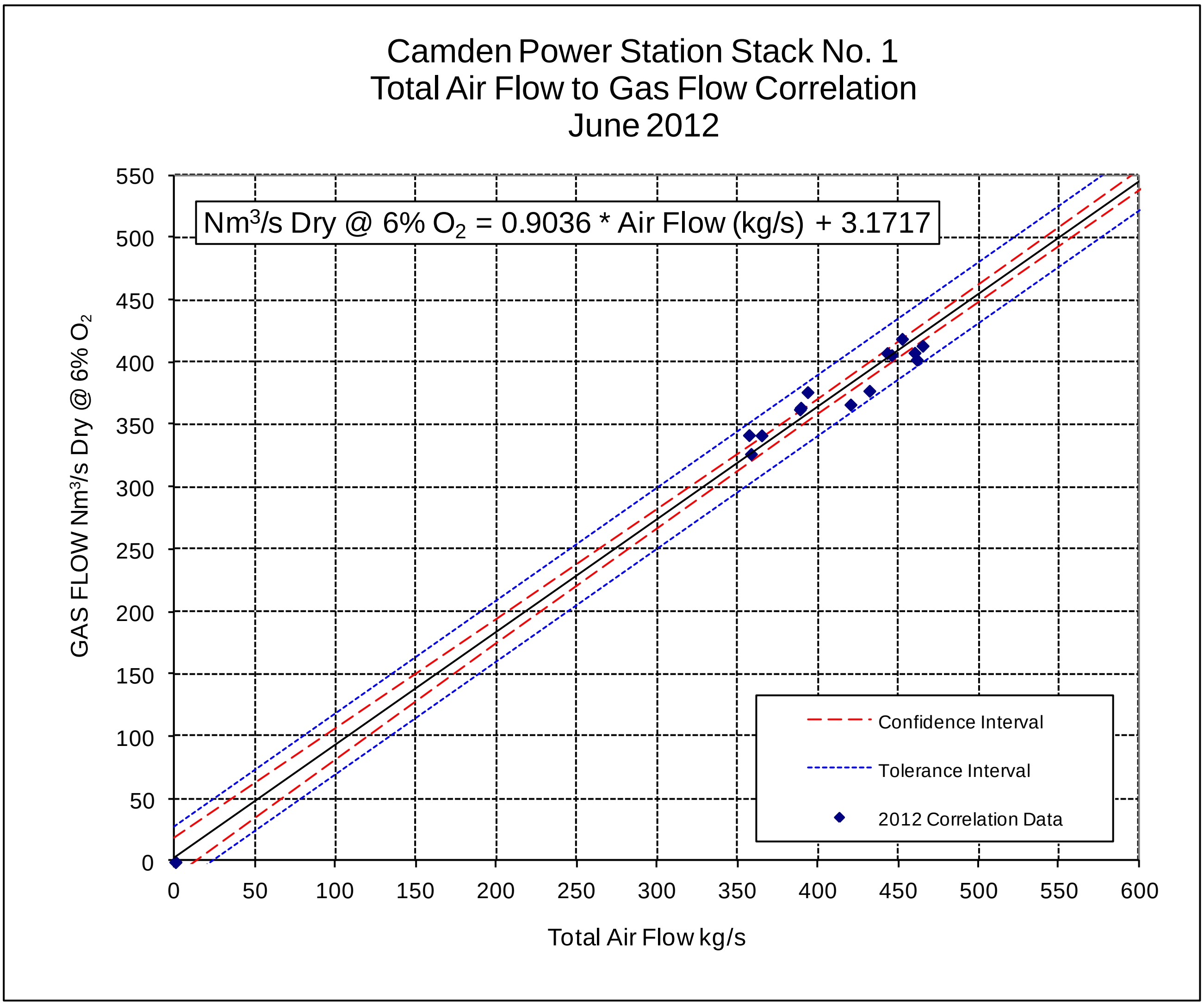


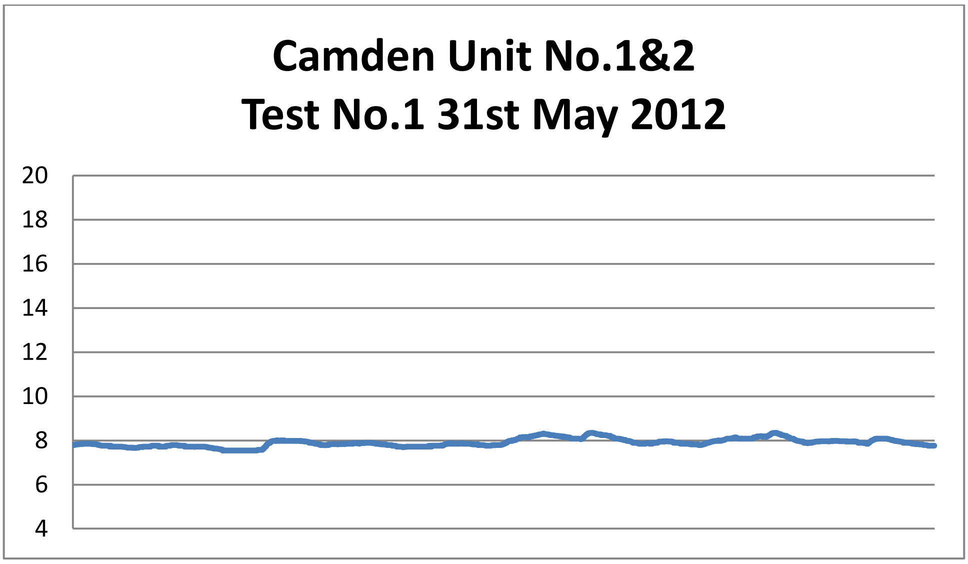
