FACULTATIEVE TECHNOLOGIES LTD

Examples of

Flue Gas Analysis Testwork

Performed on *FTII* / *FTIII* cremators
Verifying compliance with UK
PG 5/2 (04)

Example Site 1

Charnock Richard Crematorium, Lancashire. UK.

Example Site 2

East Lancashire Crematorium, Lancashire. UK.

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EMISSIONS MONITORING TEST REPORT

CHARNOCK RICHARD CREMATORIUM,
PRESTON ROAD
CHARNOCK RICHARD
CHORLEY
LANCASHIRE
PR7 5JP

18th – 19th OCTOBER 2007

S. Atherton

Report Authorised by ______________________ Date 8 January 2008

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CONTENTS

1. INTRODUCTION

The cremator at Charnock Richard Crematorium, Preston Road, Charnock Richard, Chorley was monitored on the 18th and 19th October 2007 to the requirements given in Process Guidance Note PG5/2 (2004) for emission releases to atmosphere.

The work involved monitoring a range of flue gas components at the waste gas outlet of the cremator. The cremator is not fitted with any form of abatement plant.

The cremator and ancillary equipment were manufactured, installed and commissioned by Facultatieve Technologies Limited to meet the requirements of the Pollution Prevention and Control Regulations 2000 (PPC 2000) as relevant to existing crematoria installations, summarised in Process Guidance Note PG5/2 (2004).

The cremator installed is that designated as the FTIII by Facultatieve Technologies Ltd with LPG gas as the support fuel via two nozzle mix burners. The FTIII cremator has a has a wider primary combustion chamber than has been typical in order that it is capable of accepting very large coffins.

Measurements were undertaken to enable comparisons to be made of the operation of the cremator with the requirements of the Guidance Note in terms of emission releases to air.

This report details the monitoring procedures used and the results obtained from this test work along with comparisons with the Guidance Note requirements and comments where appropriate.

Relevant procedures were followed to enable quality control to be maintained throughout the test preparation, site test work, laboratory analysis, calculations and reporting.

2. PROCEDURES

2.1 Total Particulate Matter

A flue gas sample was extracted and filtered to collect total particulate matter. A Whatman QM-A filter paper was used with a particle retention of not less than 99.5% at a particle size of 0.3 micron. The flue gas extraction employed techniques given in BS EN 13284 Part 1, and the adaptations given in PG Note 5/2 (2004) Clause 9.5, allowing sampling in one line of the flue duct due to the batch nature of the cremation process.

The method employed was BS EN 13284 Part 1 and the PG Note 5/2 (2004) Clause 9.5 adaptations.

The sampling was conducted using apparatus in accordance with the requirements of BS EN 13284 Part 1.

This consisted of a heated known dimension Pyrex glass nozzle, heated Pyrex glass probe liner, heated Pyrex glass filter housing with Titanium frit containing quartz microfibre filter (all heaters set to 160°C), PTFE sample line, dreschel absorption bottles, gas dryer (silica gel), sample line to pump, pump, gas meter, rotameter, pitot and impulse lines, electronic manometer, type K thermocouple, balance (for gravimetric moisture) and datalogger. Settings tables were pre-prepared to enable isokinetic flow to be maintained (based on online measurements of flue gas velocity and temperature to set nozzle flow / pump rate (l/min)).

Particulate matter analysis was carried out by weighing the filter and probe rinse collection on a calibrated balance, with the media being dried and weighed prior to and following the test.

2.2 Hydrogen Chloride

A flue gas sample was extracted and filtered. The gas sample was then passed through an absorption medium of de-ionised water to collect hydrogen chloride.

The method employed was BS EN 1911 Parts 1-3.

Laboratory analysis for hydrogen chloride was carried out on the absorption medium using Ion Chromatography (IC).

2.3 Carbon Monoxide

A flue gas sample was continuously extracted, filtered and dried before being passed through a pre-calibrated Siemens Ultramat 21/O_2 infrared analyser for the on-line measurement of carbon monoxide. The analyser has a fixed range of 0-1250 mg/Nm^3 and was zeroed with air and calibrated with a nominal 800 ppmv carbon monoxide in balance nitrogen gas.

The method employed was BS ISO 12039.

The analyser output was continuously recorded using a Grant 'Squirrel' data logger.

2.4 Volatile Organic Compounds

A flue gas sample was continuously extracted and filtered before being passed via a heated line through a pre-calibrated Signal 3030PM Flame Ionisation Detection (FID) analyser for the on-line measurement of volatile organic compounds. The analyser was ranged 0-100 ppmv total hydrocarbons and was zeroed with air passed through a catalytic converter and calibrated with a nominal 50 ppmv propane in balance air gas.

The method employed was BS EN 12619.

The analyser output was continuously recorded using a Grant 'Squirrel' data logger.

2.5 Oxygen

A flue gas sample was continuously extracted from the same position in the flue as the other pollutants extraction, filtered and dried before being passed through a pre-calibrated Siemens Ultramat 21/O_2 electrochemical cell analyser for the on-line measurement of flue oxygen.

The method employed was BS ISO 12039.

