Severn Power Limited

Annual surveillance testing of continuous emissions monitoring systems serving two gas turbines



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1015

ANNUAL SURVEILLANCE TESTING OF CONTINUOUS EMISSIONS MONITORING SYSTEMS SERVING TWO GAS TURBINES

Permit No.	HP3737UE
Operator	Severn Power Limited
Installation	West Nash Road Nash Newport NP18 2BZ
Contact	Mr H Edwards
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Test laboratory

Environmental Scientifics Group Limited
Unit D
Bankside Trade Park
Cirencester
Gloucestershire
GL7 1YT

UKAS 1015
Tel +44 (0) 1285 700593
e-mail nick.ford@esg.co.uk

Author

Dr N Ford

MM 02 084
Level 2 – TE1 TE2 TE3 TE4

Approved

Mr M Davies
Operations Manager
MM 02 087
Level 2 – TE1 TE2 TE3 TE4

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Section 1 Executive Summary

1.1 Summary of results

Severn Power Limited contracted Environmental Scientifics Group Limited (ESG) to undertake an annual surveillance test (AST) on the continuous emissions monitoring (CEM) systems serving the exhausts of the two gas turbines (emission points A1 and A2) at their Nash site. This testing is undertaken to confirm that the system performance continues to meet permit requirements.

The assessment was undertaken in accordance with the requirements of BS EN 14181:2014, amended according to TGN M20, which includes MID 14181 as Annex A.

One CEM system operates on each of the gas turbine exhausts.

Both systems have already undergone QAL 2 assessments and subsequent annual surveillance tests:

AST	27 to 28 March 2012	Report 120325 14 May 2012
AST	22 to 25 April 2013	Report 130409, 27 August 2013
AST	9 & 10 June 2014	Report 140311, 23 June 2104
AST	22 & 23 June 2015	Report 150613, 12 November 2015
QAL 2	31 May to 7 June 2016	Report 160518, 30 June 2016

An AST comprises the following activities:

- Installation and management of the CEM systems - undertaking of a functional test.
- Acceptance of variability and verification of calibration function – by means of parallel measurements with standard reference methods (SRMs) and their subsequent comparison with acceptance criteria.
- Determination of the revised calibration range – assessment to determine whether the existing valid calibration range may be extended.

All tasks were undertaken by ESG staff with the exception of certain activities associated with the functional test which were undertaken by Siemens, Severn Power's regular service provider.

All SRM measurements and the subsequent data evaluation in accordance with BS EN 14181 methodology are within the scope of UKAS accreditation. All opinions and interpretations are outside the scope of UKAS accreditation.

The following tables summarise the main results of the assessment.

Table 1.1

Summary of Results – HRSG 10 – A1 Duty CEM

BS EN 14181 AST							
HRSG 10 exhaust (A1)							
Duty CEM							
31 May to 1 June 2017							
Determinand	Calibration function (y = bx + a)		Valid calibration	Extrapolated	Units	Variability Test	Calibration Test
	b	a	Range[4] 0-				
Oxygen (duty)[1]	1.0340	0	16	21	% O_2	Pass	Pass
Nitrogen monoxide[2]	0.8135	2.25	24	-	mgNO/m^3	Pass	Pass
Carbon monoxide	1.0027	2.42	10	50	mgCO/m^3	Pass	Pass
The above calibration functions, once applied, only remain valid as long as the QAL 3 data remains within control limits and as long as there are no manual adjustments made to the CEM other than those allowed to bring the settings back within QAL 3 control limits.							

Table 1.2

Summary of Results – HRSG 20 – A2 Duty CEM

BS EN 14181 AST							
HRSG 20 exhaust (A2)							
Duty CEM							
31 May 2017							
Determinand	Calibration function (y = bx + a)		Valid calibration	Extrapolated	Units	Variability Test	Calibration Test
	b	a	Range[4] 0-				
Oxygen (duty)[1]	1.0296	0	16	21	% O_2	Pass	Pass
Nitrogen monoxide[2]	1.1036	-3.60	21	33	mgNO/m^3	Pass	Pass
Carbon monoxide	1.0429	0.62	10	50	mgCO/m^3	Pass	Pass
The above calibration functions, once applied, only remain valid as long as the QAL 3 data remains within control limits and as long as there are no manual adjustments made to the CEM other than those allowed to bring the settings back within QAL 3 control limits.							

Notes

1 Oxygen is a peripheral measurement which does not strictly require a calibration function (M20, 3.5.17). The AST assessment for this parameter may be viewed as confirmation of satisfactory CEM performance.

2 In accordance with current guidance (M20, 6.5) the annual surveillance test was based on a comparison of CEM and SRM total nitrogen oxides (NO + NO_2) measurements. However, the comparison is undertaken on the nitrogen monoxide calibration function applicable to the nitrogen monoxide measurement prior to conversion to nitrogen dioxide for final reporting.

3 The valid calibration range is that range over which the calibration function is considered to be valid. The extrapolated range is a higher level at which the calibration function is considered valid during occasional excursions above the valid calibration range. Frequent exceedences of the valid calibration range, as defined in BS EN 14181, 6.5, may indicate the need for a reassessment.

In cases where reference materials have been employed to determine the calibration function, the extrapolated range is assumed to be lesser of the applicable ELV and maximum concentration of reference gas applied. The calibrated range is taken as the maximum CEM value achieved in the corresponding parallel testing plus 10% or 20% of the emission limit value, whichever is the higher.

EN 14181, 8.6 specifies the circumstances under which the existing valid calibration range determined during QAL2 may be extended during an AST. On this occasion the calibration ranges for all parameters remain unchanged.

1.2 Deviations and discussion

In the following section any deviations from the requirements of the standard reference methods and BS EN 14181 and their impact on the results obtained are highlighted and discussed.

1.2.1 Compliance with standard reference methods

Measurements undertaken using all standard reference methods met the requirements of the relevant standards with no deviations. The standard reference methods employed are described in Section 3.2.

1.2.2 Compliance with BS EN 14181

The assessment undertaken for all analysers complied fully with the requirements of BS EN 14181:2014, with the following exceptions:

All equipment associated with the permanent analytical systems has MCERTs certification and all analysers were operated within their lower certified ranges. The certified ranges are within the maximum allowable based on a 2.5 multiple of the daily average ELV, with the exception of that for carbon monoxide which has a lower certified range in excess of the maximum.

Direct reading analysers employed as SRMs have MCERTs certification. All analysers were operated within their lower certified ranges.

The conversion efficiencies for the nitrogen dioxide converters serving both CEM systems were below the required level of 95%. However, during the linearity assessment it was noted that at concentrations around those used for the efficiency tests, both analysers were reading between 2 to 4 mg/m^3 lower than the certified reference material. Correcting for the low response would provide a conversion efficiency in both cases above the required 95%. It is therefore considered that the failure is not a result of poor converter performance and as such no further action is required on this occasion.

1.2.3 Impact on results

For determinands with specified emission limit values (nitrogen oxides and carbon monoxide) and those where default ELVs are specified in general guidance (oxygen) the existing calibration functions meet AST acceptability criteria for the CEM systems serving both exhaust streams and are suitable for continued use.

On this occasion the calibration ranges for all parameters remain unchanged.

Oxygen is a peripheral measurement which does not strictly require a calibration function (M20, 3.5.17), although an AST assessment for this parameter provides confidence in the analyser performance.

1.2.4 Required actions

The following actions are recommended:

HRSG 10 (A1) - Duty CEM

Parameter	Comment	Action
O_2	Met AST acceptance criteria.	The existing calibration function is suitable for continued use. No further action is required.
NO	Met AST acceptance criteria based on a comparison of total nitrogen oxides as nitrogen monoxide.	The existing calibration function is suitable for continued use. No further action is required.
CO	Met AST acceptance criteria.	The existing calibration function is suitable for continued use. No further action is required.

HRSG 20 (A2) - Duty CEM

Parameter	Comment	Action
O_2	Met AST acceptance criteria.	The existing calibration function is suitable for continued use. No further action is required.
NO	Met AST acceptance criteria based on a comparison of total nitrogen oxides as nitrogen monoxide.	The existing calibration function is suitable for continued use. No further action is required.
CO	Met AST acceptance criteria.	The existing calibration function is suitable for continued use. No further action is required.

Section 2 Information about the regulated installation

2.1 Regulatory information

Table 2.1 provides information on the installation and its regulation.

Table 2.1

Regulatory Information

Operator		Severn Power Limited			
Installation		Nash			
Address		West Nash Road Nash Newport Gwent NP18 2BZ			
Industry sector		Power generation			
Permit No.		HP3737UE			
Date of last QAL 2 or AST		31 May to 7 June 2016 (QAL2)			
Regulated determinands and emission limit values (STP, 15% oxygen, dry gas basis)					
HRSG exhaust stacks (A1 & A2)					
Determinand		Short term ELV	Daily average ELV	Maximum allowable certified CEM range	Uncertainty requirement (%)
Oxygen	%	-	(21)	-	(10)
Nitrogen oxides	$mgNO_2/m^3$	-	50	125	20
Carbon monoxide	$mgCO/m^3$	-	50	125	20

Maximum allowable certified ranges are based on a multiple of 2.5 times the daily average ELV.

Factors for the peripheral measurement of oxygen are based on M20, 3.5.17.

2.2 Operational information and site monitoring provisions

The installation is an 800MW natural gas fired combined cycle gas turbine (CCGT) plant comprising two generators, a waste heat recovery boiler and a steam turbine.

Exhaust gases from the system are passed to two exhaust stacks (denoted emission points A1 and A2) for release to atmosphere.

2.2.1 Process type and variation in emissions

Is the process continuous or batch?	Process is continuous when required.
Were there any variations in emissions during the BS EN 14181 test (e.g. load changes)?	Load is dependent on demand, although load was reasonably stable over the periods of the AST taking into account the pattern of demand.
Will these variations affect the representativeness of the data collected?	No.
Are there any factors that may affect the collected data (e.g. auto-calibrations, start up, shutdown)?	Periods of auto calibration and start up and shutdown have been excluded from the assessment.
Based on historical plant information were low emissions expected for any determinand, and if so were any special provisions made?	Low concentrations, relative to the ELV, were expected for carbon monoxide, although no special provisions were considered necessary for the assessment.
Was the CEM reading zero for any determinands and if so was this investigated to ensure proper operation?	No persistent zero readings were encountered. The CEM's response for all parameters was checked during the linearity assessment and found to be compliant with acceptance requirements.

2.2.2 Type of fuel

Type of fuel used during the AST?	Natural gas.
Is the fuel use typical of that during a normal operating year?	Yes.

2.2.3 Abatement

What abatement systems are applied to the exhaust gases?	Dry low NO_x burners
What impact do these measures have on emissions?	Controls the formation of nitrogen oxides.

2.3 Monitoring provisions at the installation for periodic monitoring

2.3.1 Stack and sampling ports

The sampling locations associated with the exhaust of the gas turbines are illustrated in Figure 1. The sampling platform for each stack (see Figure 1) is located just above the roof exit and is accessed via stairs and a short hooped ladder. Each of the exhaust stacks has a circular cross section of diameter 8.0 m providing a sampling plane area of around 50.5 m^2. Four off 5" (125 mm) sampling sockets (denoted A to D) are available positioned at 90° to each other on each stack which provide access to each sampling plane along four radii.

The sampling of determinands in accordance with the requirements of BS EN 13284-1 for this geometry of flue requires sampling at a total of at 20 points, located at the centres of equal areas on two sampling lines. This is most conveniently achieved in this case by sampling at five points on each of the radii accessible via sockets A to D.

In this case all manual extractive sampling of gaseous parameters was undertaken at a single representative point within each stack. The suitability of this approach was confirmed by an assessment of the stack gas conditions which confirmed homogeneity in accordance with the requirements of BS EN 15259, Clause 8.3.

The sampling heads for the CEM systems are also present on each platform.

In each case all measurements were made downstream of all inlets to the stack and represent the final emission to atmosphere of the process.

2.3.2 Monitoring platform and site provisions

The platform around the sampling area for each stack also houses the sampling head for the analysers. The analyser is located in a cabinet at ground level. Both the sampling head and analyser cabinet are protected from the weather. The working area available is adequate both at the sampling platform and around the analyser cabinet.

The CEM systems are covered by an external service contract with Siemens Limited. Materials are provided under this arrangement and as such the site holds a limited supply of tools and spares.

An adequate stock of reference materials is held on site (see Table 2.2). All materials held were within their certification expiry dates at the time of this assessment.

The analysers have facilities for introducing reference materials both at the inlet of the sampling line and the inlet of the analyser.

In view of the size of the stack and restricted access, it was not possible to measure the average flow conditions at the stack or determine whether these met the flow stability requirements of BS EN 13284-1, 5.2.

The manual extractive sampling positions have been assessed to determine homogeneity. Compliance with the requirements of BS EN 15259 (and MID 15259) has been confirmed for all determinands where appropriate (report reference NEL 2011/93, 23 March 2011).