FIGURE 3

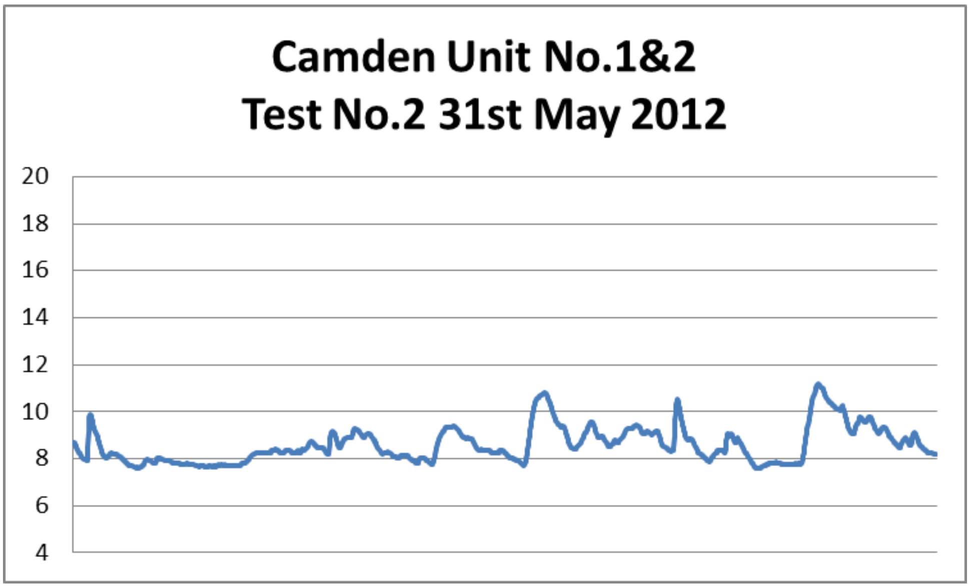
Prepared by: Stacklabs report No. RSL171

