DETERMINATION OF COMBUSTION PLANT FLUE GAS VELOCITY, VOLUMETRIC FLOW RATE AND GASEOUS EMISSIONS

at

FARMERS BOY (Deeside)

Prepared for:

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QUALITY REVIEW AND APPROVAL RECORD

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As part of this process, your deliverable has been checked and authorised for issue, as evidenced by the approval record below.

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INTRODUCTION

In order to complete an application for an IPPC permit to operate a Meat Processing operation at their Deeside production unit, Farmers Boy (Deeside) Limited contacted NIFES Consulting Group to determine the velocity and volumetric flow of flue gases, plus to measure the emissions of oxides of Nitrogen and Carbon Monoxide in two process and six boiler stacks.

The tests were subsequently carried out on the 19th November 2010.

The flue gas velocity was determined for the following stacks:-

- Steam Boiler 1
- Steam Boiler 2
- Hot Water Heater 1
- Hot Water Heater 2
- LTHW Boiler 1
- LTHW Boiler 2
- Roaster A
- Roaster B
- Smoker

SUMMARY

As a result of the tests carried out, the following flue gas velocities volumetric flows were determined:-

	Velocity (m/s)	Volumetric Flow (m^3/h)		Concentration @ 3% O_2, 0°C, dry)		Mass Emissions	
		@ Stack Conditions	@ 0°C	CO mg/m^3	NO_x mg/m^3	CO g/h	NO_x g/h
Steam Boiler 1	12.1	5464	2851	13	157	29	357
Steam Boiler 2	7.3	2524	1438	15	117	18	146
Hot Water Heater 1	4.2	743	537	1	396	1	49
Hot Water Heater 2	5.6	982	764	23	267	3	33
Office Boiler 1	1.8	115	63	84	225	3	8
Office Boiler 2	3.6	101	58	22	135	1	5
Roaster 1	<1.5	<330	<230	1744	<1	<9	<1
Roaster 2	<1.5	281	<172	675	<1	<3	<1
Smoker	<1.4	<154	<128	2813	<1	<8	<1

Note: The above flue gas velocities and volumetric flows are quoted at the stack conditions existing at the time of the test, but will vary with firing rate and combustion conditions.

Pollutant concentrations are shown at the normally applied reference conditions for gas fired boilers.

In the case of smokers and roasters, no flue gas flows could be measured in the exhaust stack, although high flue gas temperatures indicated the plant was operational.

The high concentration of carbon monoxide indicated for the roasters and smoker reflects the high oxygen levels detected in the flue and the correspondingly large correction factor required to report the emissions at 3% oxygen. The actual concentrations at stack conditions is shown in Section 4.0.

Based on the above figures, emission from the cookers and, to a large extent, the office boilers can be largely discounted when considered in relation to the process plant.

1.0 METHODOLOGY

1.1 Sample Position

All sampling was carried out at sample points provided by Farmers Boy (Deeside) Ltd personnel on the advice of NIFES' Engineer.

The positions selected were chosen with a view to them providing a flat flow profile across the duct which would allow representative measurements to be taken. The position was however subject to limitations imposed by access to the test position.

1.2 Velocity

Where possible, flue gas velocity was determined by carrying out a ten point traverse across each of the ducts using an NPL pitot tube in conjunction with an electronic micromanometer.

1.3 Stack Temperature

Flue gas temperatures were measured using a K-type thermocouple and electronic temperature indicator.

1.4 Stack Gas Concentration

The flue gas composition was determined using an ECOM SG Plus combustion analyser which measured oxygen, carbon monoxide, nitrogen oxide and nitrogen dioxide.

1.5 Stack Area

The cross sectional area of the duct was derived from the diameter of the duct at the sample point.