Table 2.2

Reference material audit – 30 May 2017

Gas	Certified concentration	Cylinder No.	Expiry date
Unit 10 CO	101.2 ppm	163264	27.10.2020
Unit 10 NO	94.6 ppm		
Unit 20 CO	100.6 ppm	108632	27.10.2020
Unit 20 NO	94.5 ppm		

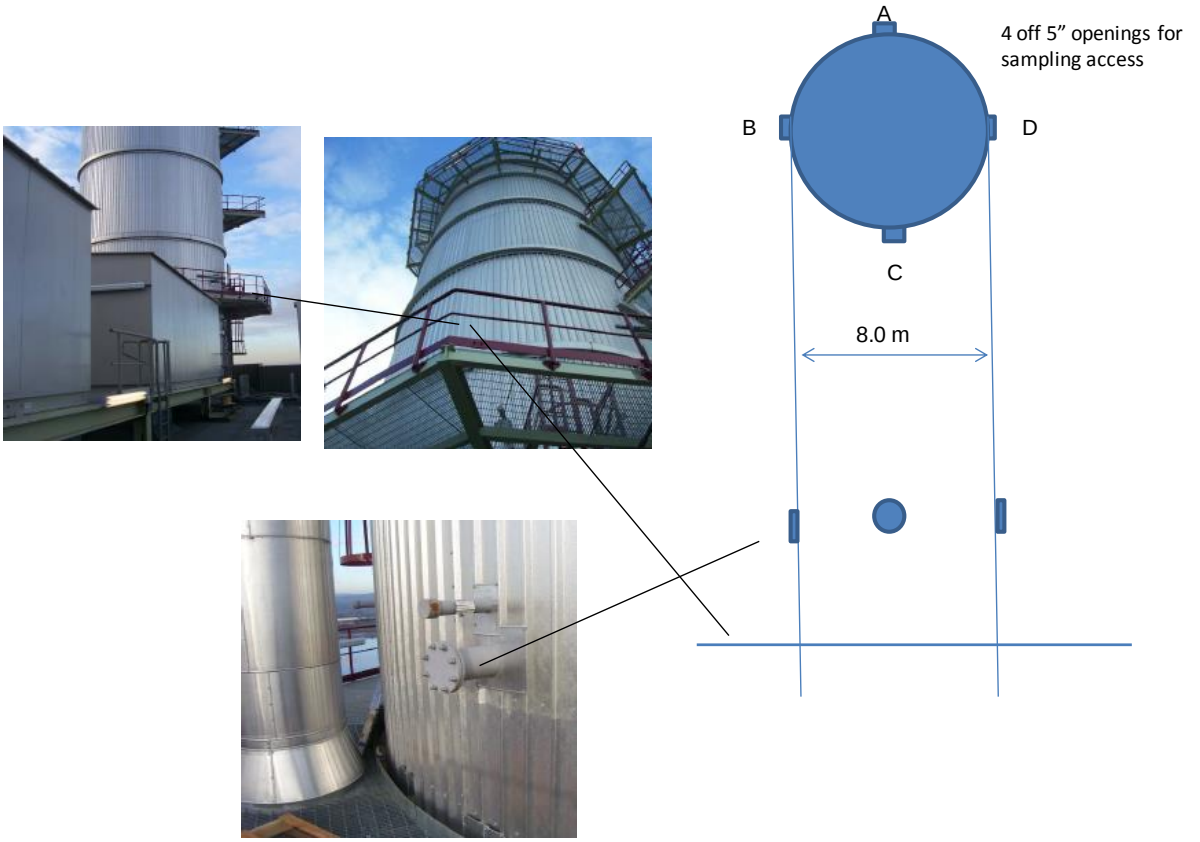

Figure 1 Typical exhaust stack and sampling platform

2.4 Continuous emissions monitoring systems at the installation

Table 2.3

Continuous Emissions Monitoring System Description

Determinand	Certified Range	Measurement basis	Operating principle
Manufacturer	Siemens Production Automatisation S.A.S		
Model	Ultramat 23 Multi gas analyser		
MCERTS certification	MCERTS: MC 040033/05		
Nitrogen monoxide	0-100/250/400/750 $mgNO/m^3$	dry	Non dispersive infra red
Oxygen	0-10/25 $\%O_2$	dry	Paramagnetic
Carbon monoxide	0-150/250 $mgCO/m^3$	dry	Non dispersive infra red

The sampling positions for the CEMs are located at the same level as the manual sampling positions.

All equipment associated with the CEM systems has MCERTs certification. The certified ranges are within the maximum allowable based on a 2.5 multiple of the daily average ELV, with the exception of carbon monoxide which has a lower certified range in excess of the maximum.

The CEM system assessed meets the relevant MCERTs specification and is QAL 1 compliant.

Water vapour is not measured.

Neither temperature nor pressure are recorded.

All analysers operate on an extractive basis.

Section 3 Information about the monitoring campaign

3.1 Test laboratory staff

Table 3.1 summarises the qualifications of the test laboratory staff involved in the execution of this assessment. All staff were suitably qualified under the MCERTs scheme for the tasks undertaken.

Table 3.1

Staff Competency

Function	Name	MCERTs					
		Reg. No. MM	Level Expiry	Certification expiry			
				TE1	TE2	TE3	TE4
Manager	N Ford	02084	2 (09/17)	01/19	10/19	10/19	10/19
Team leader	M Davies	02087	2 (09/17)	03/18	06/18	06/18	08/18
Team leader	O May	101072	2 (02/18)	09/21	07/21	02/18	03/22
Technician	A Holmes	131218	1 (03/18)	01/19			

3.2 Standard reference methods

The standard reference methods employed are summarised in Table 3.2. All methods are UKAS accredited to the MCERTs performance standard under certificate 1015.

Table 3.2

Standard reference methods

Determinand	Sampling method	ESG Procedure No.	UKAS No.
NO	BS EN 14792 (Chemiluminescent analyser)	AE102	1015
CO	BS EN 15058 (Infra red analyser)	AE102	1015
O_2	BS EN 14789 (Zirconium cell analyser)	AE102	1015

There are no separate analytical tasks associated with these measurements.

Table 3.3 summarises the operational details of the direct reading analysers employed in the standard reference methods.

Table 3.3

Direct reading analysers

Determinand	Certified Range	Operating range	Measurement basis
Manufacturer	Horiba		
Model	PG 250		
Identifier	P1334		
MCERTS certification	MC050056/04 (valid for products manufactured before 10.2.10)		
Oxygen	25%	25%	dry
Carbon monoxide	95 mgCO/m^3	200	dry
Nitrogen monoxide	125 mgCO/m^3	250 ppm	dry

All direct reading analysers used in the standard reference methods have MCERTs certification. The certified ranges are within the maximum allowable based on a 2.5 multiple of the daily average ELV.

The uncertainty associated with the standard reference methods employed in this assessment is no more than the maximum allowable for the corresponding CEM. Table 3.4 summarises the measurement uncertainties.

Table 3.4

Standard reference method uncertainty

Determinand		Allowable uncertainty	Measurement uncertainty
NO_x	$mgNO_2/m^3$	10	10
CO	mg/m^3	10	5
O_2	%	2.1	0.5

Section 4B Data & calculations AST

Annex G and Sections 8.3 to 8.7 of BS EN 14181:2014 specify the requirements for undertaking parallel SRM and CEM measurements and evaluating the subsequent data to determine the acceptability of variability and the validity of the existing calibration function. Based on at least 5 parallel measurements from the CEM system and corresponding SRM, it is required to determine the following properties for each determinand:

- SRM signals at reference conditions
- CEM signals at reference conditions
- A comparison of variability with the allowable measurement uncertainty
- Determination of the validity of the calibration function by comparison with defined limits
- Determination of the revised calibration range, if applicable

This approach has been employed for the assessment for all gaseous parameters.

These calculations are presented in the attached reporting forms for each determinand. The reporting forms contain:

- Details of the SRM and CEM systems
- The measurement pairs employed
- The methodology for calculation of variability and its acceptability
- The methodology for determination of the validity of the existing calibration function
- The determination of the revised calibration range

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4.1 HRSG 10 (A1) Duty CEM

4.1.1 Oxygen

Sample point HRSG 10 exhaust flue (A1)

Determinand Oxygen

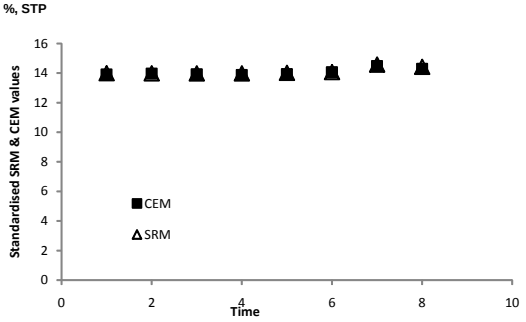
B4.1 **Raw monitoring data (Table 4.1)**

Sample No.	Date	Start time	End time	CEM measurements (dry)			SRM measurements (dry)			
				CEM	O_2	H_2O	SRM	O_2	H_2O	CEM basis
				%	%, dry	%	%	%, dry	%	%
1	31.5.17	1700	1800	13.91	n.a.	n.a.	13.99	n.a.	n.a.	13.99
2	31.5.17	1800	1900	13.97	n.a.	n.a.	13.98	n.a.	n.a.	13.98
3	31.5.17	1900	2000	13.92	n.a.	n.a.	13.98	n.a.	n.a.	13.98
4	31.5.17	2000	2100	13.88	n.a.	n.a.	13.98	n.a.	n.a.	13.98
5	31.5.17	2100	2200	13.94	n.a.	n.a.	14.01	n.a.	n.a.	14.01
6	31.5.17	2200	2300	14.06	n.a.	n.a.	14.06	n.a.	n.a.	14.06
7	1.6.17	0630	0730	14.48	n.a.	n.a.	14.57	n.a.	n.a.	14.57
8	1.6.17	0730	0830	14.30	n.a.	n.a.	14.42	n.a.	n.a.	14.42

B4.2 **Standardised monitoring data (Table 4.2)**

Sample No.	CEM	SRM
	Standard conditions[1]	
	%	%
1	13.91	13.99
2	13.97	13.98
3	13.92	13.98
4	13.88	13.98
5	13.94	14.01
6	14.06	14.06
7	14.48	14.57
8	14.30	14.42

B4.3 **Plot 1 - Oxygen**



[1] *Raw CEM and SRM values from Table 4.1 corrected to standard conditons using peripheral measurements in Table 4.1 as appropriate.*

B4.4 **Test for outliers**

Sample No.	CEM	SRM	Difference			Outlier condition	Data point used
	CEM conditions		$y_i - x_i = D_i$	$D_i - \bar{D}$	$(D_i - \bar{D})^2$	$\frac{D_i - \bar{D}}{\sigma_D}$	
	%	%					
i	x	y					
1	13.91	13.99	0.08	0.01	0.00	0.31	include
2	13.97	13.98	0.02	-0.05	0.00	1.30	include
3	13.92	13.98	0.05	-0.02	0.00	0.38	include
4	13.88	13.98	0.10	0.03	0.00	0.74	include
5	13.94	14.01	0.08	0.01	0.00	0.19	include
6	14.06	14.06	0.01	-0.06	0.00	1.52	include
7	14.48	14.57	0.10	0.03	0.00	0.64	include
8	14.30	14.42	0.13	0.06	0.00	1.33	include

A data point will be considered an outlier and excluded from the assessment if: $D_i - \bar{D} > 2\sigma_D$

where $D = y_s - \hat{y}_s$ and $\bar{D} = \frac{\sum_n^1 (y_s - \hat{y}_s)}{n}$

where n *is the number of samples = 8*
and σ_D is the standard deviation or variability of the CEM = 0.04 given by $\sigma_D = \sqrt{\frac{1}{n-1}\sum_n^1 (D_i - \bar{D})^2}$

B4.5 **Calculation of calibrated values (Table 4.3)**

Original calibration function **y = + 1.034 x**

Sample No.	Raw	Calibrated		SRM[4]
	CEM	CEM[2]	CEM[3]	
	CEM conditions		Standard conditions	
	%	%	%	%
1	13.91	14.38	14.38	13.99
2	13.97	14.44	14.44	13.98
3	13.92	14.40	14.40	13.98
4	13.88	14.35	14.35	13.98
5	13.94	14.41	14.41	14.01
6	14.06	14.54	14.54	14.06
7	14.48	14.97	14.97	14.57
8	14.30	14.78	14.78	14.42

[2] *Raw CEM data at CEM conditions calibrated using existing calibration function*
[3] *Calibrated CEM values at CEM conditions corrected to standard conditions using perpheral measurements in Table 4.1.*
[4] *Raw SRM values in Table 4.1 corrected to standard conditions using peripheral measurements in Table 4.1.*

B4.6 **Data used for variability test (Table 4.4)**
(excludes outliers - see B4.4)

Sample No.	Calibrated CEM	SRM	Difference		
	Standard conditions				
	%	%			
i	$\hat{y}_s$	y_s	$y_s - \hat{y}_s$	$D_i - \bar{D}$	$(D_i - \bar{D})^2$
1	14.38	13.99	-0.39	0.02	0.00
2	14.44	13.98	-0.46	-0.05	0.00
3	14.40	13.98	-0.42	-0.01	0.00
4	14.35	13.98	-0.37	0.04	0.00
5	14.41	14.01	-0.40	0.01	0.00
6	14.54	14.06	-0.47	-0.06	0.00
7	14.97	14.57	-0.40	0.01	0.00
8	14.78	14.42	-0.36	0.05	0.00

See Table 3 for determination of above parameters.

B4.7 **Variability test**

The limit for variability is specfied as $1.5\sigma_0 k_v$ = 1.53

where $\sigma_0 = \frac{pELV}{f}$

p is the allowable uncertainty = 10%
f is the coverage factor = 1.96
ELV is the daily average emission limit value = 21%
k_v is the value from a χ^2 test with a β value of 50% = 0.9521

The variability test is passed when $\sigma_D \leq 1.5\sigma_0 k_v$

σ_D	0.04
$1.5\sigma_0 k_v$	1.53

Variability test passed - 3% of limit

Acceptance test

The existing calibration function is considered to be valid if the variability test is passed and:

$$\left|\bar{D}\right| \leq t_{0.95(n-1)} \frac{\sigma_D}{\sqrt{n}} + \sigma_0$$

where $t_{0.95(n-1)}$ is the Student-t value for n-1 degress of freedom and a 95% confidence interval = 1.94
$\left|\bar{D}\right|$ is the absolute value of the average difference = 0.41

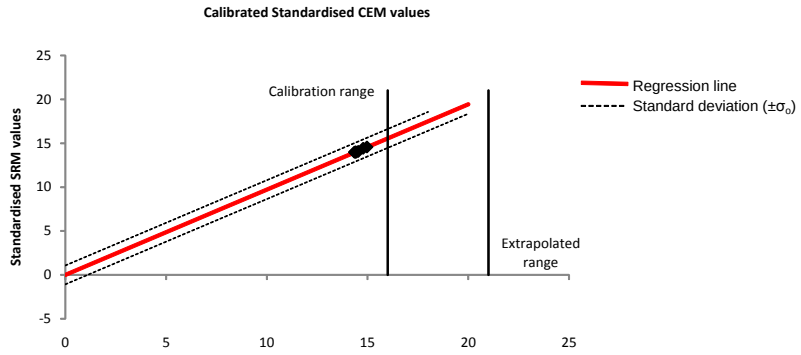
$t_{0.95(n-1)} \frac{\sigma_D}{\sqrt{n}} + \sigma_0 =$ 1.10

Calibration is acceptable - 37% of limit

B4.8 **Valid calibration range**

Plot 2 - Oxygen

%, STP



The existing valid calibration range may be extended if:
the AST demonstrates that the calibration function is valid beyond the existing range
The competent authority can allow an extension of the calibration range up to
the maximum measured concentration of the calibrated CEM at standard conditions
plus an extension of 10% up to a maximum equivalent to 50% of the ELV.