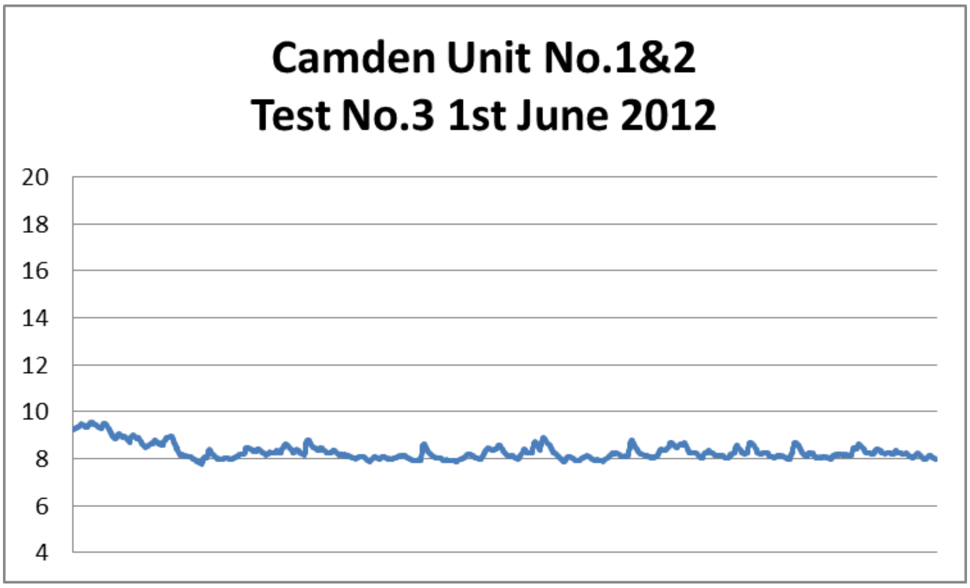
ISO 9096, 12141 & 10155
ISO 9096:2003(E)