2.0 TEST RESULTS

Details of the test measurement are included in Appendix 1, but the figures derived are summarised below:-

2.1 Steam Boiler No.2 (DEE 254)

BIB, Beevor, 1881 kW

Stack Diameter	400mm
Flue Gas Temperature	250 °C
Flue Gas Oxygen Content	3.4% O_2
Flue Gas Velocity	12.1 m/s
Volumetric Flow @ Stack Conditions	5464 m^3/h
Volumetric Flow @ 0°C	2851 m^3/h

2.2 Steam Boiler No.2 (DEE 255)

Babcock Wanson, 1500 LNH 10, 1679 kg/h

Stack Diameter	350mm
Flue Gas Temperature	206 °C
Flue Gas Oxygen Content	5.5% O_2
Flue Gas Velocity	7.3 m/s
Volumetric Flow @ Stack Conditions	2524 m^3/h
Volumetric Flow @ 0°C	1438 m^3/h

2.3 Hot Water Heater 1 (DEE 280)

State, SCE 65-5009, 128 kW

Stack Diameter	250mm
Flue Gas Temperature	105 °C
Flue Gas Oxygen Content	16.9% O_2
Flue Gas Velocity	4.2 m/s
Volumetric Flow @ Stack Conditions	743 m^3/h
Volumetric Flow @ 0°C	537 m^3/h

2.4 Hot Water Heater 2 (DEE 281)

State, SBE 80500 NEUK, 146 kW

Stack Diameter	250mm
Flue Gas Temperature	78 °C
Flue Gas Oxygen Content	18.1% O_2
Flue Gas Velocity	5.7 m/s
Volumetric Flow @ Stack Conditions	982 m^3/h
Volumetric Flow @ 0°C	764 m^3/h

2.5 Office LTHW Boiler No.1

Ideal Mexico Super 2

Stack Diameter	150mm
Flue Gas Temperature	230 °C
Flue Gas Oxygen Content	9.7% O_2
Flue Gas Velocity	1.8 m/s
Volumetric Flow @ Stack Conditions	115 m^3/h
Volumetric Flow @ 0°C	63 m^3/h

2.6 Office LTHW Boiler No.2

Worcester 28i (Combi)	
Stack Diameter	100mm
Flue Gas Temperature	200 °C
Flue Gas Oxygen Content	9.2% O_2
Flue Gas Velocity	3.6 m/s
Volumetric Flow @ Stack Conditions	101 m^3/h
Volumetric Flow @ 0°C	58 m^3/h

2.7 Roaster 1

Stack Diameter	280mm
Flue Gas Temperature	118 °C
Flue Gas Oxygen Content	20.6% O_2
Flue Gas Velocity	<1.5 m/s
Volumetric Flow @ Stack Conditions	<330 m^3/h
Volumetric Flow @ 0°C	<230 m^3/h

2.8 Roaster 2

Stack Diameter	280mm
Flue Gas Temperature	172 °C
Flue Gas Oxygen Content	20.6% O_2
Flue Gas Velocity	<1.6 m/s
Volumetric Flow @ Stack Conditions	<352 m^3/h
Volumetric Flow @ 0°C	<216 m^3/h

2.9 Smoker

Stack Diameter	250mm
Flue Gas Temperature	56 °C
Flue Gas Oxygen Content	20.4% O_2
Flue Gas Velocity	<1.4 m/s
Volumetric Flow @ Stack Conditions	<241 m^3/h
Volumetric Flow @ 0°C	<200 m^3/h

3.0 THEORETICAL FLUE GAS VOLUME

In addition to the flue gas volumes derived from measurements taken during the site visit, the theoretical flue gas volumes were also derived for the steam boilers when operating at their maximum capacity.

3.1 Boiler 1 - BIB Beevor

Flue gas volumetric flow (@ 250 °C and 3.4% O_2)	5299 m³/h
Flue gas volumetric flow (@ 0 °C and 3.4% O_2 dry)	2324 m³/h
Flue gas volumetric flow (@ 0 °C and 0% O_2 dry)	1948 m³/h

(250 °C and 3.4% O_2 were as-found conditions)

3.2 Boiler 2 - Babcock Wanson

Flue gas volumetric flow (@ 206 °C and 5.5% O_2)	3034 m³/h
Flue gas volumetric flow (@ 0 °C and 5.5% O_2 dry)	1481 m³/h
Flue gas volumetric flow (@ 0 °C and 0% O_2 dry)	1093 m³/h

(206 °C and 5.5% O_2 were as-found conditions)