The output of the analyser was continuously recorded using a Grant 'Squirrel' data logger.

2.6 Moisture

A flue gas sample was extracted and filtered. The gas sample was then passed through an absorption medium to collect any water vapour.

The method employed was US EPA Method 4.

Flue gas moisture was determined gravimetrically by weighing the absorption medium and final gas drier prior to and following the test.

2.7 Temperature

The cremator secondary chamber exit and flue temperatures were measured by the use of calibrated Type K thermocouples.

The method employed was BS EN 13284 Part 1.

The gas temperatures were continuously recorded using a Grant 'Squirrel' data logger.

2.8 Velocity and Volumetric Flow

Flue gas velocity was found from inserting a calibrated s-type pitot tube into the flue. The pitot head pressure was then measured using a calibrated electronic manometer.

The method employed was BS EN 13284 Part 1.

The electronic manometer output was continuously recorded using a Grant 'Squirrel' data logger.

Flue gas velocity was then calculated from Bernoulli's equation as the density of the flue gas was known (from measurements of flue gas moisture and temperature).
Flue gas volumetric flowrate was found from the measurement of the flue duct size and hence its area and corrected to normalised conditions (again from measurements of flue gas moisture and temperature).

2.9 Secondary Combustion Chamber Gas Residence Time

The stated secondary chamber volume (provided by the cremator manufacturer) divided by the calculated gas volumetric flow exiting the secondary combustion zone gives the secondary combustion zone gas residence times, which are expressed as one-minute averages.

3. RESULTS

The emissions results are summarised in Table1.

The secondary combustion chamber gas residence times are shown in Plots 1 to 3.

All values in the table are corrected to the reference conditions of 273K, 101.3kPa, 11%v/v oxygen and dry gas as given in PG5/2(04) where required.

Data logs and calculations are shown in Appendix 1.

Analysis reports are shown in Appendix 2.

TABLE 1
Charnock Richard Cremator No. 1
Emissions Monitoring 18th - 19th October 2007

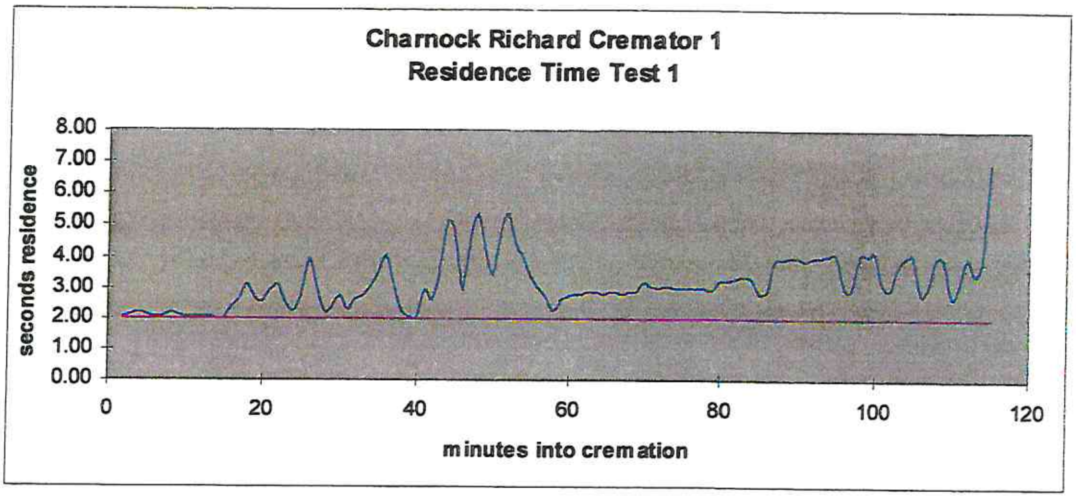
		Test 1	Test 2	Test 3	Average	Requirement to PG5/2 (2004)
Total Particulate Matter	- mg/Nm^{3}c.	45.18 ± 2.68	31.98 ± 1.90	97.65 ± 5.78	58.27	<80
	- g/h	44.82 ± 2.66	30.88 ± 1.83	94.32 ± 5.92	56.68	<120
Hydrogen Chloride	- mg/Nm^{3}c.	0.60 ± 0.66	41.46 ± 2.35	38.40 ± 2.27	26.82	<200
	- g/h	0.60 ± 0.65	40.04 ± 2.27	37.09 ± 0.06	25.91	<300
Carbon Monoxide	- mg/Nm^{3}c.	5.22 ± 0.26	10.14 ± 0.51	10.25 ± 0.51	8.54	<100
	- g/h	5.18 ± 0.26	9.80 ± 0.49	9.90 ± 0.50	8.29	<150
Organic Compounds	- mg/Nm^{3}c.	0.67 ± 0.03	0.59 ± 0.03	0.14 ± 0.01	0.47	<20
	- g/h	0.67 ± 0.03	0.57 ± 0.03	0.14 ± 0.01	0.46	<30