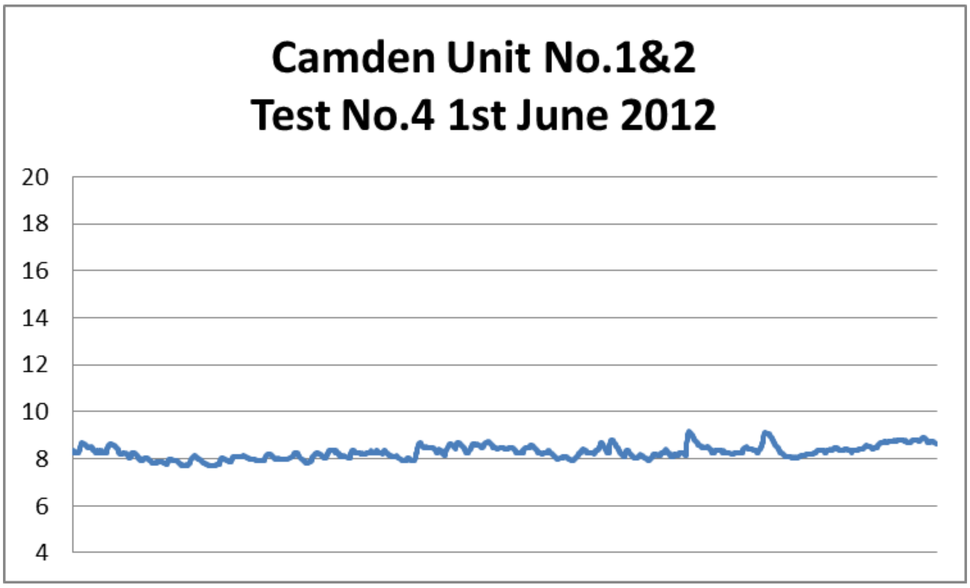
Appendix No. 3

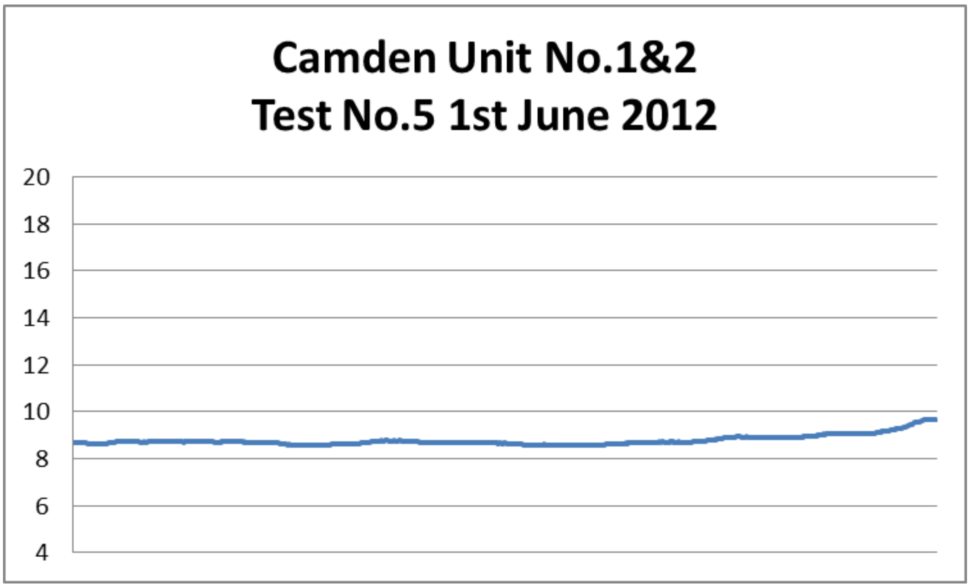
Monitor Signal Data Trends

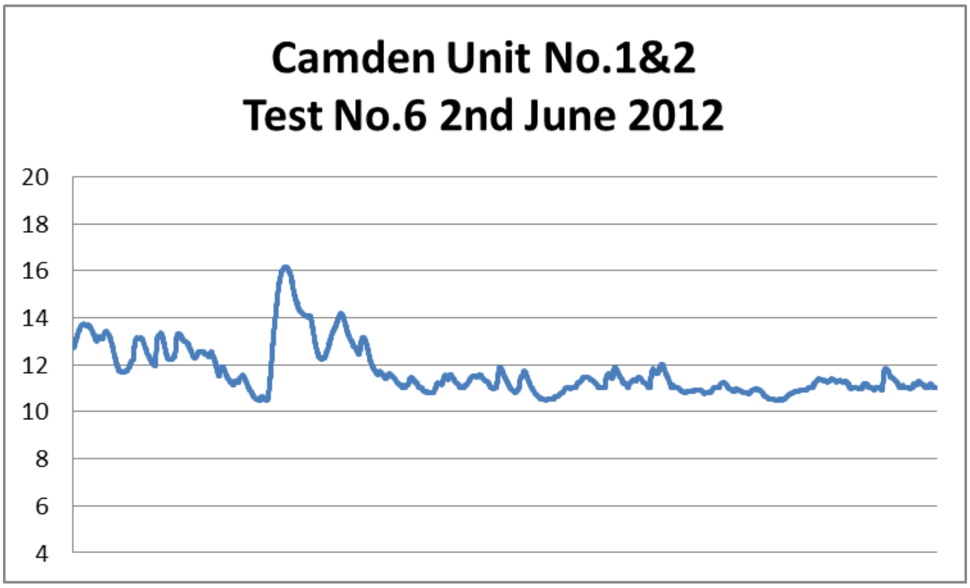

Camden Unit No.1&2
Test No.1 31st May 2012
20
18
16
14
12
10
8
6
4

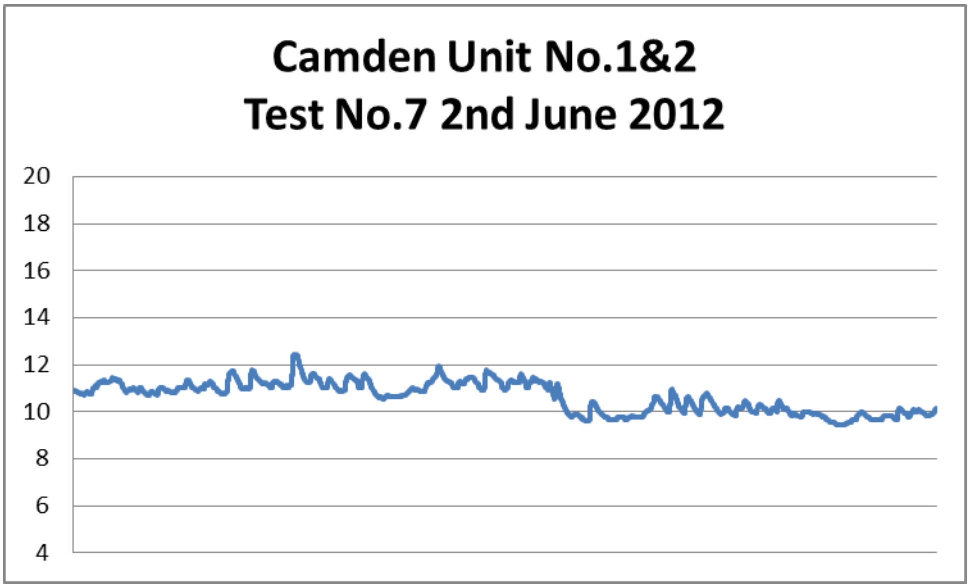

Camden Unit No.1&2
Test No.2 31st May 2012
20
18
16
14
12
10
8
6
4