3.3 Hot Water Heater 1

Flue gas volumetric flow (@ 248 °C and 7.7% O_2)	366 m³/h
Flue gas volumetric flow (@ 0 °C and 7.7% O_2 dry)	168 m³/h
Flue gas volumetric flow (@ 0 °C and 0% O_2 dry)	106 m³/h

(248 °C and 7.7% O_2 were as-found conditions)

3.4 Hot Water Heater 2

Flue gas volumetric flow (@ 184 °C and 10.4% O_2)	448 m³/h
Flue gas volumetric flow (@ 0 °C and 10.4% O_2 dry)	240 m³/h
Flue gas volumetric flow (@ 0 °C and 0% O_2 dry)	121 m³/h

(184 °C and 10.4% O_2 were as-found conditions)

3.5 Office Boiler 1

Flue gas volumetric flow (@ 230 °C and 9.7% O_2)	115 m³/h
Flue gas volumetric flow (@ 0 °C and 9.7% O_2 dry)	56 m³/h
Flue gas volumetric flow (@ 0 °C and 0% O_2 dry)	30 m³/h

(230 °C and 9.7% O_2 were as-found conditions)

3.6 Office Boiler 2

Flue gas volumetric flow (@ 200 °C and 9.2% O_2)	101 m³/h
Flue gas volumetric flow (@ 0 °C and 9.2% O_2 dry)	52 m³/h
Flue gas volumetric flow (@ 0 °C and 0% O_2 dry)	29 m³/h

(200 °C and 9.2% O_2 are anticipated conditions)

4.0 FLUE GAS EMISSIONS

All the stacks identified were tested to determine the concentrations of the following gases in the flue gas:-

- oxygen (0_2)
- carbon monoxide (CO)
- nitrogen monoxide (NO)
- nitrogen dioxide (NO_2)
- sulphur dioxide (SO_x)

In all instances, no sulphur dioxide was recorded and the emissions are not reported.

In the case of the nitrogen oxides (NO & NO_2), these are combined in this report and reported as NO_x (oxides of nitrogen). In all instances, the proportion of NO_2 detected is less than 5%.

Using the measured concentrations and the flue gas volumetric flow rates, a mass emission figure has been devised for the boiler load at the time of testing.

	Flue Gas Concentration at Stack Conditions					Concentration @ 3% oxygen dry gas		Mass Emissions	
	0_2 %	CO ppm	NOx ppm	CO mg/m³	NO_2 mg/m³	CO mg/m³	NOx mg/m³	CO g/h	NOx g/h
Steam Boiler 1	3.4	10	75	13	154	13	158	29	357
Steam Boiler 2	5.5	10	4.9	13	100	15	117	18	146
Hot Water Heater 1	169	1	44	1	90	1	396	1	49
Hot Water Heater 2	18.1	3	21	4	43	23	267	3	33
Office Boiler 1	9.7	42	69	53	141	84	225	3	8
Office Boiler 2	9.2	12	43	15	88	23	135	1	5
Roaster 1	20.6	31	<1	39	<1	1744	<1	9	<1
Roaster 2	20.6	30	<1	38	<1	1688	<1	8	<1
Roaster 3	20.4	50	<1	63	<1	2813	<1	13	

APPENDIX 1

TEST RESULTS

SITE	Famers Boy - Deeside
POINT	Steam Boiler - BIB Beevor
DUCT SHAPE	ROUND
FLUE DIAMETER	0.40 m
FLUE AREA	0.13 m2
TEST CONDITION	**As Found - High Fire**
STACK TEMPERATURE	250 C
STACK TEMPERATURE	523 K
FLUE GAS OXYGEN	3.4 %
STATIC PRESSURE	25 pA

PLANE POINT	PITOT READING (Pa) in	out	AVE. PITOT	SQ RT PITOT
1	48	45	47	6.82
2	48	48	48	6.93
3	51	48	50	7.04
4	51	48	50	7.04
5	51	51	51	7.14
6	48	51	50	7.04
7	48	51	50	7.04
8	48	48	48	6.93
9	48	48	48	6.93
10	53	53	53	7.25
AVERAGE IN PLANE				7.01
AVERAGE OVERALL				

STACK VELOCITY	12.08 m/s
VOLUME FLOW	1.52 m^3/s
(AT STACK CONDITIONS)	5464 m^3/h
VOLUME FLOW	0.79 m^3/s
(AT OC)	2851 m^3/h