Flue Oxygen	- %v/v dry	16.14 ± 0.10	15.87 ± 0.10	16.26 ± 0.10	16.09
Flue Moisture	- %v/v	2.8 ± 0.3	5.7 ± 0.6	4.7 ± 0.5	4.4
	- %w/w	1.8 ± 0.2	3.6 ± 0.4	3.0 ± 0.3	2.8
Flue Temperature	- Deg C	437 ± 2	444 ± 2	449 ± 2	443
Volumetric Flow	- Nm^3/h dry	2054 ± 41	1891 ± 38	2047 ± 41	1997

Note 1: All emissions as concentration levels are given as mg/Nm^3 corrected to 11%v/v oxygen and dry gas

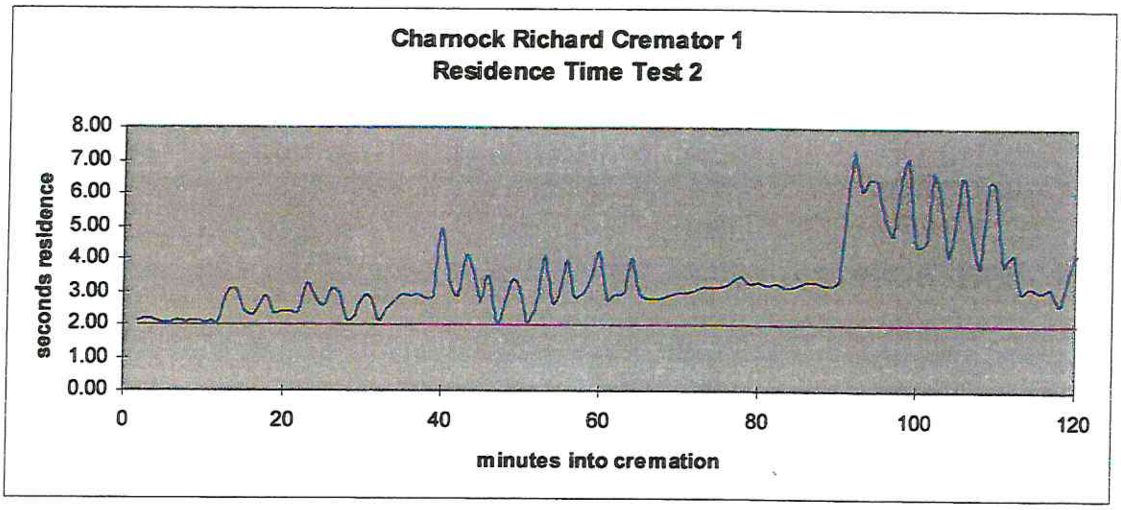
Note 2: All uncertainties (±) are calculated to a 95% confidence interval
Uncertainties estimated using the procedure suggested in the STA Quality Guidance Note QGN001-01

PLOT 1



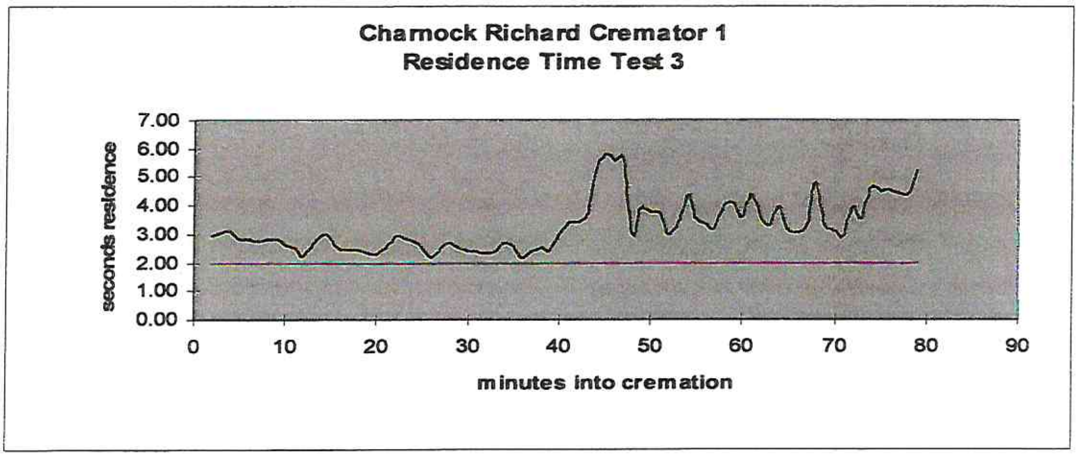
Charnock Richard Cremator 1
Residence Time Test 1
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
seconds residence
0
20
40
60
80
100
120
minutes into cremation

PLOT 2



Charnock Richard Cremator 1
Residence Time Test 2
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
seconds residence
0
20
40
60
80
100
120
minutes into cremation

PLOT 3



Charnock Richard Cremator 1
Residence Time Test 3
seconds residence
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
10
20
30
40
50
60
70
80
90
minutes into cremation

4. COMMENTS

The results obtained from this monitoring test work show compliance with the requirements given in Process Guidance Note PG5/2 (2004) on the basis of mass emissions to air that is understood to be the basis of the permit issued by the Regulator.

No visible smoke or emission was observed throughout the test work.

The Secondary Combustion Chamber conditions met the requirements of a 2 second gas residence time for all tests, and temperatures were maintained above 850 deg.C at all times.