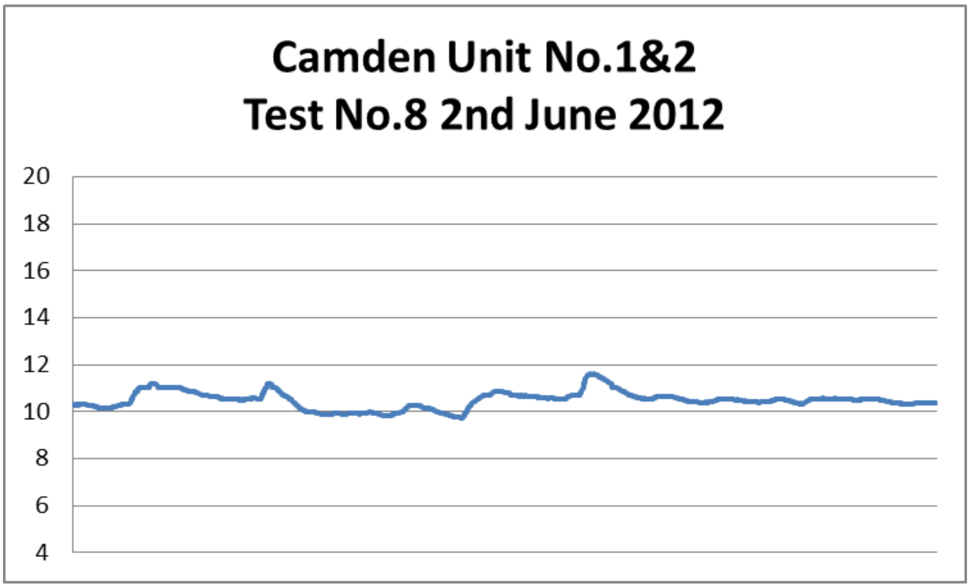

Camden Unit No.1&2
Test No.3 1st June 2012
20
18
16
14
12
10
8
6
4

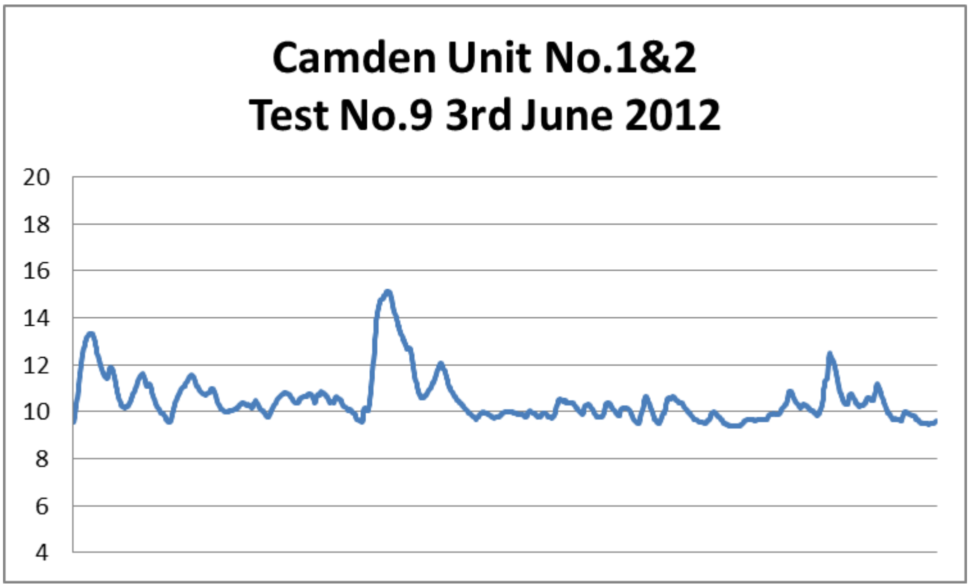

Camden Unit No.1&2
Test No.4 1st June 2012
20
18
16
14
12
10
8
6
4

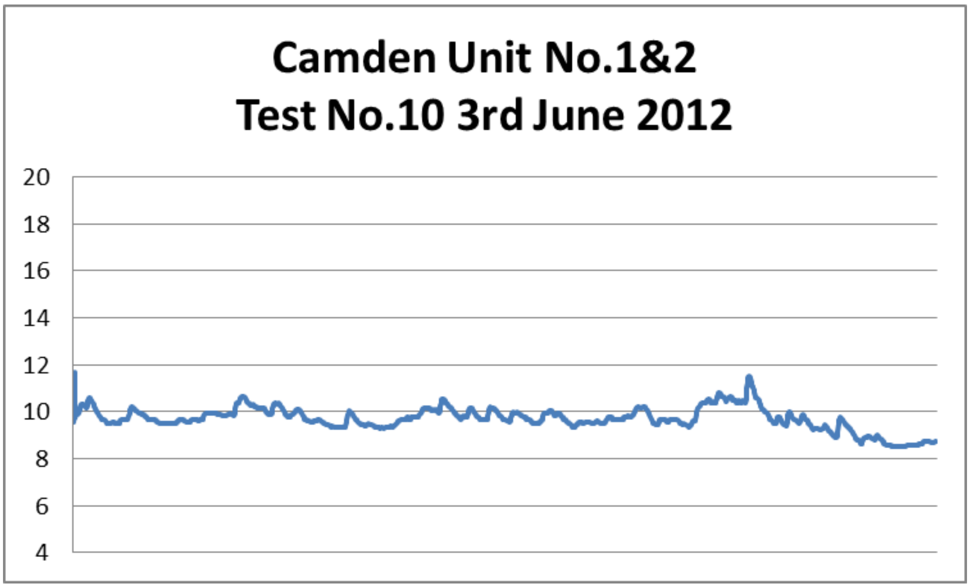

Camden Unit No.1&2
Test No.5 1st June 2012
20
18
16
14
12
10
8
6
4

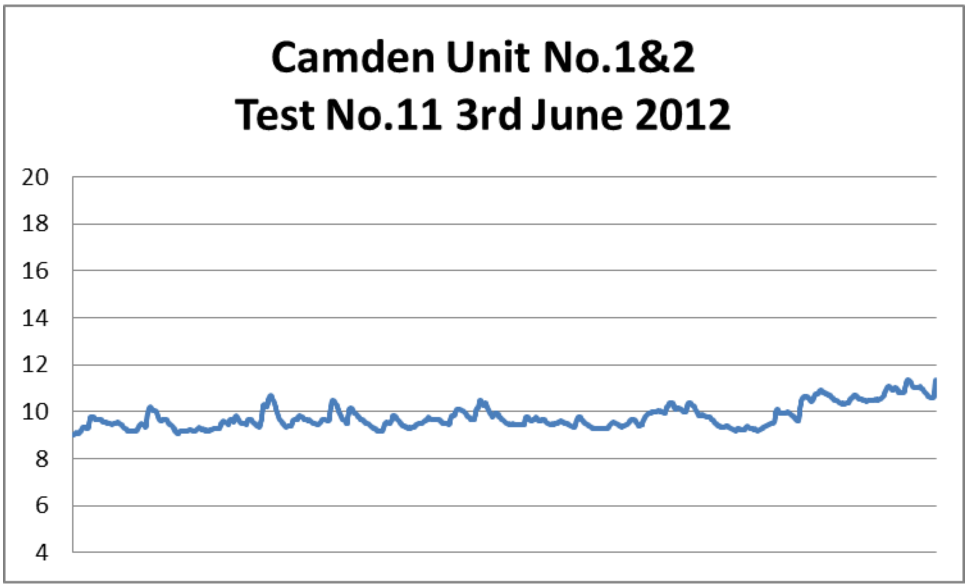

Camden Unit No.1&2