SITE	Famers Boy - Deeside
POINT	Steam Boiler - BIB Beevor
DUCT SHAPE	ROUND
FLUE DIAMETER	0.40 m
FLUE AREA	0.13 m2
TEST CONDITION	**As Found - Low Fire**
STACK TEMPERATURE	240 C
STACK TEMPERATURE	513 K
FLUE GAS OXYGEN	0.8 %
STATIC PRESSURE	0 pA

PLANE POINT	PITOT READING (Pa) in	out	AVE. PITOT	SQ RT PITOT
1	4	3	4	1.87
2	4	4	4	2.00
3	5	4	5	2.12
4	4	5	5	2.12
5	5	5	5	2.24
6	4	4	4	2.00
7	4	4	4	2.00
8	4	4	4	2.00
9	4	4	4	2.00
10	3	4	4	1.87
AVERAGE IN PLANE				2.02
AVERAGE OVERALL				

STACK VELOCITY	3.45 m/s
VOLUME FLOW	0.43 m^3/s
(AT STACK CONDITIONS)	1560 m^3/h
VOLUME FLOW	0.23 m^3/s
(AT OC)	830 m^3/h

SITE	Famers Boy - Deeside
POINT	**BABCOCK WANSON**
DUCT SHAPE	ROUND
FLUE DIAMETER	0.35 m
FLUE AREA	0.10 m2
TEST CONDITION	**As Found - High Fire**
STACK TEMPERATURE	206 C
STACK TEMPERATURE	479 K
FLUE GAS OXYGEN	5.5 %
STATIC PRESSURE	25 pA

PLANE POINT	PITOT READING (Pa) in	out	AVE. PITOT	SQ RT PITOT
1	15	15	15	3.87
2	16	18	17	4.12
3	20	22	21	4.58
4	25	27	26	5.10
5	30	32	31	5.57
6	25	37	31	5.57
7	20	23	22	4.64
8	15	18	17	4.06
9	11	14	13	3.54
10	10	10	10	3.16
AVERAGE IN PLANE				4.42
AVERAGE OVERALL				

STACK VELOCITY	7.29 m/s
VOLUME FLOW	0.70 m^3/s
(AT STACK CONDITIONS)	2524 m^3/h
VOLUME FLOW	0.40 m^3/s
(AT OC)	1438 m^3/h

SITE	Famers Boy - Deeside
POINT	Hot Water Boiler 1
DUCT SHAPE	ROUND
FLUE DIAMETER	0.25 m
FLUE AREA	0.05 m2
TEST CONDITION	As Found
STACK TEMPERATURE	105 C
STACK TEMPERATURE	378 K
FLUE GAS OXYGEN	16.9 %
STATIC PRESSURE	30 pA

PLANE POINT	PITOT READING (Pa) in	out	AVE. PITOT	SQ RT PITOT
1	5	6	6	2.38
2	7	7	7	2.65
3	7	7	7	2.65
4	10	11	10	3.21
5	10	11	10	3.21
6	9	10	10	3.11
7	9	10	10	3.11
8	8	9	8	2.89
9	8	9	8	2.89
10	7	7	7	2.65
AVERAGE IN PLANE				2.87
AVERAGE OVERALL				

STACK VELOCITY	4.21 m/s
VOLUME FLOW	0.21 m^3/s
(AT STACK CONDITIONS)	743 m^3/h
VOLUME FLOW	0.15 m^3/s
(AT OC)	537 m^3/h

SITE	Famers Boy - Deeside
POINT	Hot Water Boiler 2
DUCT SHAPE	ROUND
FLUE DIAMETER	0.25 m
FLUE AREA	0.05 m2
TEST CONDITION	As Found
STACK TEMPERATURE	78 C
STACK TEMPERATURE	351 K
FLUE GAS OXYGEN	18.1 %
STATIC PRESSURE	30 pA