Combustion conditions were consistently very good as demonstrated by the low emissions of carbon monoxide and VOC's.

5. QUALITY CONTROL

All the tests performed were carried out to the methods given in the appropriate listed Standards using calibrated equipment. The gas analysers were calibrated prior to use using suitable calibration gases.

Analysis of the filters and absorber solutions was carried out in-house and at an external laboratory.

For this test work the following external laboratory was used for the given determinations:

Scientific Analysis Laboratories (SAL) } Hydrogen Chloride

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EMISSIONS MONITORING TEST REPORT

EAST LANCASHIRE CREMATORIUM,
CEMETERY ROAD
RADCLIFFE
BURY
LANCASHIRE
M26 0EU

7th – 8th AUGUST 2007

Report Authorised by S. Atherton Date 30 November 2007

Mr S P Atherton
Business Manager
MCertS Level 2 + TE1,2,3,4
MM 03 336

ST/DEM/EL/30.11.07

CONTENTS

1. INTRODUCTION

The two cremators at East Lancashire Crematorium, Cemetery Road, Radcliffe were monitored on the 7th and 8th August 2007 to the requirements given in Process Guidance Note PG5/2 (2004) for emission releases to atmosphere.

The work involved monitoring a range of flue gas components at the waste gas outlet of each cremator. The cremators are not fitted with any form of abatement plant.

The cremators and ancillary equipment were manufactured, installed and commissioned by Facultatieve Technologies Limited to meet the requirements of the Pollution Prevention and Control Regulations 2000 (PPC 2000) as relevant to new crematoria installations, summarised in Process Guidance Note PG5/2 (2004).

The cremators are those designated as the FTII (No.2) and FTIII (No.1) by Facultatieve Technologies Ltd with gas as the support fuel via two nozzle mix burners on each cremator. The FTII & FTIII are of similar construction and configuration, the major difference being that the FTIII has a wider primary combustion chamber that is capable of accepting very large coffins.

Measurements were undertaken to enable comparisons to be made of the operation of the cremators with the requirements of the Guidance Note in terms of emission releases to air.

This report details the monitoring procedures used and the results obtained from this test work along with comparisons with the Guidance Note requirements and comments where appropriate.

Relevant procedures were followed to enable quality control to be maintained throughout the test preparation, site test work, laboratory analysis, calculations and reporting.

2. PROCEDURES

2.1 Total Particulate Matter

A flue gas sample was extracted and filtered to collect total particulate matter. A Whatman QM-A filter paper was used with a particle retention of not less than 99.5% at a particle size of 0.3 micron. The flue gas extraction employed techniques given in BS EN 13284 Part 1, and the adaptations given in PG Note 5/2 (2004) Clause 9.5, allowing sampling in one line of the flue duct due to the batch nature of the cremation process.

The method employed was BS EN 13284 Part 1 and the PG Note 5/2 (2004) Clause 9.5 adaptations.

The sampling was conducted using apparatus in accordance with the requirements of BS EN 13284 Part 1.

This consisted of a heated known dimension Pyrex glass nozzle, heated Pyrex glass probe liner, heated Pyrex glass filter housing with Titanium frit containing quartz microfibre filter (all heaters set to 160°C), PTFE sample line, dreschel absorption bottles, gas dryer (silica gel), sample line to pump, pump, gas meter, rotameter, pitot and impulse lines, electronic manometer, type K thermocouple, balance (for gravimetric moisture) and datalogger. Settings tables were pre-prepared to enable isokinetic flow to be maintained (based on online measurements of flue gas velocity and temperature to set nozzle flow / pump rate (l/min)).

Particulate matter analysis was carried out by weighing the filter and probe rinse collection on a calibrated balance, with the media being dried and weighed prior to and following the test.

2.2 Hydrogen Chloride

A flue gas sample was extracted and filtered. The gas sample was then passed through an absorption medium of de-ionised water to collect hydrogen chloride.

The method employed was BS EN 1911 Parts 1-3.

Laboratory analysis for hydrogen chloride was carried out on the absorption medium using Ion Chromatography (IC).

2.3 Carbon Monoxide

A flue gas sample was continuously extracted, filtered and dried before being passed through a pre-calibrated Siemens Ultramat 21/O_2 infrared analyser for the on-line measurement of carbon monoxide. The analyser has a fixed range of 0-1250 mg/Nm^3 and was zeroed with air and calibrated with a nominal 800 ppmv carbon monoxide in balance nitrogen gas.

The method employed was BS ISO 12039.

The analyser output was continuously recorded using a Grant 'Squirrel' data logger.

2.4 Volatile Organic Compounds

A flue gas sample was continuously extracted and filtered before being passed via a heated line through a pre-calibrated Signal 3030PM Flame Ionisation Detection (FID) analyser for the on-line measurement of volatile organic compounds. The analyser was ranged 0-100 ppmv total hydrocarbons and was zeroed with air passed through a catalytic converter and calibrated with a nominal 50 ppmv propane in balance air gas.

The method employed was BS EN 12619.

The analyser output was continuously recorded using a Grant 'Squirrel' data logger.