No extension to range
Calibration range **0 to 16 % (76.2 %ELV)**

4.1.2 Nitrogen monoxide

Sample point HRSG 10 exhaust flue (A1)

Determinand Nitrogen monoxide

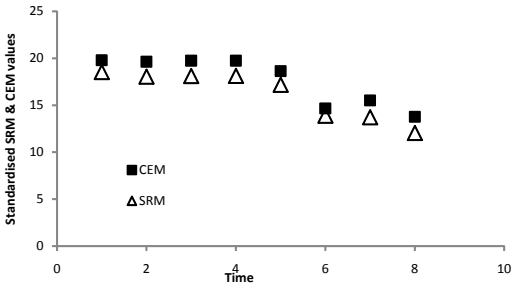
B4.1 **Raw monitoring data (Table 4.1)**

Sample No.	Date	Start time	End time	CEM measurements (dry)			SRM measurements (dry)			
				CEM	O_2	H_2O	SRM	O_2	H_2O	CEM basis
				mg/m3	%, dry	%	ppm	%, dry	%	mg/m3
1	31.5.17	1700	1800	21.87	14.38	0.00	16.21	13.99	0.00	21.70
2	31.5.17	1800	1900	21.51	14.44	0.00	15.81	13.98	0.00	21.16
3	31.5.17	1900	2000	21.77	14.40	0.00	15.87	13.98	0.00	21.24
4	31.5.17	2000	2100	21.93	14.35	0.00	15.88	13.98	0.00	21.26
5	31.5.17	2100	2200	20.51	14.41	0.00	14.97	14.01	0.00	20.04
6	31.5.17	2200	2300	15.82	14.54	0.00	12.02	14.06	0.00	16.09
7	1.6.17	0630	0730	15.60	14.97	0.00	10.99	14.57	0.00	14.72
8	1.6.17	0730	0830	14.29	14.78	0.00	9.89	14.42	0.00	13.24

B4.2 **Standardised monitoring data (Table 4.2)**

Sample No.	CEM	SRM
	Standard conditions[1]	
	mg/m3	mg/m3
1	19.79	18.53
2	19.64	18.04
3	19.75	18.11
4	19.75	18.12
5	18.64	17.17
6	14.67	13.89
7	15.52	13.72
8	13.78	12.05

B4.3 **Plot 1 - Nitrogen monoxide**
mg/m3, 15%, dry, STP



[1] *Raw CEM and SRM values from Table 4.1 corrected to standard conditons using peripheral measurements in Table 4.1 as appropriate.*

B4.4 **Test for outliers**

Sample No.	CEM	SRM	Difference			Outlier condition	Data point used
	CEM conditions		$y_i - x_i = D_i$	$D_i - \bar{D}$	$(D_i - \bar{D})^2$	$\frac{D_i - \bar{D}}{\sigma_D}$	
	mg/m3	mg/m3					
i	x	y					
1	21.87	21.70	0.17	-0.37	0.14	1.22	include
2	21.51	21.16	0.35	-0.20	0.04	0.66	include
3	21.77	21.24	0.52	-0.02	0.00	0.08	include
4	21.93	21.26	0.67	0.12	0.02	0.40	include
5	20.51	20.04	0.46	-0.09	0.01	0.29	include
6	15.82	16.09	0.27	-0.28	0.08	0.92	include
7	15.60	14.72	0.88	0.34	0.11	1.10	include
8	14.29	13.24	1.06	0.51	0.26	1.66	include

A data point will be considered an outlier and excluded from the assessment if: $D_i - \bar{D} > 2\sigma_D$

where $D = y_s - \hat{y}_s$ and $\bar{D} = \frac{\sum_{n}^{1}(y_s - \hat{y}_s)}{n}$

where n *is the number of samples = 8*
and σ_D is the standard deviation or variability of the CEM = 0.31 given by $\sigma_D = \sqrt{\frac{1}{n-1}\sum_{n}^{1}(D_i - \bar{D})^2}$

B4.5 **Calculation of calibrated values (Table 4.3)**

Original calibration function **y = 2.25 + 0.8135 x**

Sample No.	Raw	Calibrated		SRM[4]
	CEM	CEM[2]	CEM[3]	
	CEM conditions		Standard conditions	
	mg/m3	mg/m3	mg/m3	mg/m3
1	21.87	20.04	18.14	18.53
2	21.51	19.75	18.04	18.04
3	21.77	19.96	18.11	18.11
4	21.93	20.09	18.10	18.12
5	20.51	18.93	17.21	17.17
6	15.82	15.12	14.02	13.89
7	15.60	14.94	14.86	13.72
8	14.29	13.88	13.38	12.05

[2] *Raw CEM data at CEM conditions calibrated using existing calibration function*
[3] *Calibrated CEM values at CEM conditions corrected to standard conditions using perpheral measurements in Table 4.1.*
[4] *Raw SRM values in Table 4.1 corrected to standard conditions using peripheral measurements in Table 4.1.*

B4.6 **Data used for variability test (Table 4.4)**
(excludes outliers - see B4.4)

Sample No.	Calibrated CEM	SRM	Difference		
	Standard conditions				
	mg/m3	mg/m3			
i	$\hat{y}_s$	y_s	$y_s - \hat{y}_s$	$D_i - \bar{D}$	$(D_i - \bar{D})^2$
1	18.14	18.53	0.39	0.67	0.44
2	18.04	18.04	0.01	0.29	0.08
3	18.11	18.11	0.00	0.28	0.08
4	18.10	18.12	0.03	0.30	0.09
5	17.21	17.17	-0.04	0.24	0.06
6	14.02	13.89	-0.13	0.15	0.02
7	14.86	13.72	-1.14	-0.86	0.74
8	13.38	12.05	-1.33	-1.05	1.11

See Table 3 for determination of above parameters.

B4.7 **Variability test**

The limit for variability is specfied as $1.5\sigma_0 k_v$ = 7.29

where $\sigma_0 = \frac{pELV}{f}$

p is the allowable uncertainty = 20%
f is the coverage factor = 1.96
ELV is the daily average emission limit value = 50mg/m3
k_v is the value from a χ^2 test with a β value of 50% = 0.9521

The variability test is passed when $\sigma_D \leq 1.5\sigma_0 k_v$

σ_D 0.61
$1.5\sigma_0 k_v$ 7.29

Variability test passed - 8% of limit

Acceptance test

The existing calibration function is considered to be valid if the variability test is passed and:

$$|\bar{D}| \leq t_{0.95(n-1)} \frac{\sigma_D}{\sqrt{n}} + \sigma_0$$

where $t_{0.95(n-1)}$ is the Student-t value for n-1 degress of freedom and a 95% confidence interval = 1.94
$|\bar{D}|$ is the absolute value of the average difference = 0.28

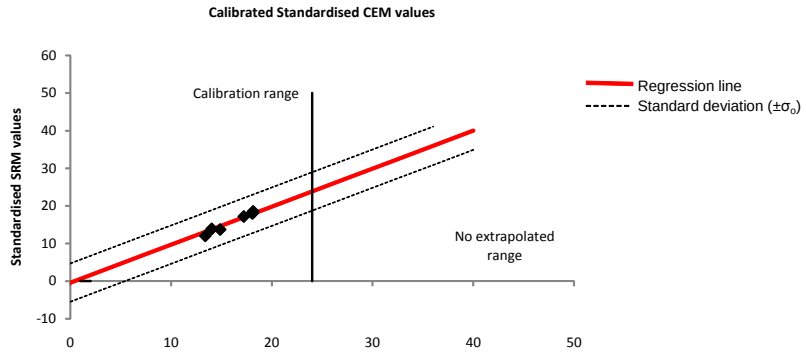
$t_{0.95(n-1)} \frac{\sigma_D}{\sqrt{n}} + \sigma_0 =$ 5.52

Calibration is acceptable - 5% of limit

B4.8 **Valid calibration range**

Plot 2 - Nitrogen monoxide

mg/m3, 15%, dry, STP



The existing valid calibration range may be extended if:
the AST demonstrates that the calibration function is valid beyond the existing range
The competent authority can allow an extension of the calibration range up to
the maximum measured concentration of the calibrated CEM at standard conditions
plus an extension of 10% up to a maximum equivalent to 50% of the ELV.

No extension to range
Calibration range **0 to 24 mg/m3 (48 %ELV)**

4.1.3 Carbon monoxide

Sample point HRSG 10 exhaust flue (A1)

Determinand Carbon monoxide

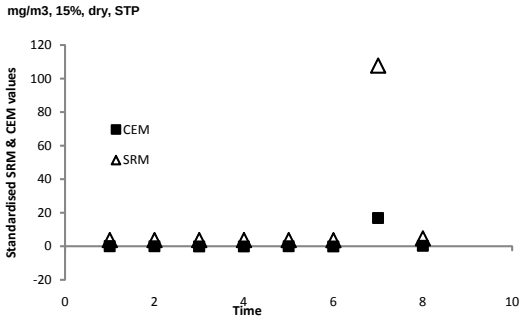
B4.1 **Raw monitoring data (Table 4.1)**

Sample No.	Date	Start time	End time	CEM measurements (dry)			SRM measurements (dry)			
				CEM	O_2	H_2O	SRM	O_2	H_2O	CEM basis
				mg/m3	%, dry	%	ppm	%, dry	%	mg/m3
1	31.5.17	1700	1800	0.04	14.38	0.00	3.41	13.99	0.00	4.26
2	31.5.17	1800	1900	-0.02	14.44	0.00	3.42	13.98	0.00	4.27
3	31.5.17	1900	2000	-0.10	14.40	0.00	3.40	13.98	0.00	4.25
4	31.5.17	2000	2100	-0.09	14.35	0.00	3.42	13.98	0.00	4.28
5	31.5.17	2100	2200	-0.04	14.41	0.00	3.38	14.01	0.00	4.23
6	31.5.17	2200	2300	-0.09	14.54	0.00	3.30	14.06	0.00	4.12
7	1.6.17	0630	0730	16.91	14.97	0.00	92.46	14.57	0.00	115.51
8	1.6.17	0730	0830	0.29	14.78	0.00	4.09	14.42	0.00	5.11

B4.2 **Standardised monitoring data (Table 4.2)**

Sample No.	CEM	SRM
	Standard conditions[1]	
	mg/m3	mg/m3
1	0.04	3.64
2	-0.02	3.64
3	-0.09	3.62
4	-0.09	3.65
5	-0.03	3.62
6	-0.09	3.56
7	16.81	107.70
8	0.28	4.65

B4.3 **Plot 1 - Carbon monoxide**



[1] *Raw CEM and SRM values from Table 4.1 corrected to standard conditons using peripheral measurements in Table 4.1 as appropriate.*

B4.4 **Test for outliers**

Sample No.	CEM	SRM	Difference			Outlier condition	Data point used
	CEM conditions						
	mg/m3	mg/m3	$y_i - x_i = D_i$	$D_i - \bar{D}$	$(D_i - \bar{D})^2$	$\frac{D_i - \bar{D}}{\sigma_D}$	
i	x	y					
1	0.04	4.26	4.22	-11.92	142.06	0.36	include
2	-0.02	4.27	4.29	-11.85	140.38	0.36	include
3	-0.10	4.25	4.35	-11.79	139.06	0.35	include
4	-0.09	4.28	4.37	-11.77	138.51	0.35	include
5	-0.04	4.23	4.26	-11.88	141.12	0.36	include
6	-0.09	4.12	4.21	-11.93	142.32	0.36	include
7	16.91	115.51	98.61	82.47	6800.51	2.47	exclude
8	0.29	5.11	4.82	-11.33	128.30	0.34	include

A data point will be considered an outlier and excluded from the assessment if: $D_i - \bar{D} > 2\sigma_D$

where $D = y_s - \hat{y}_s$ and $\bar{D} = \frac{\sum_{n}^{1}(y_s - \hat{y}_s)}{n}$

where n *is the number of samples = 8*
and σ_D is the standard deviation or variability of the CEM = 33.32 given by $\sigma_D = \sqrt{\frac{1}{n-1}\sum_{n}^{1}(D_i - \bar{D})^2}$

B4.5 **Calculation of calibrated values (Table 4.3)**

Original calibration function **y = 2.42 + 1.0027 x**

Sample No.	Raw	Calibrated		SRM[4]
	CEM	CEM[2]	CEM[3]	
	CEM conditions		Standard conditions	
	mg/m3	mg/m3	mg/m3	mg/m3
1	0.04	2.46	2.23	3.64
2	-0.02	2.40	2.19	3.64
3	-0.10	2.32	2.10	3.62
4	-0.09	2.32	2.09	3.65
5	-0.04	2.38	2.17	3.62
6	-0.09	2.33	2.16	3.56
7	16.91	19.37	19.27	107.70
8	0.29	2.71	2.62	4.65

[2] *Raw CEM data at CEM conditions calibrated using existing calibration function*
[3] *Calibrated CEM values at CEM conditions corrected to standard conditions using perpheral measurements in Table 4.1.*
[4] *Raw SRM values in Table 4.1 corrected to standard conditions using peripheral measurements in Table 4.1.*

B4.6 **Data used for variability test (Table 4.4)**
(excludes outliers - see B4.4)

Sample No.	Calibrated CEM	SRM	Difference		
	Standard conditions				
	mg/m3	mg/m3			
i	$\hat{y}_s$	y_s	$y_s - \hat{y}_s$	$D_i - \bar{D}$	$(D_i - \bar{D})^2$
1	2.23	3.64	1.41	-0.13	0.02
2	2.19	3.64	1.45	-0.09	0.01
3	2.10	3.62	1.52	-0.03	0.00
4	2.09	3.65	1.55	0.01	0.00
5	2.17	3.62	1.45	-0.09	0.01
6	2.16	3.56	1.40	-0.15	0.02
7					
8	2.62	4.65	2.03	0.49	0.24

See Table 3 for determination of above parameters.

B4.7 **Variability test**

The limit for variability is specfied as $1.5\sigma_0 k_v$ = 7.23

where $\sigma_0 = \frac{pELV}{f}$

p is the allowable uncertainty = 20%
f is the coverage factor = 1.96
ELV is the daily average emission limit value = 50mg/m3
k_v is the value from a χ^2 test with a β value of 50% = 0.9441

The variability test is passed when $\sigma_D \leq 1.5\sigma_0 k_v$

σ_D	0.22
$1.5\sigma_0 k_v$	7.23

Variability test passed - 3% of limit

Acceptance test

The existing calibration function is considered to be valid if the variability test is passed and:

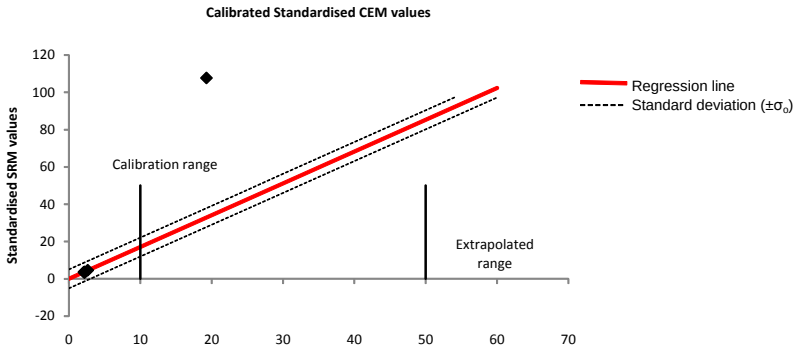
$$\left|\bar{D}\right| \leq t_{0.95(n-1)} \frac{\sigma_D}{\sqrt{n}} + \sigma_0$$

where $t_{0.95(n-1)}$ is the Student-t value for n-1 degress of freedom and a 95% confidence interval = 2.02
$\left|\bar{D}\right|$ is the absolute value of the average difference = 1.55

$t_{0.95(n-1)} \frac{\sigma_D}{\sqrt{n}} + \sigma_0 =$ 5.27

Calibration is acceptable - 29% of limit

B4.8 **Valid calibration range**
Plot 2 - Carbon monoxide
mg/m3, 15%, dry, STP



The existing valid calibration range may be extended if:
the AST demonstrates that the calibration function is valid beyond the existing range
The competent authority can allow an extension of the calibration range up to
the maximum measured concentration of the calibrated CEM at standard conditions
plus an extension of 10% up to a maximum equivalent to 50% of the ELV.