PLANE POINT	PITOT READING (Pa) in	out	AVE. PITOT	SQ RT PITOT
1	14	14	14	3.74
2	14	14	14	3.74
3	18	14	16	3.97
4	18	18	18	4.18
5	21	18	19	4.39
6	18	18	18	4.18
7	18	14	16	3.97
8	14	14	14	3.74
9	14	14	14	3.74
10	14	14	14	3.74
AVERAGE IN PLANE				3.94
AVERAGE OVERALL				

STACK VELOCITY	5.56 m/s
VOLUME FLOW	0.27 m^3/s
(AT STACK CONDITIONS)	982 m^3/h
VOLUME FLOW	0.21 m^3/s
(AT OC)	764 m^3/h

SITE	Famers Boy - Deeside
POINT	Roaster 1
DUCT SHAPE	ROUND
FLUE DIAMETER	0.28 m
FLUE AREA	0.06 m2
TEST CONDITION	As Found
STACK TEMPERATURE	118 C
STACK TEMPERATURE	391 K
FLUE GAS OXYGEN	20.6 %
STATIC PRESSURE	10 pA

PLANE POINT	PITOT READING (Pa) in	out	AVE. PITOT	SQ RT PITOT
1	1	1	1	<1
2	1	1	1	<1
3	<1	<1	<1	<1
4	<1	<1	<1	<1
5	<1	<1	<1	<1
6	<1	<1	<1	<1
7	<1	<1	<1	<1
8	<1	<1	<1	<1
9	1	1	1	<1
10	1	1	1	<1

AVERAGE IN PLANE	<	1.00
AVERAGE OVERALL		

STACK VELOCITY	<	1.49	m/s
VOLUME FLOW	<	0.09	m^3/s
(AT STACK CONDITIONS)	<	330	m^3/h
VOLUME FLOW	<	0.06	m^3/s
(AT OC)	<	230	m^3/h

	ppm	mg/m3@ stack O2	mg/m3@3%	g/h
NOx	0	0	0	0
CO	31	39	1744	9

SITE	Famers Boy - Deeside
POINT	Roaster 2
DUCT SHAPE	ROUND
FLUE DIAMETER	0.28 m
FLUE AREA	0.06 m2
TEST CONDITION	As Found
STACK TEMPERATURE	172 C
STACK TEMPERATURE	445 K
FLUE GAS OXYGEN	20.6 %
STATIC PRESSURE	10 pA

PLANE POINT	PITOT READING (Pa) in	PITOT READING (Pa) out	AVE. PITOT	SQ RT PITOT
1	<1	<1	<1	<1
2	<1	<1	<1	<1
3	<1	<1	<1	<1
4	<1	<1	<1	<1
5	<1	<1	<1	<1
6	<1	<1	<1	<1
7	<1	<1	<1	<1
8	<1	<1	<1	<1
9	<1	<1	<1	<1
10	<1	<1	<1	<1
AVERAGE IN PLANE			<	1
AVERAGE OVERALL				

STACK VELOCITY	<	1.59	m/s
VOLUME FLOW	<	0.10	m³/s
(AT STACK CONDITIONS)	<	352	m³/h
VOLUME FLOW	<	0.06	m³/s
(AT OC)	<	216	m³/h

	ppm	mg/m3@ stack O2	mg/m3@3%	g/h
NOx	0	0	0	0
CO	30	38	1688	8

SITE	Famers Boy - Deeside
POINT	smoker
DUCT SHAPE	ROUND
FLUE DIAMETER	0.25 m
FLUE AREA	0.05 m2
TEST CONDITION	As Found
STACK TEMPERATURE	56 C
STACK TEMPERATURE	329 K
FLUE GAS OXYGEN	20.4 %
STATIC PRESSURE	10 pA

PLANE POINT	PITOT READING (Pa) in	out	AVE. PITOT	SQ RT PITOT
1	<1	<1	<1	<1
2	<1	<1	<1	<1
3	<1	<1	<1	<1
4	<1	<1	<1	<1
5	<1	<1	<1	<1
6	<1	<1	<1	<1
7	<1	<1	<1	<1
8	<1	<1	<1	<1
9	<1	<1	<1	<1
10	<1	<1	<1	<1
AVERAGE IN PLANE			<	1
AVERAGE OVERALL				