2.5 Oxygen

A flue gas sample was continuously extracted from the same position in the flue as the other pollutants extraction, filtered and dried before being passed through a pre-calibrated Siemens Ultramat 21/O_2 electrochemical cell analyser for the on-line measurement of flue oxygen.
Also, a sample of gas was continuously extracted from the inlet duct of the waste heat boiler (secondary combustion chamber exit), filtered and dried before being passed through a pre-calibrated Servomex 570A paramagnetic analyser for the on-line measurement of secondary combustion chamber oxygen.

The method employed was BS ISO 12039.

The outputs of the analysers were continuously recorded using a Grant 'Squirrel' data logger.

2.6 Moisture

A flue gas sample was extracted and filtered. The gas sample was then passed through an absorption medium to collect any water vapour.

The method employed was US EPA Method 4.

Flue gas moisture was determined gravimetrically by weighing the absorption medium and final gas drier prior to and following the test.

2.7 Temperature

The cremator secondary chamber exit and flue (filter outlet) temperatures were measured by the use of calibrated Type K thermocouples.

The method employed was BS EN 13284 Part 1.

The gas temperatures were continuously recorded using a Grant 'Squirrel' data logger.

2.8 Velocity and Volumetric Flow

Flue gas velocity was found from inserting a calibrated s-type pitot tube into the flue. The pitot head pressure was then measured using a calibrated electronic manometer.

The method employed was BS EN 13284 Part 1.

The electronic manometer output was continuously recorded using a Grant 'Squirrel' data logger.

Flue gas velocity was then calculated from Bernoulli's equation as the density of the flue gas was known (from measurements of flue gas moisture and temperature).
Flue gas volumetric flowrate was found from the measurement of the flue duct size and hence its area and corrected to normalised conditions (again from measurements of flue gas moisture and temperature).

2.9 Secondary Combustion Chamber Gas Residence Time

The stated secondary chamber volume (provided by the cremator manufacturer) divided by the calculated gas volumetric flow exiting the secondary combustion zone gives the secondary combustion zone gas residence times, which are expressed as one-minute averages.

3. RESULTS

The emissions results are summarised in Tables 1 & 2.

The secondary combustion chamber gas residence times are shown in Plots 1 to 6.

All values in the tables are corrected to the reference conditions of 273K, 101.3kPa, 11%v/v oxygen and dry gas as given in PG5/2(04) where required.

Data logs and calculations are shown in Appendix 1.

Analysis reports are shown in Appendix 2.

TABLE 1
East Lancashire Cremator No. 1
Emissions Monitoring 7th August 2007

		Test 1	Test 2	Test 3	Average	Requirement to PG5/2 (2004)
Total Particulate Matter	- mg/Nm^{3}c.	56.87 ± 3.14	71.12 ± 3.99	104.44 ± 5.76	77.48	<80
	- g/h	59.12 ± 3.26	68.09 ± 3.82	95.73 ± 5.51	74.31	<120
Hydrogen Chloride	- mg/Nm^{3}c.	29.52 ± 1.61	22.69 ± 1.27	19.16 ± 1.10	23.79	<200
	- g/h	30.69 ± 1.67	21.72 ± 1.22	17.56 ± 0.06	23.32	<300
Carbon Monoxide	- mg/Nm^{3}c.	27.24 ± 1.36	16.92 ± 0.85	3.28 ± 0.16	15.82	<100
	- g/h	28.32 ± 1.42	16.20 ± 0.81	3.01 ± 0.15	15.84	<150
Organic Compounds	- mg/Nm^{3}c.	0.92 ± 0.05	0.19 # 0.01	0.04 ± 0.00	0.38	<20
	- g/h	0.96 ± 0.05	0.18 # 0.01	0.03 ± 0.00	0.39	<30

		Test 1	Test 2	Test 3	Average
Flue Oxygen	- %v/v dry	15.74 ± 0.10	15.98 ± 0.10	16.23 ± 0.10	15.98
Flue Moisture	- %v/v	4.7 ± 0.5	5.8 ± 0.6	3.5 ± 0.4	4.7
	- %w/w	3.0 ± 0.3	3.7 ± 0.4	2.2 ± 0.2	2.9
Flue Temperature	- Deg C	465 ± 2	462 ± 2	474 ± 2	467
Volumetric Flow	- Nm^3/h dry	1985 ± 40	1916 ± 38	1933 ± 39	1944

Note 1: All emissions as concentration levels are given as mg/Nm^3 corrected to 11%v/v oxygen and dry gas

Note 2: All uncertainties (±) are calculated to a 95% confidence interval
Uncertainties estimated using the procedure suggested in the STA Quality Guidance Note QGN001-01