No extension to range
Calibration range **0 to 10 mg/m3 (20 %ELV)**

4.2 HRSG 20 (A2) Duty CEM

4.2.1 Oxygen

Sample point HRSG 20 exhaust flue (A2)

Determinand Oxygen

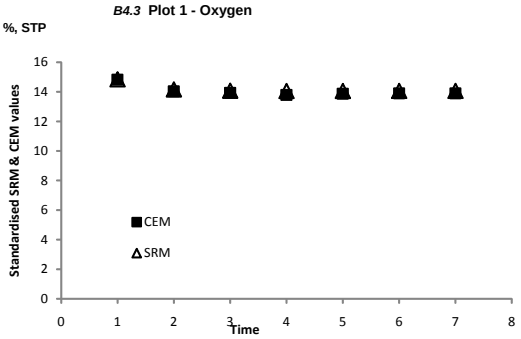
B4.1 **Raw monitoring data (Table 4.1)**

Sample No.	Date	Start time	End time	CEM measurements (dry)			SRM measurements (dry)			
				CEM	O_2	H_2O	SRM	O_2	H_2O	CEM basis
				%	%, dry	%	%	%, dry	%	%
1	31.5.17	0600	0700	14.82	n.a.	n.a.	14.84	n.a.	n.a.	14.84
2	31.5.17	0700	0800	14.03	n.a.	n.a.	14.16	n.a.	n.a.	14.16
3	31.5.17	0800	0900	13.93	n.a.	n.a.	14.07	n.a.	n.a.	14.07
4	31.5.17	0900	1000	13.79	n.a.	n.a.	14.05	n.a.	n.a.	14.05
5	31.5.17	1000	1100	13.87	n.a.	n.a.	14.05	n.a.	n.a.	14.05
6	31.5.17	1100	1200	13.89	n.a.	n.a.	14.06	n.a.	n.a.	14.06
7	31.5.17	1200	1300	13.90	n.a.	n.a.	14.06	n.a.	n.a.	14.06

B4.2 **Standardised monitoring data (Table 4.2)**

Sample No.	CEM	SRM
	Standard conditions[1]	
	%	%
1	14.82	14.84
2	14.03	14.16
3	13.93	14.07
4	13.79	14.05
5	13.87	14.05
6	13.89	14.06
7	13.90	14.06

B4.3 **Plot 1 - Oxygen**



[1] *Raw CEM and SRM values from Table 4.1 corrected to standard conditons using peripheral measurements in Table 4.1 as appropriate.*

B4.4 **Test for outliers**

Sample No.	CEM	SRM	Difference			Outlier condition	Data point used
	CEM conditions						
	%	%	$y_i - x_i = D_i$	$D_i - \bar{D}$	$(D_i - \bar{D})^2$	$\frac{D_i - \bar{D}}{\sigma_D}$	
i	x	y					
1	14.82	14.84	0.02	-0.13	0.02	1.82	include
2	14.03	14.16	0.13	-0.03	0.00	0.35	include
3	13.93	14.07	0.14	-0.01	0.00	0.12	include
4	13.79	14.05	0.26	0.11	0.01	1.52	include
5	13.87	14.05	0.18	0.03	0.00	0.40	include
6	13.89	14.06	0.17	0.02	0.00	0.22	include
7	13.90	14.06	0.16	0.01	0.00	0.16	include

A data point will be considered an outlier and excluded from the assessment if: $D_i - \bar{D} > 2\sigma_D$

where $D = y_s - \hat{y}_s$ and $\bar{D} = \frac{\sum_{n}^{1}(y_{si} - \hat{y}_{si})}{n}$

where n *is the number of samples = 7*
and σ_D is the standard deviation or variability of the CEM = 0.07 given by $\sigma_D = \sqrt{\frac{1}{n-1}\sum_{n}^{1}(D_i - \bar{D})^2}$

B4.5 **Calculation of calibrated values (Table 4.3)**

Original calibration function **y = 0 + 1.0296 x**

Sample No.	Raw	Calibrated		SRM[4]
	CEM	CEM[2]	CEM[3]	
	CEM conditions		Standard conditions	
	%	%	%	%
1	14.82	15.26	15.26	14.84
2	14.03	14.45	14.45	14.16
3	13.93	14.34	14.34	14.07
4	13.79	14.20	14.20	14.05
5	13.87	14.28	14.28	14.05
6	13.89	14.30	14.30	14.06
7	13.90	14.31	14.31	14.06

[2] *Raw CEM data at CEM conditions calibrated using existing calibration function*
[3] *Calibrated CEM values at CEM conditions corrected to standard conditions using perpheral measurements in Table 4.1.*
[4] *Raw SRM values in Table 4.1 corrected to standard conditions using peripheral measurements in Table 4.1.*

B4.6 **Data used for variability test (Table 4.4)**
(excludes outliers - see B4.4)

Sample No.	Calibrated CEM Standard conditions %	SRM %	Difference		
i	$\hat{y}_s$	y_s	$y_s - \hat{y}_s$	$D_i - \bar{D}$	$(D_i - \bar{D})^2$
1	15.26	14.84	-0.42	-0.16	0.02
2	14.45	14.16	-0.29	-0.03	0.00
3	14.34	14.07	-0.27	-0.01	0.00
4	14.20	14.05	-0.15	0.12	0.01
5	14.28	14.05	-0.23	0.03	0.00
6	14.30	14.06	-0.24	0.02	0.00
7	14.31	14.06	-0.25	0.02	0.00

See Table 3 for determination of above parameters.

B4.7 **Variability test**

The limit for variability is specfied as $1.5\sigma_0 k_v$ = 1.52

where $\sigma_0 = \frac{pELV}{f}$

p is the allowable uncertainty = 10%
f is the coverage factor = 1.96
ELV is the daily average emission limit value = 21%
k_v is the value from a χ^2 test with a β value of 50% = 0.9441

The variability test is passed when $\sigma_D \leq 1.5\sigma_0 k_v$

σ_D	0.08
$1.5\sigma_0 k_v$	1.52

Variability test passed - 5% of limit

Acceptance test

The existing calibration function is considered to be valid if the variability test is passed and:

$$\left|\bar{D}\right| \leq t_{0.95(n-1)} \frac{\sigma_D}{\sqrt{n}} + \sigma_0$$

where $t_{0.95(n-1)}$ is the Student-t value for n-1 degress of freedom and a 95% confidence interval = 2.02
$\left|\bar{D}\right|$ is the absolute value of the average difference = 0.26

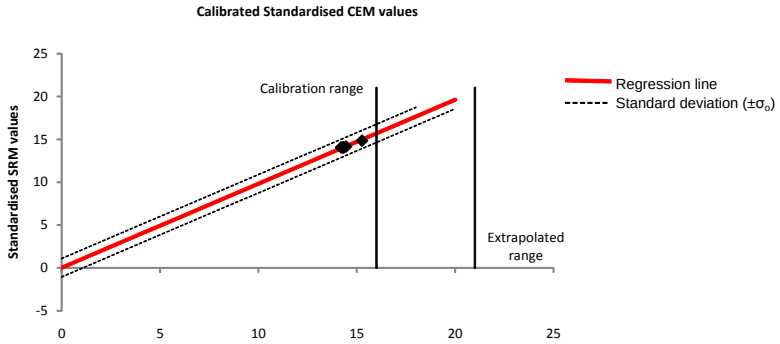
$t_{0.95(n-1)} \frac{\sigma_D}{\sqrt{n}} + \sigma_0 =$ 1.13

Calibration is acceptable - 23% of limit

B4.8 **Valid calibration range**

Plot 2 - Oxygen

%, STP



The existing valid calibration range may be extended if:
the AST demonstrates that the calibration function is valid beyond the existing range
The competent authority can allow an extension of the calibration range up to
the maximum measured concentration of the calibrated CEM at standard conditions
plus an extension of 10% up to a maximum equivalent to 50% of the ELV.

No extension to range
Calibration range 0 to 16 % (76.2 %ELV)

4.2.2 Nitrogen monoxide

Sample point HRSG 20 exhaust flue (A2)

Determinand Nitrogen monoxide

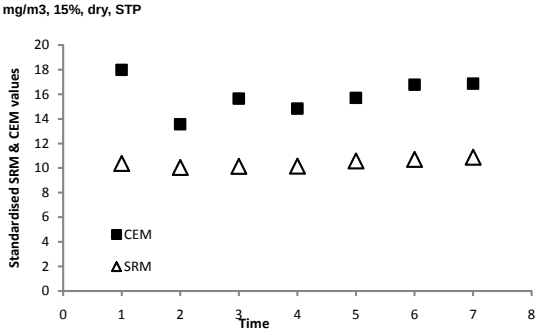
B4.1 **Raw monitoring data (Table 4.1)**

Sample No.	Date	Start time	End time	CEM measurements (dry)			SRM measurements (dry)			
				CEM	O_2	H_2O	SRM	O_2	H_2O	CEM basis
				mg/m3	%, dry	%	ppm	%, dry	%	mg/m3
1	31.5.17	0600	0700	17.18	15.26	0.00	7.95	14.84	0.00	10.65
2	31.5.17	0700	0800	14.82	14.45	0.00	8.58	14.16	0.00	11.48
3	31.5.17	0800	0900	17.39	14.34	0.00	8.77	14.07	0.00	11.73
4	31.5.17	0900	1000	16.84	14.20	0.00	8.81	14.05	0.00	11.79
5	31.5.17	1000	1100	17.61	14.28	0.00	9.17	14.05	0.00	12.28
6	31.5.17	1100	1200	18.77	14.30	0.00	9.27	14.06	0.00	12.41
7	31.5.17	1200	1300	18.85	14.31	0.00	9.43	14.06	0.00	12.62

B4.2 **Standardised monitoring data (Table 4.2)**

Sample No.	CEM	SRM
	Standard conditions[1]	
	mg/m3	mg/m3
1	17.98	10.37
2	13.55	10.05
3	15.64	10.14
4	14.83	10.16
5	15.71	10.58
6	16.78	10.71
7	16.87	10.88

B4.3 **Plot 1 - Nitrogen monoxide**



[1] *Raw CEM and SRM values from Table 4.1 corrected to standard conditons using peripheral measurements in Table 4.1 as appropriate.*

B4.4 **Test for outliers**

Sample No.	CEM	SRM	Difference			Outlier condition	Data point used
	CEM conditions						
	mg/m3	mg/m3					
i	x	y	$y_i - x_i = D_i$	$D_i - \bar{D}$	$(D_i - \bar{D})^2$	$\frac{D_i - \bar{D}}{\sigma_D}$	
1	17.18	10.65	6.54	1.03	1.07	0.94	include
2	14.82	11.48	3.34	-2.16	4.67	1.97	include
3	17.39	11.73	5.66	0.16	0.02	0.14	include
4	16.84	11.79	5.06	-0.44	0.20	0.40	include
5	17.61	12.28	5.34	-0.17	0.03	0.15	include
6	18.77	12.41	6.35	0.85	0.72	0.77	include
7	18.85	12.62	6.23	0.73	0.53	0.66	include

A data point will be considered an outlier and excluded from the assessment if: $D_i - \bar{D} > 2\sigma_D$

where $D = y_s - \hat{y}_s$ and $\bar{D} = \frac{\sum_n^1 (y_s - \hat{y}_s)}{n}$

where n *is the number of samples = 7*
and σ_D is the standard deviation or variability of the CEM = 1.1 given by $\sigma_D = \sqrt{\frac{1}{n-1}\sum_n^1 (D_i - \bar{D})^2}$

B4.5 **Calculation of calibrated values (Table 4.3)**

Original calibration function **y = -3.6 + 1.1036 x**

Sample No.	Raw	Calibrated		SRM[4]
	CEM	CEM[2]	CEM[3]	
	CEM conditions		Standard conditions	
	mg/m3	mg/m3	mg/m3	mg/m3
1	17.18	15.36	16.08	10.37
2	14.82	12.76	11.66	10.05
3	17.39	15.59	14.03	10.14
4	16.84	14.99	13.20	10.16
5	17.61	15.84	14.12	10.58
6	18.77	17.11	15.30	10.71
7	18.85	17.20	15.39	10.88

[2] *Raw CEM data at CEM conditions calibrated using existing calibration function*
[3] *Calibrated CEM values at CEM conditions corrected to standard conditions using perpheral measurements in Table 4.1.*
[4] *Raw SRM values in Table 4.1 corrected to standard conditions using peripheral measurements in Table 4.1.*

B4.6 **Data used for variability test (Table 4.4)**
(excludes outliers - see B4.4)

Sample No.	Calibrated CEM	SRM	Difference		
	Standard conditions				
	mg/m3	mg/m3			
i	$\hat{y}_s$	y_s	$y_s - \hat{y}_s$	$D_i - \bar{D}$	$(D_i - \bar{D})^2$
1	16.08	10.37	-5.71	-1.86	3.47
2	11.66	10.05	-1.62	2.23	4.95
3	14.03	10.14	-3.89	-0.04	0.00
4	13.20	10.16	-3.04	0.80	0.64
5	14.12	10.58	-3.54	0.30	0.09
6	15.30	10.71	-4.59	-0.75	0.56
7	15.39	10.88	-4.51	-0.67	0.45

See Table 3 for determination of above parameters.