Test No.6 2nd June 2012
20
18
16
14
12
10
8
6
4

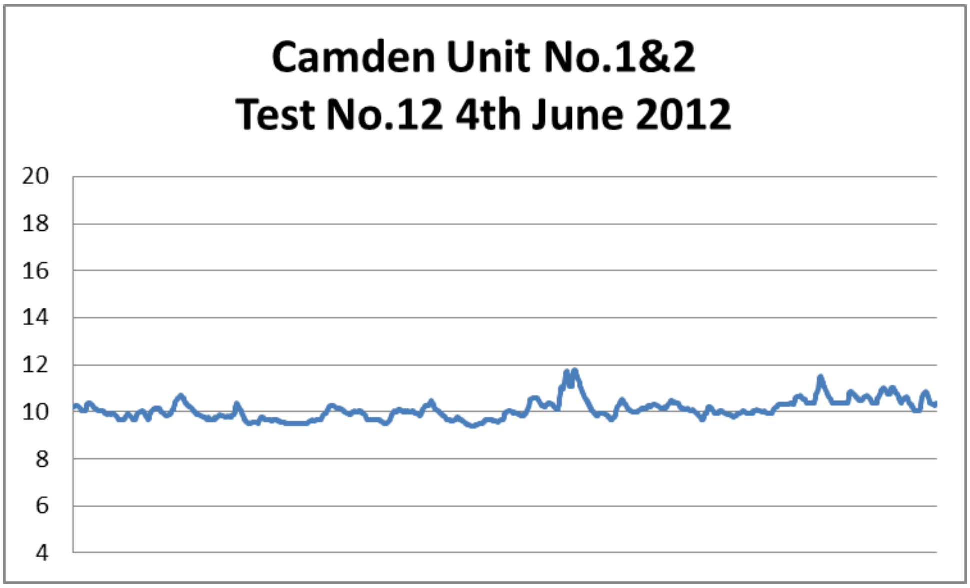

Camden Unit No.1&2
Test No.7 2nd June 2012
20
18
16
14
12
10
8
6
4

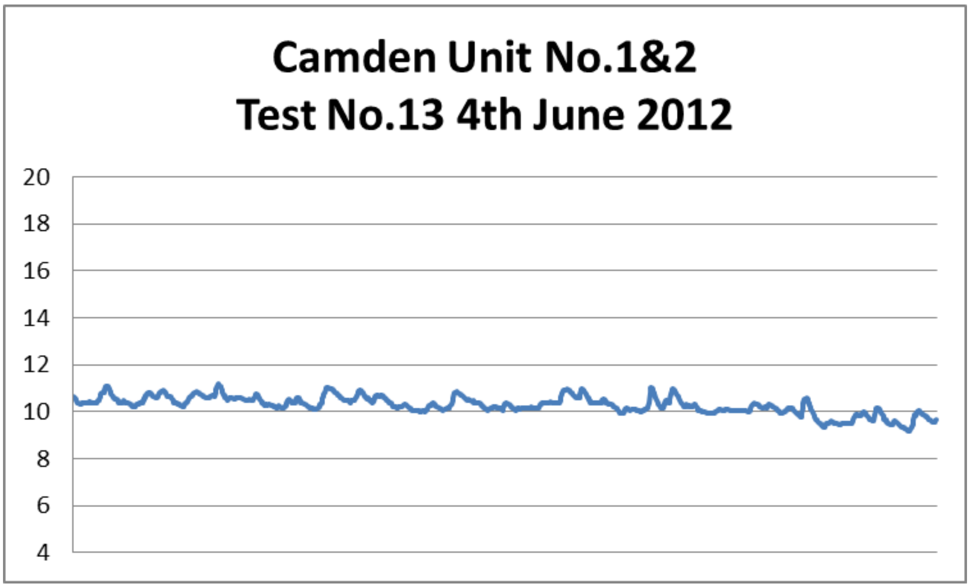

Camden Unit No.1&2
Test No.8 2nd June 2012
20
18
16
14
12
10
8
6
4


Camden Unit No.1&2
Test No.9 3rd June 2012
20
18
16
14
12
10
8
6
4


Camden Unit No.1&2
Test No.10 3rd June 2012
20
18
16
14
12
10
8
6
4


Camden Unit No.1&2
Test No.11 3rd June 2012
20
18
16
14
12
10
8
6
4


Camden Unit No.1&2
Test No.12 4th June 2012
20
18
16
14
12
10
8
6
4


Camden Unit No.1&2
Test No.13 4th June 2012
20
18
16
14
12
10
8
6
4

Appendix No. 4

Water Vapour Concentration Calculation

$$\mathbf{Vwsg\ (std) = (Wf - Wi) / \rho}$$

Where:

Wf	**=**	**Final weight of silica gel & inpinger (g)**
Wi	**=**	**Initial weight of silica gel & inpinger (g)**
ρ	**=**	**Density of water vapour at NTP (0.804 kg/m^3)**
Vwsg (std)	**=**	**Volume of water vapour collected in silica gel (g) at NTP**

$$\mathbf{Bws = \frac{Vwsg\ (std)}{Vwsg\ (std) + Vm\ (std)}}$$

Where:

Bws	**=**	**Proportion of water by volume %v/v**
Vm (std)	**=**	**Dry gas volume measured by dry gas meter (Nm^3 dry)**

Appendix No. 5

Outlines of
Filter Weighing Procedure
Pre-test Preparations Procedure
Sampling System Integrity Checks
And
Sampling Procedures

1. FILTER WEIGHING

Before the test, the filters are prepared as follows:

The required numbers of filters are marked with a unique number. The filters are then heated in an oven at 120 degrees Celsius for a period of one hour. After heating, all the filters are set out together with three reference filters in a dedicator where they will condition for a period of 48 hours. Each filter is then weighed three times, in a temperature controlled clean room, where the masses are captured on a dedicated computer system. Following the weighing process, the filters are packed and sealed into a separate container ready for use. The reference filters are treated in the same manner as those earmarked for the tests, but are not taken to site.

After the site measurements, the used and reference filters are again set out in the desiccators and allowed to condition for up to 100 hours. The same weighing procedure is again followed and the final contaminant masses are calculated by the computer system.

2. PRE-TEST PREPARATIONS

On site, the equipment is set up at the measuring location. The inside dimensions of the duct are determined. The number of test points per traverse is determined according to the standards and the sampling probe marked accordingly

3. SAMPLING SYSTEM INTEGRITY

A leak check is performed on the impulse lines to ensure measurement integrity.

With each change in filter or any other operation which might influence the integrity of the vacuum system, a vacuum check is performed. This ensures that only the gas which entered the nozzle will be measured by the gas test meter. Gaseous analysers are zero and span checked with calibration gas at the measurement points.

4. SAMPLING PROCEDURE

Gas temperature, pressure and velocity head readings are logged at each sampling point. Velocity head readings are updated at intervals of 1 minute. During this time, the computer program calculates the orifice flow settings required for isokineticity and the flow is adjusted accordingly with each update, either automatically or manually depending on the particular system used.

Oxygen in the flue gas is measured to determine gas density.

An orifice flow meter is used to facilitate the adjustment of the sampling flow rate at one-minute intervals. The relevant parameters for flow calculation are entered into the computer. The computer is programmed to determine the flow rate through the orifice in order to achieve isokineticity. A dry gas meter is incorporated into the sampling train and is used to record the total actual volume sampled and therewith to determine the percentage isokineticity.

Moisture is separated from the sampled gases during sampling, using a water trap and silica gel. The ‘A’ indicator in the silica gel changes colour as moisture is absorbed. The accumulated liquid is used after the test to determine the moisture content on a percentage-by-volume basis. This value is again incorporated into the volume of dry gas sampled to determine the concentration of pollutants in the gases at Actual and Normal (sometimes referred to as Standard) conditions.

The uncertainty before the test, about the moisture content in the gas, fluctuation in the gas flows and human error contribute towards the final deviation from 100 % isokineticity.

After completion of a measurement the relevant sampling components may be rinsed in order to capture pollutants that may have become attached to the sampling system's exposed surfaces. The rinse medium is captured and contaminants within will be added to the total sampled mass.

Relevant plant operating parameters are logged, where possible, for reference purposes and it is usually recommended to take raw product samples during the tests. The content of certain elements in the raw product has specific bearing on plant performance and is useful for comparative reference.

On completion of all the site measurements the equipment will be removed from the plant, returned to the laboratory and work shop for processing and cleaning. Where necessary, additional calibration checks will be conducted on specific instruments to determine operational continuity.