TABLE 2
East Lancashire Cremator No. 2
Emissions Monitoring 8th August 2007

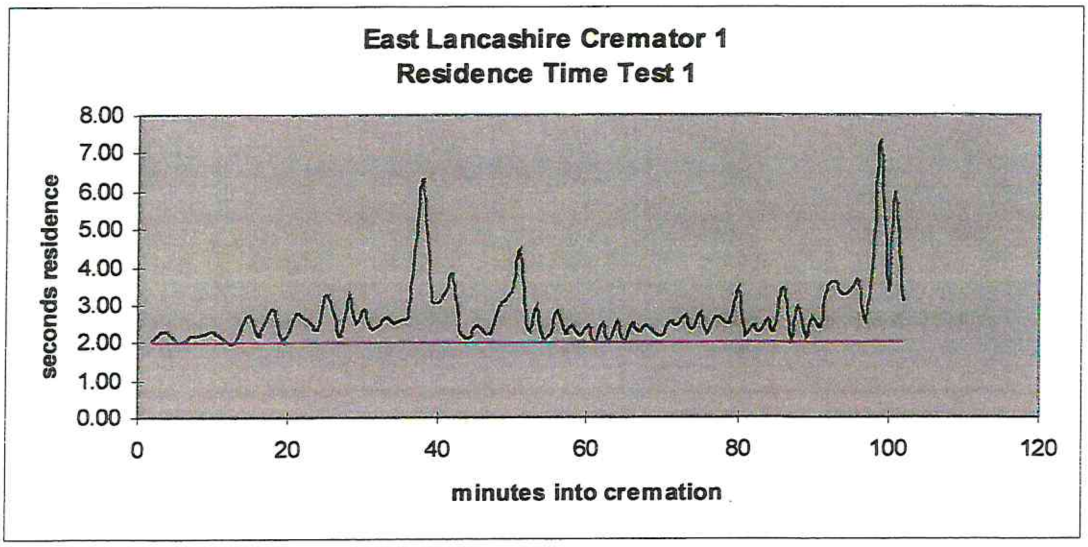
		Test 1	Test 2	Test 3	Average	Requirement to PG5/2 (2004)
Total Particulate Matter	- mg/Nm^{3}c.	38.40 ± 2.28	72.52 ± 3.80	102.19 ± 6.08	71.03	<80
	- g/h	48.12 ± 2.86	80.70 ± 4.23	105.88 ± 5.95	78.23	<120
Hydrogen Chloride	- mg/Nm^{3}c.	39.93 ± 2.26	72.22 ± 3.71	30.21 ± 1.63	47.45	<200
	- g/h	50.03 ± 2.83	80.37 ± 4.13	31.30 ± 0.05	53.90	<300
Carbon Monoxide	- mg/Nm^{3}c.	5.48 ± 0.27	6.83 ± 0.34	3.76 ± 0.19	5.36	<100
	- g/h	6.87 ± 0.34	7.60 ± 0.38	3.90 ± 0.19	6.12	<150
Organic Compounds	- mg/Nm^{3}c.	0.87 ± 0.04	0.26 ± 0.01	0.49 ± 0.02	0.54	<20
	- g/h	1.09 ± 0.05	0.29 ± 0.01	0.51 ± 0.03	0.63	<30
Flue Oxygen	- %v/v dry	16.11 ± 0.10	15.04 ± 0.10	15.66 ± 0.10	15.60	
Flue Moisture	- %v/v	4.7 ± 0.5	3.9 ± 0.4	6.0 ± 0.6	4.8	
	- %w/w	2.9 ± 0.3	2.4 ± 0.2	3.8 ± 0.4	3.1	
Flue Temperature	- Deg C	544 ± 2	576 ± 2	576 ± 2	565	
Volumetric Flow	- Nm^3/h dry	2577 ± 52	1875 ± 37	1948 ± 39	2133	

Note 1: All emissions as concentration levels are given as mg/Nm^3 corrected to 11%v/v oxygen and dry gas

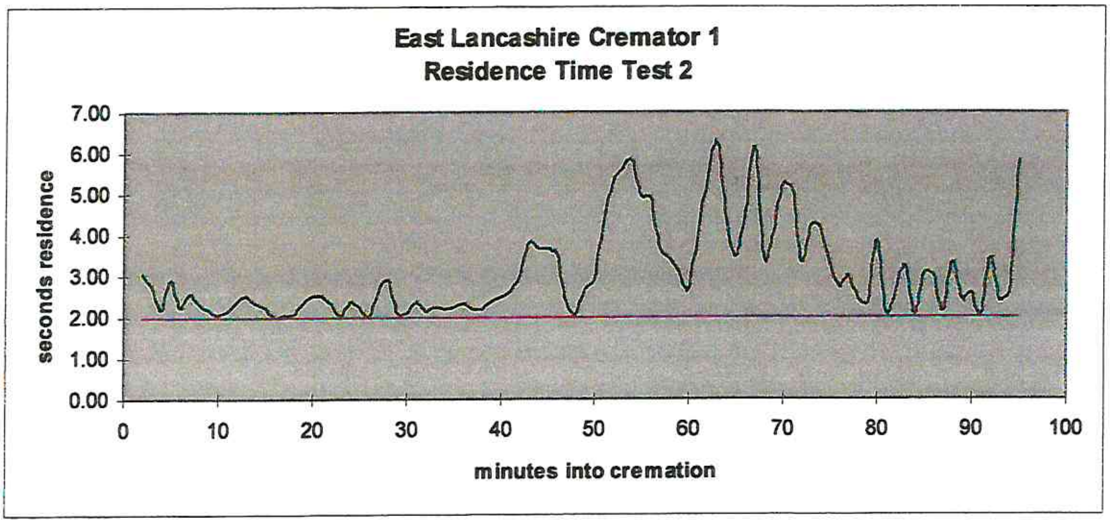
Note 2: All uncertainties (±) are calculated to a 95% confidence interval