B4.7 **Variability test**

The limit for variability is specfied as $1.5\sigma_0 k_v$ = 7.23

where $\sigma_0 = \frac{pELV}{f}$

p is the allowable uncertainty = 20%
f is the coverage factor = 1.96
ELV is the daily average emission limit value = 50mg/m3
k_v is the value from a χ test with a β value of 50% = 0.9441

The variability test is passed when $\sigma_D \leq 1.5\sigma_0 k_v$

σ_D	1.30
$1.5\sigma_0 k_v$	7.23

Variability test passed - 18% of limit

Acceptance test

The existing calibration function is considered to be valid if the variability test is passed and:

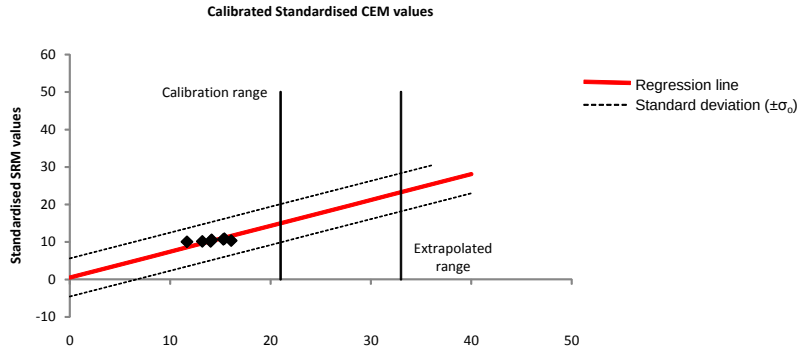
$$|\bar{D}| \leq t_{0.95(n-1)} \frac{\sigma_D}{\sqrt{n}} + \sigma_0$$

where $t_{0.95(n-1)}$ is the Student-t value for n-1 degress of freedom and a 95% confidence interval = 2.02
$|\bar{D}|$ is the absolute value of the average difference = 3.84

$t_{0.95(n-1)} \frac{\sigma_D}{\sqrt{n}} + \sigma_0 =$ 6.09

Calibration is acceptable - 63% of limit

B4.8 **Valid calibration range**
Plot 2 - Nitrogen monoxide
mg/m3, 15%, dry, STP



The existing valid calibration range may be extended if:
the AST demonstrates that the calibration function is valid beyond the existing range
The competent authority can allow an extension of the calibration range up to
the maximum measured concentration of the calibrated CEM at standard conditions
plus an extension of 10% up to a maximum equivalent to 50% of the ELV.

No extension to range
Calibration range **0 to 21 mg/m3 (42 %ELV)**

4.2.3 Carbon monoxide

Sample point HRSG 20 exhaust flue (A2)

Determinand Carbon monoxide

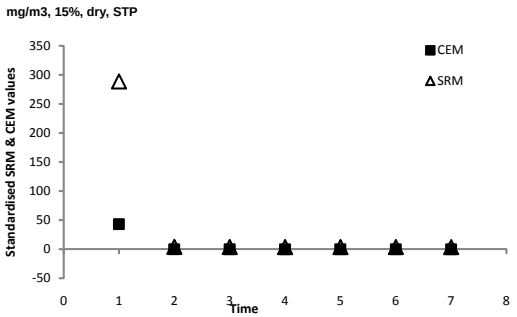
B4.1 **Raw monitoring data (Table 4.1)**

Sample No.	Date	Start time	End time	CEM measurements (dry)			SRM measurements (dry)			
				CEM	O_2	H_2O	SRM	O_2	H_2O	CEM basis
				mg/m3	%, dry	%	ppm	%, dry	%	mg/m3
1	31.5.17	0600	0700	41.15	15.26	0.00	237.18	14.84	0.00	296.32
2	31.5.17	0700	0800	-0.10	14.45	0.00	3.61	14.16	0.00	4.52
3	31.5.17	0800	0900	-0.10	14.34	0.00	3.35	14.07	0.00	4.18
4	31.5.17	0900	1000	-0.10	14.20	0.00	3.28	14.05	0.00	4.10
5	31.5.17	1000	1100	-0.10	14.28	0.00	3.33	14.05	0.00	4.16
6	31.5.17	1100	1200	-0.09	14.30	0.00	3.31	14.06	0.00	4.13
7	31.5.17	1200	1300	-0.07	14.31	0.00	3.23	14.06	0.00	4.04

B4.2 **Standardised monitoring data (Table 4.2)**

Sample No.	CEM	SRM
	Standard conditions[1]	
	mg/m3	mg/m3
1	43.06	288.66
2	-0.09	3.95
3	-0.09	3.62
4	-0.09	3.53
5	-0.09	3.58
6	-0.08	3.56
7	-0.07	3.48

B4.3 **Plot 1 - Carbon monoxide**



[1] *Raw CEM and SRM values from Table 4.1 corrected to standard conditons using peripheral measurements in Table 4.1 as appropriate.*

B4.4 **Test for outliers**

Sample No.	CEM	SRM	Difference			Outlier condition	Data point used
	CEM conditions						
	mg/m3	mg/m3					
i	x	y	$y_i - x_i = D_i$	$D_i - \bar{D}$	$(D_i - \bar{D})^2$	$\frac{D_i - \bar{D}}{\sigma_D}$	
1	41.15	296.32	255.16	215.04	46242.94	2.27	exclude
2	-0.10	4.52	4.62	-35.51	1260.69	0.37	include
3	-0.10	4.18	4.28	-35.84	1284.40	0.38	include
4	-0.10	4.10	4.20	-35.93	1290.68	0.38	include
5	-0.10	4.16	4.26	-35.86	1286.20	0.38	include
6	-0.09	4.13	4.22	-35.90	1288.73	0.38	include
7	-0.07	4.04	4.11	-36.01	1296.61	0.38	include

A data point will be considered an outlier and excluded from the assessment if: $D_i - \bar{D} > 2\sigma_D$

where $D = y_s - \hat{y}_s$ and $\bar{D} = \frac{\sum_n^1 (y_s - \hat{y}_s)}{n}$

where n *is the number of samples = 7*
and σ_D is the standard deviation or variability of the CEM = 94.82 given by $\sigma_D = \sqrt{\frac{1}{n-1}\sum_n^1 (D_i - \bar{D})^2}$

B4.5 **Calculation of calibrated values (Table 4.3)**

Original calibration function **y = 0.62 + 1.0429 x**

Sample No.	Raw	Calibrated		SRM[4]
	CEM	CEM[2]	CEM[3]	
	CEM conditions		Standard conditions	
	mg/m3	mg/m3	mg/m3	mg/m3
1	41.15	43.54	45.56	288.66
2	-0.10	0.52	0.47	3.95
3	-0.10	0.52	0.46	3.62
4	-0.10	0.52	0.45	3.53
5	-0.10	0.52	0.46	3.58
6	-0.09	0.53	0.47	3.56
7	-0.07	0.54	0.49	3.48

[2] *Raw CEM data at CEM conditions calibrated using existing calibration function*
[3] *Calibrated CEM values at CEM conditions corrected to standard conditions using perpheral measurements in Table 4.1.*
[4] *Raw SRM values in Table 4.1 corrected to standard conditions using peripheral measurements in Table 4.1.*

B4.6 **Data used for variability test (Table 4.4)**
(excludes outliers - see B4.4)

Sample No.	Calibrated CEM	SRM	Difference		
	Standard conditions				
	mg/m3	mg/m3			
i	$\hat{y}_s$	y_s	$y_s - \hat{y}_s$	$D_i - \bar{D}$	$(D_i - \bar{D})^2$
1					
2	0.47	3.95	3.48	0.33	0.11
3	0.46	3.62	3.15	0.00	0.00
4	0.45	3.53	3.07	-0.08	0.01
5	0.46	3.58	3.12	-0.03	0.00
6	0.47	3.56	3.09	-0.06	0.00
7	0.49	3.48	3.00	-0.16	0.02

See Table 3 for determination of above parameters.

B4.7 **Variability test**

The limit for variability is specfied as $1.5\sigma_0 k_v$ = 7.14

where $\sigma_0 = \frac{pELV}{f}$

p is the allowable uncertainty = 20%
f is the coverage factor = 1.96
ELV is the daily average emission limit value = 50mg/m3
k_v is the value from a χ^2 test with a β value of 50% = 0.9329

The variability test is passed when $\sigma_D \leq 1.5\sigma_0 k_v$

σ_D	0.17
$1.5\sigma_0 k_v$	7.14

Variability test passed - 2% of limit

Acceptance test

The existing calibration function is considered to be valid if the variability test is passed and:

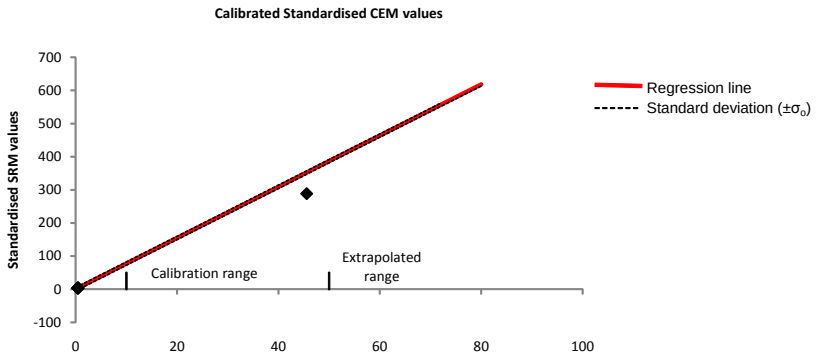
$$\left|\bar{D}\right| \leq t_{0.95(n-1)} \frac{\sigma_D}{\sqrt{n}} + \sigma_0$$

where $t_{0.95(n-1)}$ is the Student-t value for n-1 degress of freedom and a 95% confidence interval = 2.13
$\left|\bar{D}\right|$ is the absolute value of the average difference = 3.15

$t_{0.95(n-1)} \frac{\sigma_D}{\sqrt{n}} + \sigma_0 =$ 5.25

Calibration is acceptable - 60% of limit

B4.8 **Valid calibration range**
Plot 2 - Carbon monoxide
mg/m3, 15%, dry, STP



The existing valid calibration range may be extended if:
the AST demonstrates that the calibration function is valid beyond the existing range
The competent authority can allow an extension of the calibration range up to
the maximum measured concentration of the calibrated CEM at standard conditions
plus an extension of 10% up to a maximum equivalent to 50% of the ELV.

No extension to range
Calibration range **0 to 10 mg/m3 (20 %ELV)**

Section 5 Results of the functional test

The functional test in accordance with BS EN 14181 Annex A was undertaken by ESG with certain parts, which require manipulation of the CEM system, undertaken by Siemens on the 24 May 2017 as part of their fortnightly system check. A copy of the report detailing the work undertaken is presented in Annex 3. ESG undertook linearity testing of the CEM systems on the 1 June 2017. A copy of the report detailing the work undertaken is presented in Annex 1. A summary of the findings of the functional test covering the prescribed elements is provided below.

1	**Alignment & cleanliness**		
A visual inspection, with reference to the CEM's manuals shall be carried out on the following when applicable:			
1.1	Internal check of CEM	n.a.	
1.2	Cleanliness of optical components	n.a.	
1.3	Flushing air supply	n.a.	
1.4	Obstructions in the optical path	n.a.	
1.5	After re-assembly check of alignment	n.a.	
1.6	Contamination control (internal check of optical surfaces)	n.a.	
2	**Sampling systems**		
A visual inspection of the sampling system shall be performed, noting the condition of the following components, when fitted:			
2.1	Sampling probe	✓	The CEM was inspected by Siemens during their most recent service and again, by ESG, prior to the commencement of parallel testing. Both inspections indicated that the system was in satisfactory condition The NO_x converter efficiency checks were undertaken by ESG on the 1 June (HRSG 10) and 31 May 2017 (HRSG 20) as reported in Annex 2. Both converters failed to demonstrate the required efficiency, although this is not considered to be due to converter performance (see section 1.2.2).
2.2	Gas conditioning systems	✓	
2.3	Pumps	✓	
2.4	All connections	✓	
2.5	Sample lines	✓	
2.6	Power supplies	✓	
2.7	Filters	✓	
2.8	NO_x converters – if the sampling system contains a NO_x converter, then the test laboratory shall record when the last efficiency test was performed, and the result of this test.	✓.	
2.9	The sampling system shall be in good condition and free of any visible faults, which may decrease the quality of data.	✓	
	Siemens Limited 24 May 2017		
3	**Leak testing**		
	Leak testing shall be performed according to the CEM's manuals. The test shall cover the entire sampling system.	✓	A leak check was undertaken as part of the service by Siemens on the 24 May 2017 and as part of the linearity assessment on the 1 June 2017. No significant leakage was detected in either case.
	Siemens Limited 24 May 2017		

4	Zero & span check		
4.1	Reference zero and span materials shall be used to verify the corresponding readings of the CEM.	✓	Zero and span checks were undertaken by ESG as part of the linearity assessment on the 1 June 2017 and by Siemens during the service check on the 24 May 2017. In both cases responses were determined to be satisfactory.
4.2	In the case of non-extractive CEMs, zero and span checks shall be performed using a reference path free of flue gas before and after re-adjustment and after re-assembly of the CEM at the measurement location.	n.a.	
	Siemens Limited 24 May 2017		
5	Linearity		
5.1	During the calibration/linearity tests the applied concentrations should be logged onto the DAHS to prove the complete system i.e. concentration applied to the instrument is represented by the instrument output and identical to the value logged on the DAHS. DAHS logged values should be included in the instrument service report.	✓	
5.2	The linearity of the CEM's response shall be checked using five different reference materials including a zero concentration.	✓	ESG undertook linearity assessments of the analysers measuring oxygen, nitrogen monoxide and carbon monoxide. The ranges and concentrations tested met the requirements of EN 14181, Annex A8 – see report in Annex 1. Values logged by the DCS during the linearity test period on the 1 June 2017 are presented in Annex 1 and a full record for the entire period of linearity testing is retained on the system DCS. The assessment made demonstrated acceptable linearity, in accordance with criteria specified in BS EN 14181, for all analysers.
5.3	The reference material with zero concentration, as well as the reference materials with four different concentrations, shall have a verifiable quantity and quality.	✓	
5.4	In the case of gaseous reference materials, these four reference materials can be obtained from different gas cylinders or can be prepared by means of a calibrated dilution system from one single gas concentration.	✓	
5.5	The reference material concentrations shall be selected such that the measured values are at approximately 20%, 40%, 60% and 80% of a range that is at least the short term emission limit value. It is necessary to know the values of the ratios of their concentrations precisely enough so that an incorrect failure of the linearity test does not occur. The dry test reference materials shall be applied at the inlet of the CEM.	✓	
The individual CEMs are tested using the following concentrations applied in a randomised sequence:			
5.6	Reference material with zero concentration	✓	
5.7	Reference material approx. 20% of the range		
5.8	Reference material approx. 40% of the range		
5.9	Reference material approx. 60% of the range		
5.10	Reference material approx. 80% of the range		
5.11	Reference material with zero concentration		
The linearity assessment for all analysers met the linearity acceptance criteria in EN 14181, Annex B. Details of all testing and subsequent data evaluation are provided in Annex 1.			
	ESG 1 June 2017		