STACK VELOCITY	<	1.37	m/s
VOLUME FLOW	<	0.07	m³/s
(AT STACK CONDITIONS)	<	241	m³/h
VOLUME FLOW	<	0.06	m³/s
(AT OC)	<	200	m³/h

	ppm	mg/m3@ stack O2	mg/m3@3%	g/h
NOx	0	0	0.00	**0**
CO	50	62.5	2812.50	**13**

APPENDIX 2

THEORETICAL FLUE GAS VOLUMES

FARMERS BOY LTD - DEESIDE

BOILER	**No1 (ref DEE 254)**
MAKE	**BIB**
MODEL	**BEEVOR**
AGE	**2001**
BURNER	**Nuway**
MODEL	**NGN 80 T 3S 430**
FUEL	**Nat. Gas**
	High Fire

From Steam

steam out put	6,700	lbs/h	
	2,991	kg/h	
	0.83	kg/s	
Energy to Steam	2264	kj/kg	
heatoutput	1.88	MW	
efficiency (nominal)	80	%	
Heatinput	2.35	MW	

From Burner

burner	2.351	MW(MJ/s)	
cv gas	*38.500*	*MJ/m3*	
gas flow	0.06	m3/s	219.86 m3/h
flue gas volume/m3gas	10.87	*m3/m3*	*0%,0C,wet*
	8.86	*m3/m3*	*0%,0C,dry*

GasConditions

OXYGEN	3.4	%
TEMP	250	C

FLUE GAS CONDITIONS			FLUE GAS VOLUMES	
MOISTURE	TEMPERATURE	OXYGEN	m3/s	m3/h
DRY	0	0	0.541	1948
WET	0	0	0.66	2390
WATER	0	0	0.12	442
DRY	0	3.4	0.65	2324
WET	0	3.4	0.77	2766
DRY	250	3.4	1.24	4453
WET	**250**	**3.4**	**1.47**	**5299**

	ppm	mg/m3@ stack O2	mg/m3@3 %	g/h
NOx	75	153.75	157.24	**357**
CO	10	12.5	12.78	**29**

FARMERS BOY LTD - DEESIDE

BOILER	**No1 (ref DEE 254)**
MAKE	**BIB**
MODEL	**BEEVOR**
AGE	**2001**
BURNER	**Nuway**
MODEL	**NGN 80 T 3S 430**
FUEL	**Nat. Gas**
	Low fire

From Steam

steam out put	6,700	lbs/h	
	2,991	kg/h	
	0.83	kg/s	
Energy to Steam	2264	kj/kg	
heatoutput	1.88	MW	
efficiency (nominal)	80	%	
Heatinput	2.35	MW	

From Burner

burner	2.351	MW(MJ/s)	
cv gas	*38.500*	*MJ/m3*	
gas flow	0.06	m3/s	219.86 m3/h
flue gas volume/m3gas	10.87	*m3/m3*	*0%,0C,wet*
	8.86	*m3/m3*	*0%,0C,dry*

GasConditions

OXYGEN	11.2	%
TEMP	200	C

FLUE GAS CONDITIONS			FLUE GAS VOLUMES	
MOISTURE	TEMPERATURE	OXYGEN	m3/s	m3/h
DRY	0	0	0.541	1948
WET	0	0	0.66	2390
WATER	0	0	0.12	442
DRY	0	11.2	1.16	4174
WET	0	11.2	1.28	4616
DRY	200	11.2	2.01	7232
WET	**200**	**11.2**	**2.22**	**7998**

	ppm	mg/m3@ stack O2	mg/m3@3 %	g/h
NOx	43	88.15	161.91	**205**
CO	60	75	137.76	**174**

FARMERS BOY LTD - DEESIDE

BOILER	**No2 (ref DEE 255)**
MAKE	**BABCOCK WANSON**
MODEL	**15 LNH 10**
AGE	**n/a**
BURNER	**Riello**
MODEL	**RS 130**
FUEL	**Nat. Gas**
	High Fire

From Steam

steam out put	3,760	lbs/h	
	1,679	kg/h	
	0.47	kg/s	
Energy to Steam	2264	kj/kg	
heatoutput	1.06	MW	
efficiency (nominal)	80	%	
Heatinput	1.32	MW	