Uncertainties estimated using the procedure suggested in the STA Quality Guidance Note QGN001-01

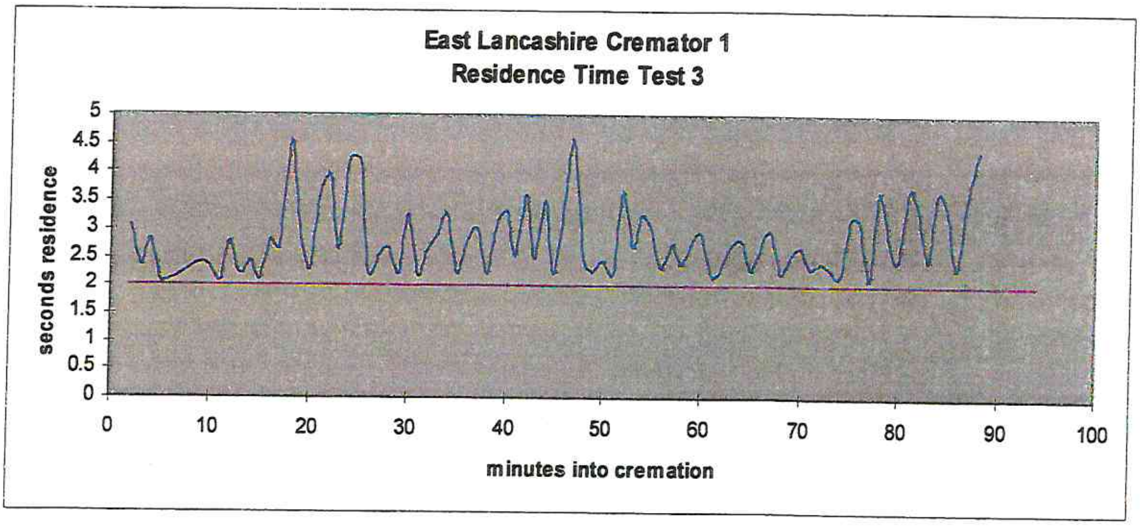
PLOT 1


East Lancashire Cremator 1
Residence Time Test 1
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
seconds residence
0
20
40
60
80
100
120
minutes into cremation

PLOT 2

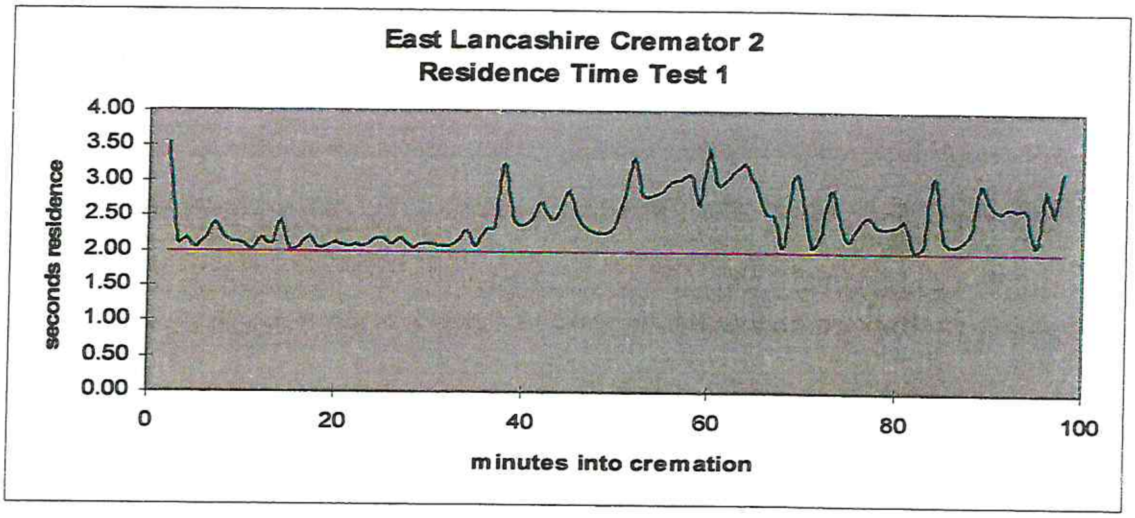

East Lancashire Cremator 1
Residence Time Test 2
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
seconds residence
0
10
20
30
40
50
60
70
80
90
100
minutes into cremation