6	Interferences		
6.1	A test shall be undertaken if the process gases to be monitored contain components that are known interferences, as identified during QAL 1, and there is a failure of the QAL 2 or AST which could be due to interferents.	✓	An assessment of interferences has not been undertaken, although this assessment is not required where there is compliance with acceptance criteria.
	-		
7	Zero & span drift (Audit)		
7.1	The test laboratory shall assess whether the operator has a QAL 3 procedure in place, and whether the operator has applied this procedure. The evidence would comprise: i) a documented procedure ii) zero & span data iii) control charts	✓	The CEM is checked on a regular basis (15 day intervals) by DR. An example is provided in Annex 3 for 24 May 2017. Records are maintained electronically on the BFS. There is no record of an assessment of data using control charts, although Envirosoft software has been recently installed which will allow for operation in accordance with QAL 3 requirements.
	ESG 31 May 2017		
8	Response time		
8.1	The response time of the CEM shall be checked. This can be performed, if appropriate, by feeding of the reference material at the end of the sampling probe. The response time shall not exceed the performance requirement applied during the QAL 1 tests.	✓	ESG assessed response time during the linearity assessment. All measured response times met the requirements of the MCERTs specification for the analysers (<200s for all parameters). These results compare reasonably with those determined for the SRMs (110 seconds). No adjustment for differences in response times was considered necessary
	ESG 1 June 2017		
9	Service report		
As a minimum requirement the service report should include the following: All items are covered in the main report			
9.1	Document reference for work instruction for the type of work being undertaken	✓	
9.2	Instrument manufacturer	✓	
9.3	Instrument type	✓	
9.4	Instrument model	✓	
9.5	Instrument serial number	✓	
9.6	Operating principle	✓	
9.7	Operating range	✓	
9.8	Certification details	✓	
9.9	Compliance with MCERTs (including certificate number)	✓	
9.10	Location	✓	
9.11	Date and time work was undertaken	✓	
9.12	Equipment used – type, serial nos, calibration dates	✓	
9.13	Gases used – certificate nos, expiry dates, binary/mix	✓	

9.14	NO_x converter efficiency test, if applicable	n.a.	
9.15	Calibration & linearity data as required by EN 14181	✓	Provided, see comments in 5.
9.16	Logged data for period of calibration and linearity	✓	Provided, see comments in 5.
9.17	Name & signature of service engineer	✓	
	ESG 7 June 2017		
10	Documentation & records		
The following documentation shall be controlled readily accessible and up to date			
10.1	A plan of the CEM	✓	Site plan and permit
10.2	All manuals (maintenance, users etc.)	✓	In office and CEM's cabinet
10.3	Log books to document malfunctions and remedial actions	✓	Electronic - BFS/T3000
10.4	Service reports	✓	Electronic - BFS
10.5	Management system procedures for maintenance, calibration & training	✓	Calibrations and checks are undertaken by DR, and records maintained on the BFS.
10.6	Training records	✓	Records for D Rowland and team.
10.7	Maintenance schedules	✓	Electronic - BFS
10.8	Auditing plans and records	✓	Electronic - BFS
	ESG 1 June 2017		

The following items are considered to be outside of the requirements of the BS EN 14181 specification for a functional test (BS EN 14181, Annex A):

Item	Comment
9	The service report provided by Siemens does not cover fully the requirements of MID 14181. It may be noted that the report does not claim to meet the full functional test requirements of BS EN 14181 and tends to be more of an analyser check record. All omissions are covered elsewhere within the main report and as such this is not considered significant.

The functional test was undertaken on the 31 May 2017 by O May of ESG. Selected elements, requiring manipulation of the CEM system, were undertaken by Siemens as part of their regular analyser checks on the 24 May 2017. Annexes 1 and 2 provide details of the linearity assessment and NO_x converter efficiency checks respectively, undertaken by ESG. Reports for the analyser checks undertaken before parallel testing by Siemens are presented in Annex 3.

Annex 1 Linearity assessment

ESG attended the Nash site on the 1 June 2017 to undertake a linearity check on the CEM systems. The work undertaken on the analysers measuring oxygen, nitrogen monoxide and carbon monoxide is documented below.

HRSG 10

Linearity check of a direct reading analyser
(BS EN 14181:2014, Annex B)

Determinand	Carbon monoxide			
Analyser Type	Siemens Ultramat 23 multigas analsyer			
Analyser No.	-			
Full scale	150	mg/m3 CO		
RM Conc.	510.4	mg/m3 CO	RM Reference	CD2
Certified Range	150	mg/m3 CO		
ELV (daily)	50	mg/m3 CO		

Company	Severn Power Limited
Site	Newport
Sample point	HRSG 10 exhaust (A1)
Test carried out by	O May

Date	01-Jun-17
Test Ref	170524/A1LCO
Time Start	-
Time End	-

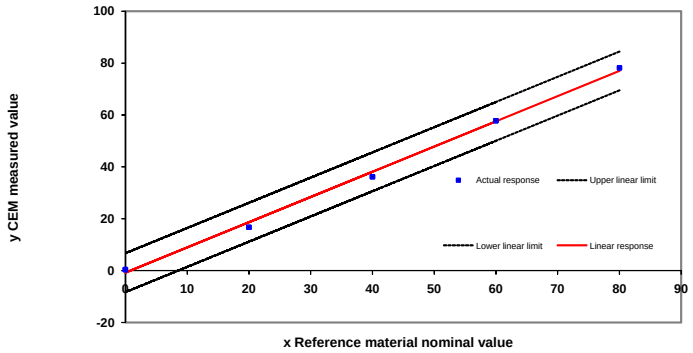
Measurements for Linearity test

Sample Number	Proportion of RM concentration (%)	RM value (mg/m3, x)	Analyser measured signal (mg/m3, y)				Residual	Residual	Measured value
			1	2	3	Mean	% certified range	% range	% ELV
1	16	80.00	78.20	78.20	78.20	78.20	0.8	0.8	156.4
2	0	0.00	0.40	0.40	0.40	0.40	0.8	0.8	0.8
3	12	60.00	57.80	57.80	57.80	57.80	0.2	0.2	115.6
4	0	0.00	0.40	0.40	0.40	0.40	0.8	0.8	0.8
5	8	40.00	36.20	36.20	36.20	36.20	1.3	1.3	72.4
6	4	20.00	16.70	16.70	16.70	16.70	1.3	1.3	33.4

Allowable residual	5.0 % of range
Maximum residual	1.3 % of operating range
Maximum residual	1.3 % of certified range

Analyser measured signals (y) versus RM nominal values (x)

Regression line	y =0.972x + -0.775
Regression coefficient	R2 = 0.998



Analyser passes test of linearity in accordance with BS EN 14181, Annex B

Linearity check of a direct reading analyser (BS EN 14181:2014, Annex B)

Determinand	Nitrogen monoxide			
Analyser Type	Siemens Ultramat 23 multigas analsyer			
Analyser No.	-			
Full scale	100	mg/m3 NO		
RM Conc.	282.6	mg/m3 NO	RM Reference	SM12
Certified Range	100	mg/m3 NO		
ELV (daily)	32.7	mg/m3 NO		

Company	Severn Power Limited	Date	01-Jun-17
Site	Newport	Test Ref	170524/A1LNO
Sample point	HRSG 10 exhaust (A1)	Time Start	-
Test carried out by	O May	Time End	-

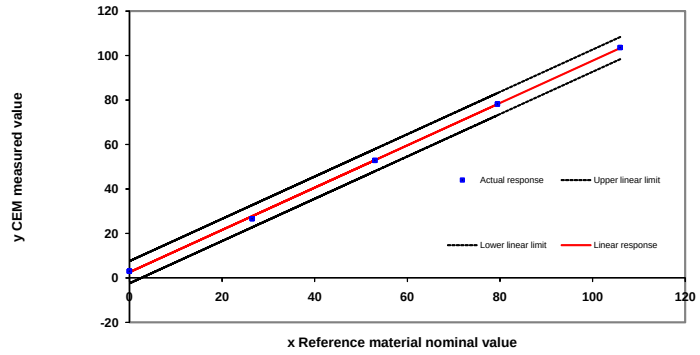
Measurements for Linearity test

Sample Number	Proportion of RM concentration (%)	RM value (mg/m3, x)	Analyser measured signal (mg/m3, y)				Residual	Residual	Measured value
			1	2	3	Mean	% certified range	% range	% ELV
1	37	105.96	103.60	103.60	103.60	103.60	0.3	0.3	316.8
2	0	0.00	3.00	3.00	3.00	3.00	0.5	0.5	9.2
3	28	79.47	78.20	78.20	78.20	78.20	0.1	0.1	239.1
4	0	0.00	3.00	3.00	3.00	3.00	0.5	0.5	9.2
5	19	52.98	52.80	52.80	52.80	52.80	0.1	0.1	161.5
6	9	26.49	26.60	26.60	26.60	26.60	1.1	1.1	81.3

Allowable residual 5.0 % of range
Maximum residual 1.1 % of operating range
Maximum residual 1.1 % of certified range

Analyser measured signals (y) versus RM nominal values (x)

Regression line y =0.951x + 2.55
Regression coefficient R2 = 1



Analyser passes test of linearity in accordance with BS EN 14181, Annex B

Linearity check of a direct reading analyser (BS EN 14181:2014, Annex B)

Determinand	Oxygen			
Analyser Type	Siemens Ultramat 23 multigas analsyer			
Analyser No.	-			
Full scale	25	% O2		
RM Conc.	20.6	% O2	RM Reference	OB4
Certified Range	25	% O2		
ELV (daily)	21	% O2		

Company	Severn Power Limited	Date	01-Jun-17
Site	Newport	Test Ref	170524/A1LO2
Sample point	HRSG 10 exhaust (A1)	Time Start	-
Test carried out by	O May	Time End	-

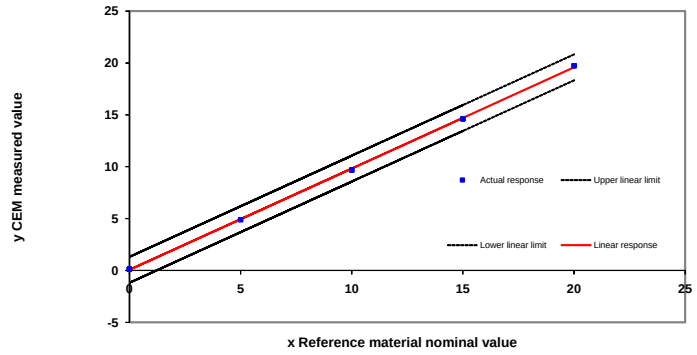
Measurements for Linearity test

Sample Number	Proportion of RM concentration (%)	RM value (%, x)	Analyser measured signal (%, y)				Residual	Residual	Measured value
			1	2	3	Mean	% certified range	% range	% ELV
1	97	20.00	19.73	19.73	19.73	19.73	0.6	0.6	94.0
2	0	0.00	0.13	0.13	0.13	0.13	0.3	0.3	0.6
3	73	15.00	14.60	14.60	14.60	14.60	0.4	0.4	69.5
4	0	0.00	0.13	0.13	0.13	0.13	0.3	0.3	0.6
5	49	10.00	9.68	9.68	9.68	9.68	0.6	0.6	46.1
6	24	5.00	4.90	4.90	4.90	4.90	0.2	0.2	23.3

Allowable residual 5.0 % of range
Maximum residual 0.6 % of operating range
Maximum residual 0.6 % of certified range

Analyser measured signals (y) versus RM nominal values (x)

Regression line y =0.975x + 0.066
Regression coefficient R2 = 1



Analyser passes test of linearity in accordance with BS EN 14181, Annex B

HRSG 20

Linearity check of a direct reading analyser (BS EN 14181:2014, Annex B)

Determinand	Carbon monoxide			
Analyser Type	Siemens Ultramat 23 multigas analsyer			
Analyser No.	-			
Full scale	150	mg/m3 CO		
RM Conc.	510.4	mg/m3 CO	RM Reference	CD2
Certified Range	150	mg/m3 CO		
ELV (daily)	50	mg/m3 CO		

Company	Severn Power Limited	Date	01-Jun-17
Site	Newport	Test Ref	170524/A2LCO
Sample point	HRSG 20 exhaust (A2)	Time Start	-
Test carried out by	O May	Time End	-

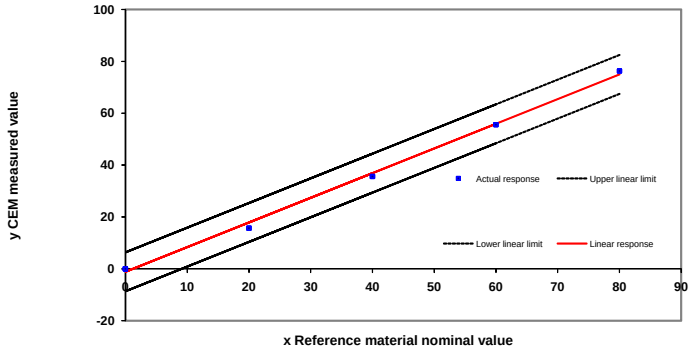
Measurements for Linearity test

Sample Number	Proportion of RM concentration (%)	RM value (mg/m3, x)	Analyser measured signal (mg/m3, y)				Residual	Residual	Measured value
			1	2	3	Mean	% certified range	% range	% ELV
1	16	80.00	76.30	76.30	76.30	76.30	0.9	0.9	152.6
2	0	0.00	0.00	0.00	0.00	0.00	0.8	0.8	0.0
3	12	60.00	55.60	55.60	55.60	55.60	0.2	0.2	111.2
4	0	0.00	0.00	0.00	0.00	0.00	0.8	0.8	0.0
5	8	40.00	35.60	35.60	35.60	35.60	0.8	0.8	71.2
6	4	20.00	15.70	15.70	15.70	15.70	1.4	1.4	31.4

Allowable residual	5.0 % of range
Maximum residual	1.4 % of operating range
Maximum residual	1.4 % of certified range

Analyser measured signals (y) versus RM nominal values (x)

Regression line	y =0.951x + -1.162
Regression coefficient	R2 = 0.998



Analyser passes test of linearity in accordance with BS EN 14181, Annex B

Linearity check of a direct reading analyser (BS EN 14181:2014, Annex B)

Determinand	Nitrogen monoxide			
Analyser Type	Siemens Ultramat 23 multigas analsyer			
Analyser No.	-			
Full scale	100	mg/m3 NO		
RM Conc.	510.4	mg/m3 NO	RM Reference	SM12
Certified Range	100	mg/m3 NO		
ELV (daily)	32.7	mg/m3 NO		

Company	Severn Power Limited	Date	01-Jun-17
Site	Newport	Test Ref	170524/A2LNO
Sample point	HRSG 20 exhaust (A2)	Time Start	-
Test carried out by	O May	Time End	-

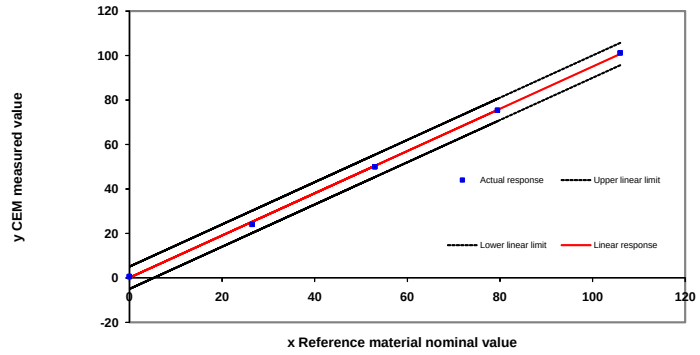
Measurements for Linearity test

Sample Number	Proportion of RM concentration (%)	RM value (mg/m3, x)	Analyser measured signal (mg/m3, y)				Residual	Residual	Measured value
			1	2	3	Mean	% certified range	% range	% ELV
1	21	105.96	101.20	101.20	101.20	101.20	0.5	0.5	309.5
2	0	0.00	0.60	0.60	0.60	0.60	0.6	0.6	1.8
3	16	79.47	75.40	75.40	75.40	75.40	0.1	0.1	230.6
4	0	0.00	0.60	0.60	0.60	0.60	0.6	0.6	1.8
5	10	52.98	50.00	50.00	50.00	50.00	0.4	0.4	152.9
6	5	26.49	24.00	24.00	24.00	24.00	1.2	1.2	73.4

Allowable residual 5.0 % of range
Maximum residual 1.2 % of operating range
Maximum residual 1.2 % of certified range

Analyser measured signals (y) versus RM nominal values (x)

Regression line y =0.949x + 0.05
Regression coefficient R2 = 1



Analyser passes test of linearity in accordance with BS EN 14181, Annex B

Linearity check of a direct reading analyser (BS EN 14181:2014, Annex B)

Determinand	Oxygen			
Analyser Type	Siemens Ultramat 23 multigas analsyer			
Analyser No.	-			
Full scale	25	% O2		
RM Conc.	20.6	% O2	RM Reference	OB4
Certified Range	25	% O2		
ELV (daily)	21	% O2		

Company	Severn Power Limited
Site	Newport
Sample point	HRSG 20 exhaust (A2)
Test carried out by	O May

Date	01-Jun-17
Test Ref	170524/A2LO2
Time Start	-
Time End	-

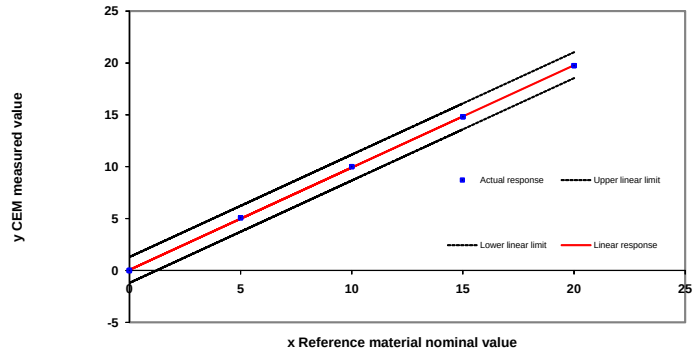
Measurements for Linearity test

Sample Number	Proportion of RM concentration (%)	RM value (%, x)	Analyser measured signal (%, y)				Residual	Residual	Measured value
			1	2	3	Mean	% certified range	% range	% ELV
1	97	20.00	19.74	19.74	19.74	19.74	0.2	0.2	94.0
2	0	0.00	0.00	0.00	0.00	0.00	0.2	0.2	0.0
3	73	15.00	14.81	14.81	14.81	14.81	0.2	0.2	70.5
4	0	0.00	0.00	0.00	0.00	0.00	0.2	0.2	0.0
5	49	10.00	10.01	10.01	10.01	10.01	0.4	0.4	47.7
6	24	5.00	5.08	5.08	5.08	5.08	0.4	0.4	24.2

Allowable residual 5.0 % of range
Maximum residual 0.4 % of operating range
Maximum residual 0.4 % of certified range

Analyser measured signals (y) versus RM nominal values (x)

Regression line y =0.986x + 0.054
Regression coefficient R2 = 1



Analyser passes test of linearity in accordance with BS EN 14181, Annex B

Severn Power Limited hold all one minute readings of the CEM systems as recorded on the DCS for the period of the linearity assessment. Examples of these for HRSG 10 from the 1 June 2017 are provided below.

HRSG10 – 1 June 2017

Unit 10, Average = 1 Minutes									
	1. CO	1. CO	2. NO	2. NO	3. O2	3. O2	4. Load	Temperature	
Date/ time	No QAL2	ppm	No QAL2	ppm	No QAL2	%	No QAL2	No QAL2	Plant
01/06/17, 11:00	-0.1	-0.1	113.3	84.6	1.07	1.07	397	100	P/L
01/06/17, 11:01	0	0	113.5	84.7	1.06	1.06	398	100	P/L
01/06/17, 11:02	-0.1	-0.1	113.9	85	1.06	1.06	396.6	100	P/L
01/06/17, 11:03	-0.1	-0.1	114.5	85.4	1.05	1.05	396.9	100.1	P/L
01/06/17, 11:04	-0.1	-0.1	114.7	85.6	1.04	1.04	397.7	100.1	P/L
01/06/17, 11:05	-0.1	-0.1	114.6	85.5	1.03	1.03	398.2	100.1	P/L
01/06/17, 11:06	0	0	115	85.8	1.03	1.03	398	100.1	P/L
01/06/17, 11:07	0	0	114.9	85.7	1.03	1.03	398.7	100.1	P/L
01/06/17, 11:08	0	0	115.3	86	1.02	1.02	398.8	100.1	P/L
01/06/17, 11:09	-0.1	-0.1	115.7	86.3	1.02	1.02	398.7	100.1	P/L
01/06/17, 11:10	-0.1	-0.1	115.8	86.4	1.02	1.02	399.7	100.2	P/L
01/06/17, 11:11	-0.1	-0.1	115.5	86.2	1.02	1.02	398.1	100.3	P/L
01/06/17, 11:12	-0.1	-0.1	116.2	86.7	1.02	1.02	397.3	100.3	P/L
01/06/17, 11:13	-0.1	-0.1	116.5	86.9	1.02	1.02	397.2	100.3	P/L
01/06/17, 11:14	0	0	116.1	86.6	1.02	1.02	395.7	100.3	P/L
01/06/17, 11:15	0	0	116.3	86.8	1.01	1.01	394.6	100.3	P/L
01/06/17, 11:16	0	0	103.5	77.2	2.54	2.54	392.8	100.3	P/L
01/06/17, 11:17	-0.1	-0.1	10.2	7.6	19.93	19.93	393.5	100.3	P/L
01/06/17, 11:18	-0.1	-0.1	3.4	2.5	20.8	20.8	392	100.2	P/L
01/06/17, 11:19	-0.1	-0.1	2.1	1.6	20.82	20.82	393.8	100.2	P/L
01/06/17, 11:20	-0.1	-0.1	1.5	1.1	20.82	20.82	392	100.1	P/L
01/06/17, 11:21	0	0	3.6	2.7	20.67	20.67	390	100.1	P/L
01/06/17, 11:22	0.2	0.2	5.6	4.2	19.66	19.66	389.6	100.1	P/L
01/06/17, 11:23	0.1	0.1	2.8	2.1	19.64	19.64	389.6	100	P/L
01/06/17, 11:24	0.1	0.1	2.1	1.6	19.69	19.69	389.6	100	P/L
01/06/17, 11:25	0.1	0.1	2	1.5	17.13	17.13	389.7	100	P/L
01/06/17, 11:26	0.1	0.1	2.1	1.6	14.55	14.55	389.8	99.9	P/L
01/06/17, 11:27	0	0	2.2	1.6	12.32	12.32	389.7	99.9	P/L
01/06/17, 11:28	0.1	0.1	2.5	1.9	9.68	9.68	389.8	99.9	P/L
01/06/17, 11:29	0.1	0.1	2.5	1.9	9.66	9.66	389.8	99.9	P/L
01/06/17, 11:30	0.1	0.1	2.5	1.9	8.32	8.32	389.5	99.9	P/L
01/06/17, 11:31	0.2	0.2	2.6	1.9	5.05	5.05	389.9	99.9	P/L
01/06/17, 11:32	0.1	0.1	2.7	2	5.01	5.01	389.9	100	P/L
01/06/17, 11:33	0.2	0.2	2.7	2	5	5	389.8	100	P/L
01/06/17, 11:34	0.2	0.2	2.8	2.1	4.98	4.98	389.7	100	P/L
01/06/17, 11:35	0.1	0.1	2.9	2.2	4.96	4.96	389.5	100	P/L
01/06/17, 11:36	0.2	0.2	2.8	2.1	4.94	4.94	389.4	100.1	P/L
01/06/17, 11:37	0.3	0.2	2.8	2.1	4.92	4.92	389.6	100.1	P/L
01/06/17, 11:38	0.2	0.2	3	2.2	4.9	4.9	389.8	100.1	P/L
01/06/17, 11:39	0.3	0.2	2.4	1.8	10.28	10.28	389.9	100.1	P/L
01/06/17, 11:40	21.9	17.5	1.2	0.9	15.6	15.6	389.8	100.1	P/L
01/06/17, 11:41	71.5	57.2	2	1.5	2.41	2.41	389.5	100.2	P/L
01/06/17, 11:42	69.4	55.5	1.9	1.4	1.69	1.69	389.7	100.2	P/L
01/06/17, 11:43	54.7	43.8	1.9	1.4	1.32	1.32	389.7	100.3	P/L
01/06/17, 11:44	55	44	1.9	1.4	1.32	1.32	389.9	100.3	P/L
01/06/17, 11:45	48.1	38.5	1.8	1.3	1.21	1.21	389.8	100.3	P/L
01/06/17, 11:46	36.2	29	1.8	1.3	0.94	0.94	389.8	100.3	P/L
01/06/17, 11:47	28.2	22.6	1.6	1.2	0.81	0.81	389.8	100.3	P/L
01/06/17, 11:48	16.8	13.4	1.8	1.3	0.51	0.51	389.8	100.3	P/L
01/06/17, 11:49	16.6	13.3	1.7	1.3	0.5	0.5	389.9	100.3	P/L
01/06/17, 11:50	8.3	6.6	1.4	1	7.63	7.63	389.7	100.3	P/L
01/06/17, 11:51	0.2	0.2	0.6	0.4	20.64	20.64	389.7	100.3	P/L
01/06/17, 11:52	6.1	4.9	43	32.1	7.89	7.89	389.5	100.3	P/L
01/06/17, 11:53	0.4	0.3	94.9	70.8	0.27	0.27	389.8	100.3	P/L
01/06/17, 11:54	0.2	0.2	90.6	67.6	0.2	0.2	389.6	100.3	P/L
01/06/17, 11:55	0.1	0.1	95.8	71.5	0.52	0.52	389.7	100.3	P/L
01/06/17, 11:56	0	0	104	77.6	0.25	0.25	389.5	100.3	P/L
01/06/17, 11:57	0	0	95.4	71.2	0.16	0.16	389.7	100.3	P/L
01/06/17, 11:58	0	0	78.4	58.5	0.16	0.16	389.8	100.3	P/L
01/06/17, 11:59	0.1	0.1	75.2	56.1	0.15	0.15	389.5	100.3	P/L
01/06/17, 12:00	0	0	55	41	0.15	0.15	389.7	100.3	P/L
01/06/17, 12:01	0.2	0.2	52.9	39.5	0.15	0.15	389.6	100.3	P/L
01/06/17, 12:02	0.3	0.2	52.7	39.3	0.15	0.15	389.4	100.3	P/L
01/06/17, 12:03	0.2	0.2	41.8	31.2	0.15	0.15	389	100.3	P/L
01/06/17, 12:04	0.2	0.2	27.8	20.7	0.14	0.14	389.7	100.3	P/L
01/06/17, 12:05	0.2	0.2	26.8	20	0.14	0.14	389	100.3	P/L
01/06/17, 12:06	0.2	0.2	24.4	18.2	0.13	0.13	389.5	100.3	P/L
01/06/17, 12:07	0.2	0.2	4.4	3.3	0.13	0.13	389.4	100.3	P/L
01/06/17, 12:08	0.3	0.2	2.8	2.1	0.13	0.13	389.7	100.3	P/L
01/06/17, 12:09	0.4	0.3	2.1	1.6	8.22	8.22	390	100.3	P/L
01/06/17, 12:10	0.1	0.1	10.7	8	17.18	17.18	389.5	100.4	P/L
01/06/17, 12:11	0.1	0.1	20.1	15	13.85	13.85	389.5	100.4	P/L
01/06/17, 12:12	-0.1	-0.1	20.2	15.1	13.83	13.83	389.3	100.4	P/L
01/06/17, 12:13	-0.1	-0.1	20.5	15.3	13.83	13.83	389.3	100.4	P/L
01/06/17, 12:14	-0.1	-0.1	20.8	15.5	13.83	13.83	389	100.5	P/L
01/06/17, 12:15	-0.1	-0.1	21	15.7	13.83	13.83	389.4	100.5	P/L
01/06/17, 12:16	-0.1	-0.1	20.8	15.5	13.84	13.84	389.7	100.5	P/L
01/06/17, 12:17	-0.1	-0.1	20.7	15.4	13.84	13.84	389.3	100.5	P/L
01/06/17, 12:18	-0.1	-0.1	21	15.7	13.84	13.84	389.5	100.6	P/L
01/06/17, 12:19	-0.1	-0.1	21.2	15.8	13.87	13.87	389.7	100.6	P/L
01/06/17, 12:20	-0.1	-0.1	21	15.7	13.86	13.86	389.5	100.6	P/L
01/06/17, 12:21	-0.1	-0.1	20.8	15.5	13.86	13.86	389.4	100.6	P/L
01/06/17, 12:22	-0.1	-0.1	20.4	15.2	13.86	13.86	389.5	100.6	P/L
01/06/17, 12:23	-0.1	-0.1	20.7	15.4	13.89	13.89	389.7	100.6	P/L
01/06/17, 12:24	-0.1	-0.1	20.9	15.6	13.91	13.91	389.2	100.6	P/L
01/06/17, 12:25	-0.1	-0.1	20.9	15.6	13.89	13.89	389.6	100.6	P/L
01/06/17, 12:26	-0.1	-0.1	20.8	15.5	13.87	13.87	389.8	100.6	P/L
01/06/17, 12:27	-0.1	-0.1	20.6	15.4	13.86	13.86	389.6	100.6	P/L
01/06/17, 12:28	-0.1	-0.1	20.7	15.4	13.85	13.85	389.4	100.6	P/L
01/06/17, 12:29	-0.1	-0.1	20.8	15.5	13.85	13.85	389.4	100.7	P/L
01/06/17, 12:30	-0.1	-0.1	20.8	15.5	13.84	13.84	389.3	100.7	P/L
01/06/17, 12:31	-0.1	-0.1	20.7	15.4	13.84	13.84	388.9	100.7	P/L
01/06/17, 12:32	-0.1	-0.1	20.5	15.3	13.84	13.84	389.3	100.7	P/L
01/06/17, 12:33	-0.1	-0.1	21.2	15.8	13.83	13.83	389.3	100.7	P/L
01/06/17, 12:34	-0.1	-0.1	21.5	16	13.83	13.83	389.4	100.8	P/L
01/06/17, 12:35	-0.1	-0.1	21.7	16.2	13.83	13.83	389.6	100.8	P/L
01/06/17, 12:36	-0.1	-0.1	21.4	16	13.83	13.83	389.6	100.9	P/L
01/06/17, 12:37	-0.1	-0.1	21.6	16.1	13.82	13.82	389.9	100.9	P/L
01/06/17, 12:38	-0.1	-0.1	21.6	16.1	13.82	13.82	389.4	100.9	P/L
01/06/17, 12:39	-0.1	-0.1	21.8	16.3	13.82	13.82	389.8	100.9	P/L
01/06/17, 12:40	-0.1	-0.1	21.9	16.3	13.82	13.82	389.2	100.9	P/L
01/06/17, 12:41	-0.1	-0.1	21.2	15.8	13.82	13.82	389.2	100.9	P/L
01/06/17, 12:42	-0.1	-0.1	21.4	16	13.82	13.82	389.4	100.9	P/L
01/06/17, 12:43	-0.1	-0.1	21.5	16	13.81	13.81	389.4	101	P/L
01/06/17, 12:44	-0.1	-0.1	21.3	15.9	13.82	13.82	390	101	P/L
01/06/17, 12:45	-0.1	-0.1	21.3	15.9	13.82	13.82	389.6	101.1	P/L
01/06/17, 12:46	-0.1	-0.1	21.3	15.9	13.8	13.8	389.5	101.1	P/L
01/06/17, 12:47	-0.1	-0.1	21.6	16.1	13.81	13.81	389.7	101.1	P/L
01/06/17, 12:48	-0.1	-0.1	21.8	16.3	13.81	13.81	389.5	101.1	P/L
01/06/17, 12:49	-0.1	-0.1	21.9	16.3	13.8	13.8	389.6	101.1	P/L
01/06/17, 12:50	-0.1	-0.1	22.1	16.5	13.8	13.8	389.5	101.1	P/L
01/06/17, 12:51	-0.1	-0.1	21.6	16.1	13.8	13.8	388.8	101.1	P/L
01/06/17, 12:52	-0.1	-0.1	21.7	16.2	13.81	13.81	389.2	101.1	P/L
01/06/17, 12:53	-0.1	-0.1	21.9	16.3	13.8	13.8	389.6	101.1	P/L
01/06/17, 12:54	-0.1	-0.1	22.2	16.6	13.8	13.8	389.5	101.1	P/L
01/06/17, 12:55	-0.1	-0.1	22.1	16.5	13.8	13.8	389.3	101.1	P/L
01/06/17, 12:56	-0.1	-0.1	21.7	16.2	13.81	13.81	389.5	101.2	P/L
01/06/17, 12:57	-0.1	-0.1	21.8	16.3	13.8	13.8	389.2	101.2	P/L
01/06/17, 12:58	-0.1	-0.1	22.3	16.6	13.81	13.81	389.5	101.2	P/L
01/06/17, 12:59	-0.1	-0.1	23.2	17.3	13.82	13.82	389.4	101.3	P/L
01/06/17, 13:00	-0.1	-0.1	23.4	17.5	13.82	13.82	390.1	101.3	P/L
01/06/17, 13:01	-0.1	-0.1	23.5	17.5	13.81	13.81	389.4	101.3	P/L
01/06/17, 13:02	-0.1	-0.1	23.2	17.3	13.81	13.81	389.4	101.4	P/L
01/06/17, 13:03	-0.1	-0.1	23.1	17.2	13.82	13.82	389.6	101.4	P/L
01/06/17, 13:04	-0.1	-0.1	22.8	17	13.83	13.83	389.6	101.4	P/L
01/06/17, 13:05	-0.1	-0.1	22.2	16.6	13.85	13.85	389.2	101.4	P/L
01/06/17, 13:06	-0.1	-0.1	22.2	16.6	13.84	13.84	389.6	101.5	P/L
01/06/17, 13:07	-0.1	-0.1	22.7	16.9	13.84	13.84	389.6	101.6	P/L
01/06/17, 13:08	-0.1	-0.1	23.1	17.2	13.82	13.82	388.6	101.6	P/L
01/06/17, 13:09	-0.1	-0.1	23.5	17.5	13.8	13.8	389	101.6	P/L
01/06/17, 13:10	-0.1	-0.1	23.4	17.5	13.8	13.8	389.5	101.6	P/L
01/06/17, 13:11	-0.1	-0.1	24.1	18	13.77	13.77	389.7	101.6	P/L
01/06/17, 13:12	-0.1	-0.1	24	17.9	13.77	13.77	389.2	101.6	P/L
01/06/17, 13:13	-0.1	-0.1	24	17.9	13.76	13.76	389.4	101.7	P/L
01/06/17, 13:14	-0.1	-0.1	23.8	17.8	13.77	13.77	389.8	101.7	P/L
01/06/17, 13:15	-0.1	-0.1	23.4	17.5	13.78	13.78	389.7	101.8	P/L
01/06/17, 13:16	-0.1	-0.1	23.4	17.5	13.78	13.78	389.9	101.9	P/L
01/06/17, 13:17	-0.1	-0.1	23.6	17.6	13.77	13.77	389.8	101.9	P/L
01/06/17, 13:18	-0.1	-0.1	23.7	17.7	13.78	13.78	389.7	101.9	P/L
01/06/17, 13:19	-0.1	-0.1	23.4	17.5	13.79	13.79	389.6	102	P/L
01/06/17, 13:20	-0.1	-0.1	22.9	17.1	13.79	13.79	389.2	102	P/L
01/06/17, 13:21	-0.1	-0.1	23.1	17.2	13.79	13.79	389.7	102.1	P/L