PLOT 3



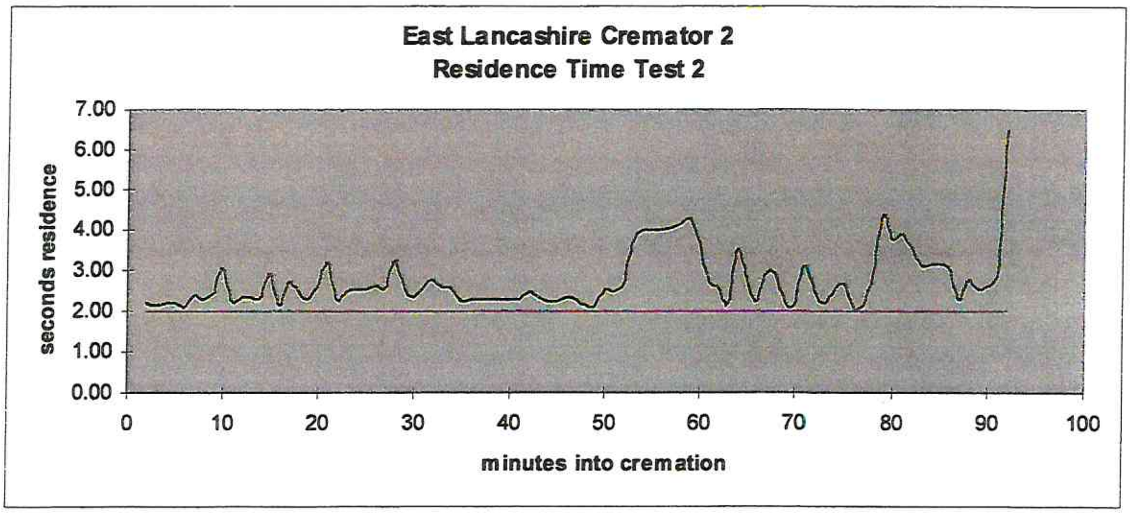
East Lancashire Cremator 1
Residence Time Test 3
seconds residence
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
10
20
30
40
50
60
70
80
90
100
minutes into cremation

PLOT 4

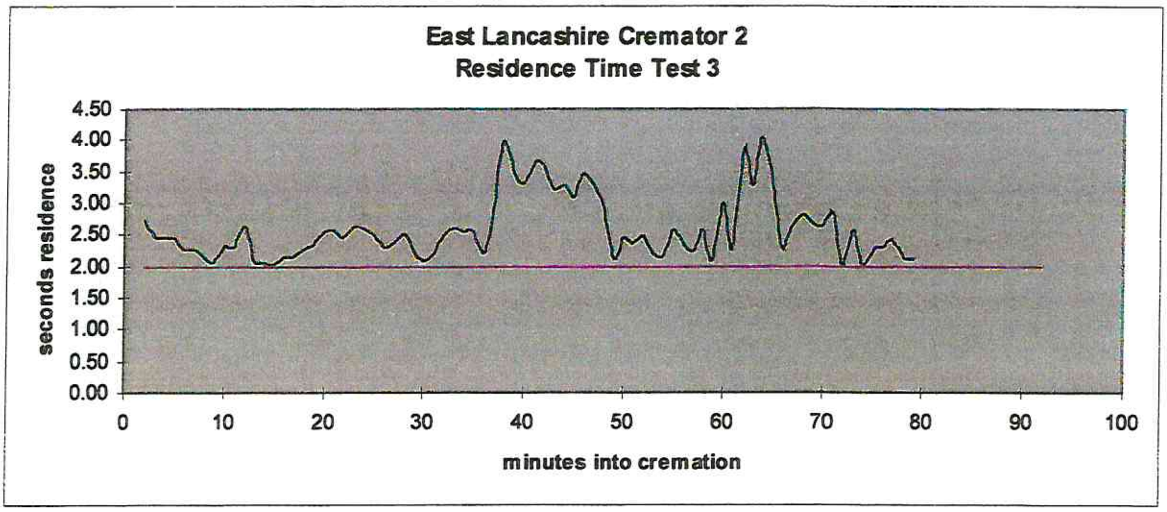


East Lancashire Cremator 2
Residence Time Test 1
seconds residence
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
20
40
60
80
100
minutes into cremation

PLOT 5



PLOT 6



Davies & Co (Engineering) Ltd

4. COMMENTS

The results obtained from this monitoring test work show compliance with the requirements given in Process Guidance Note PG5/2 (2004) on the basis of mass emissions to air that is understood to be the basis of the permit issued by the Regulator.

No visible smoke was observed throughout the test work.

The Secondary Combustion Chamber conditions met the requirements of a 2 second gas residence time for all tests, and temperatures were maintained above 850 deg.C at all times other than a slight dip for two minutes during the early stages of Test 1 for Cremator No.2 when the temperature fell to 844 deg.C. This is probably as a result of the Cremator not being fully pre-heated and can be rectified by minor changes to the pre-heat set points in the control system.

Combustion conditions were consistently very good as demonstrated by the low emissions of carbon monoxide and VOC's.

5. QUALITY CONTROL

All the tests performed were carried out to the methods given in the appropriate listed Standards using calibrated equipment. The gas analysers were calibrated prior to use using suitable calibration gases.

Analysis of the filters and absorber solutions was carried out in-house and at an external laboratory.

For this test work the following external laboratory was used for the given determinations:

Scientific Analysis Laboratories (SAL) } Hydrogen Chloride