Annex 2 NO_x converter checks

ESG attended the Nash site on the 31 May and 1 June 2017 to undertake an efficiency check on the NO_x converters associated with both CEM systems. The work undertaken is documented in the attached report.

HRSG 10

NO_2 converter efficiency check
BS EN 14792:2005 (Annex B)

Operator	Severn Power Limited
Date	1 June 2017

Analyser Type	Siemens Ultramat 23
Analsyer No.	serving GT10
Analyser Range	0-100/750 mg/m³ NO
Converter ref (if applicable)	Gas Konverter CG-2M ser no. 1325/9202677

NO_2 ref gas cylinder	XA8	94.4
NO_2 ref gas certification expiry	10 May 2019	filled May 2016
NO_2 ref gas concentration	193.52	mg/m³ NO_2

Reading	Analyser response (mg/m³)		Converter efficiency (%)
	NO	NO_x	
1	116.8	0	92.3
2	116.6	0	92.2
3	116.8	0	92.3
Mean	116.7	0	92.3

Required minimum efficiency 95 %

Converter fails efficiency test

For analysers with two reaction chambers note both the nitrogen monoxide and nitrogen oxides readings.
For analsyer with a single reaction chamber the nitrogen oxides value should be set to zero

5 **Converter efficiency check**

5.1 The converter efficiency check is only applicable to nitrogen oxides analysers and check the efficiency of conversion of NO_2 to NO in the catalytic converter.

5.2 Select a gas containing nitrogen dioxide (preferably in the range 50-100 ppm.

5.3 Span and zero the analyser accordingly.

5.4 For a dual reaction chamber system (e.g. Ecophysics), both channels (NO and NO_x) should undergo span and zero and be adjusted to give the same value.

5.5 Pass NO_2 into the analyser and note the readings (NO and NO_x as appropriate) after a stabilisation period of at least three time the response time. Undertake three determinations and note on the attached spreadsheet.

5.6 For a single channel system the analyser should be set to measure NO and the NO readings should be noted on the spreadsheet. The corresponding NO_x reading should be entered as zero.

5.7 Using the spreadsheet determine the converter efficiency and its compliance with the standard performance requirement.

NO_2 converter efficiency check
BS EN 14792:2005 (Annex B)

Operator	**Severn Power Limited**
Date	**31 May 2017**

Analyser Type	**Siemens Ultramat 23**	
Analsyer No.	**serving GT20**	
Analyser Range	**0-100/750**	**mg/m³ NO**
Converter ref (if applicable)	**Gas Konverter CG-2M ser no. 1325/9202677**	

NO_2 ref gas cylinder	**XA 8**	**94.4ppm**
NO_2 ref gas certification expiry	**10 May 2019**	**filled May 2016**
NO_2 ref gas concentration	**193.52**	**mg/m³ NO_2**

Reading	Analyser response (mg/m³)		Converter efficiency (%)
	NO	NO_x	
1	**117.8**	**0**	93.1
2	**118.0**	**0**	93.3
3	**118.0**	**0**	93.3
Mean	117.9	0	93.2

Required minimum efficiency 95 %

Converter fails efficiency test

For analysers with two reaction chambers note both the nitrogen monoxide and nitrogen oxides readings.
For analsyer with a single reaction chamber the nitrogen oxides value should be set to zero

5	**Converter efficiency check**
5.1	The converter efficiency check is only applicable to nitrogen oxides analysers and check the efficiency of conversion of NO_2 to NO in the catalytic converter.
5.2	Select a gas containing nitrogen dioxide (preferably in the range 50-100 ppm.
5.3	Span and zero the analyser accordingly.
5.4	For a dual reaction chamber system (e.g. Ecophysics), both channels (NO and NO_x) should undergo span and zero and be adjusted to give the same value.
5.5	Pass NO_2 into the analyser and note the readings (NO and NO_x as appropriate) after a stabilisation period of at least three time the response time. Undertake three determinations and note on the attached spreadsheet.
5.6	For a single channel system the analyser should be set to measure NO and the NO readings should be noted on the spreadsheet. The corresponding NO_x reading should be entered as zero.
5.7	Using the spreadsheet determine the converter efficiency and its compliance with the standard performance requirement.

Annex 3 Routine analyser checking

Siemens undertake checking of the analyser performance every 15 days. The analyser undergoes an auto calibration and is then checked with reference gases. Acceptance criteria are specified. This is not entirely consistent with QAL 3 as auto calibration prior to checking does not permit a meaningful assessment of the system measurement bias. It is expected that full QAL 3 compliance will be possible with the new Envirosoft software which has recently been installed. An example of checks on each CEM system is provided below and refers to the system checks undertaken on the 24 May 2017.

HRSG 10

SIEMENS

SEVERN POWER
O&M Form No: EF-08.007-01
Rev. 0

15 day CEMS Maintenance Checklist

Work Order:	771	Unit:	10	Date:	24/05/2017

Gas Calibration Bottle Information:

	Gas Calibration Data	Test Gas Certified Values		
Cylinder ID Number	163264	Gas	ppm	mg/m³
Certification Type		CO	101.2	126.5
Certification Date	28-Oct-2015	NO	94.6	126.764
Certification Expiry	27-Oct-2020			

Analyzer Information:

Manufacturer	Model	Meas Components	Serial Number
Siemens	Ultramat 23	CO/NO/O2	7MB2337-4AU10-PT1-Z

Calibration Information:

Component	ZERO (after AUTOCAL)	MEAS VALUE (before CAL)	MEAS VALUE (after CAL) (A)	Test Gas Certified Value (B)	Span Error (%) (C) See Notes 1&2
CO (mg/m³)	0.3	126.1	126.1	126.5	-0.316205534
NO (mg/m³)	0	126.4	126.4	126.8	-0.315457413

System General Check

Cabinet Visual Inspection:	OK	Cabinet Fans/Filter/Heater Status	OK
Line 1 Flow (l/h):	OK	Filter Status (B4 and KT2):	OK
Line 2 Flow (l/h):	OK	O² Sensor Voltage (mV):	10.93

Notes:
(1) If span error is greater than 2% following calibration then calibration should be considered failed and should be repeated.
(2) C = (A-B) * 100/B
(3) 1ppm CO = 1.25mg/m³
(4) 1ppm NO = 1.34mg/m³

Remarks:

Non-Conformance reported with FN No. _____/_____(year)

Inspector/Date: DW/WJ 24/05/2017

Confidential Z:\maintenance_management\doc_TP\Maintenance Documentation\I&C\2017\CEMS\U10\15 DAY\WO 771 24052017_Unit 10 15 Day.xls
Author: Severn Power
Date of issue: 23-08-2010
Page 1 of 2

HRSG 20

SIEMENS

SEVERN POWER
O&M Form No: EF-08.007-01
Rev. 0

15 day CEMS Maintenance Checklist

Work Order:	770	Unit:	20	Date:	24/05/2017

Gas Calibration Bottle Information:

	Gas Calibration Data	Test Gas Certified Values		
Cylinder ID Number	108632	Gas	ppm	mg/m³
Certification Type	BOC HiQ	CO	100.6	125.75
Certification Date	28-Oct-2015	NO	94.5	126.63
Certification Expiry	27-Oct-2020			

Analyzer Information:

Manufacturer	Model	Meas Components	Serial Number
Siemens	Ultramat 23	CO/NO/O2	7MB2337-4AU10-3PT1-Z

Calibration Information:

Component	ZERO (after AUTOCAL)	MEAS VALUE (before CAL)	MEAS VALUE (after CAL) (A)	Test Gas Certified Value (B)	Span Error (%) (C) See Notes 1&2
CO (mg/m³)	0.4	126.4	126.4	125.75	0.516898608
NO (mg/m³)	0.4	126.4	126.4	126.63	-0.181631525

System General Check

Cabinet Visual Inspection:	OK	Cabinet Fans/Filter/Heater Status	OK
Line 1 Flow (l/h):	OK	Filter Status (B4 and KT2):	OK
Line 2 Flow (l/h):	OK	O² Sensor Voltage (mV):	11.43

Notes:
(1) If span error is greater than 2% following calibration then calibration should be considered failed and should be repeated.
(2) C = (A-B) * 100/B
(3) 1ppm CO = 1.25mg/m³
(4) 1ppm NO = 1.34mg/m³

Remarks:

Non-Conformance reported with FN No. _____/_____(year)

Inspector/Date: WJ 24/05/17

END OF REPORT

Contact:

Dr Nick Ford
Environmental Scientifics Group Ltd
Unit D
Bankside Trade Park
Cirencester
Gloucestershire
GL7 1YT

T: 07768 257628
E: nick.ford@esg.co.uk