From Burner

burner	1.320	MW(MJ/s)		
cv gas	*38.500*	*MJ/m3*		
gas flow	0.03	m3/s	123.39	m3/h
flue gas volume/m3gas	10.87	*m3/m3*	*0%,0C,wet*	
	8.86	*m3/m3*	*0%,0C,dry*	

GasConditions

OXYGEN	5.5	%
TEMP	206	C

FLUE GAS CONDITIONS			FLUE GAS VOLUMES	
MOISTURE	TEMPERATURE	OXYGEN	m3/s	m3/h
DRY	0	0	0.304	1093
WET	0	0	0.37	1341
WATER	0	0	0.07	248
DRY	0	5.5	0.41	1481
WET	0	5.5	0.48	1729
DRY	206	5.5	0.72	2599
WET	**206**	**5.5**	**0.84**	**3034**

	ppm	mg/m3@ stack O2	mg/m3@3%	g/h
NOx	49	100	103	**149**
CO	10	13	13	**19**

FARMERS BOY LTD - DEESIDE

BOILER	**Water Heater (ref: DEE 280)**
MAKE	**State**
MODEL	**SCE 65 -500 G**
AGE	**N/A**
BURNER	**atmospheric**
FUEL	**Nat. Gas**

heatoutput	0.100	MW		
efficiency	78	%		
Heatinput	0.128	MW		
From Burner				
burner	0.128	MW(MJ/s)		
cv gas	*38.5*	*MJ/m3*		
gas flow	0.003	m3/s	11.99	m3/h
flue gas volume/m3gas	10.87	*m3/m3*	*0%,0C,wet*	
	8.86	*m3/m3*	*0%,0C,dry*	
GasConditions				
OXYGEN	7.7	%		
TEMP	248	C		

FLUE GAS CONDITIONS			FLUE GAS VOLUMES	
MOISTURE	TEMPERATURE	OXYGEN	m3/s	m3/h
DRY	0	0	0.030	106
WET	0	0	0.04	130
WATER	0	0	0.01	24
DRY	0	7.7	0.05	168
WET	0	7.7	0.05	192
DRY	248	7.7	0.09	320
WET	**248**	**7.7**	**0.10**	**366**

	ppm	mg/m3@ stack O2	mg/m3@3 %	kg/h
NOx	133	272.65	369.00	**45.73**
CO	3	3.75	5.08	**0.63**

NOx

BOILER	**Water Heater (ref: DEE 280)**
MAKE	**State**
MODEL	**SCE 65 -500 G**
AGE	**N/A**
BURNER	**atmospheric**
FUEL	**Nat. Gas**

heatoutput	0.100	MW		
efficiency	78	%		
Heatinput	0.128	MW		
From Burner				
burner	0.128	MW(MJ/s)		
cv gas	*38.5*	*MJ/m3*		
gas flow	0.003	m3/s	11.99	m3/h
flue gas volume/m3gas	10.87	*m3/m3*	*0%,0C,wet*	
	8.86	*m3/m3*	*0%,0C,dry*	
GasConditions				
OXYGEN	16.9	%		
TEMP	105	C		

FLUE GAS CONDITIONS			FLUE GAS VOLUMES	
MOISTURE	TEMPERATURE	OXYGEN	m3/s	m3/h
DRY	0	0	0.030	106
WET	0	0	0.04	130
WATER	0	0	0.01	24
DRY	0	16.9	0.15	544
WET	0	16.9	0.16	568
DRY	105	16.9	0.21	753
WET	**105**	**16.9**	**0.22**	**787**

	ppm	mg/m3@ stack O2	mg/m3@3 %	g/h
NOx	44	90	396	**49**
CO	1	1	5	**1**

FARMERS BOY LTD - DEESIDE

BOILER	**Water Heater (ref: DEE 281)**
MAKE	**State**
MODEL	**SBE 80500 NEUK**
AGE	**N/A**
BURNER	**atmospheric**
FUEL	**Nat. Gas**

heatoutput	0.114	MW		
efficiency	78	%		
Heatinput	0.146	MW		
From Burner				
burner	0.146	MW(MJ/s)		
cv gas	*38 5*	*MJ/m3*		
gas flow	0.004	m3/s	13.67	m3/h
flue gas volume/m3gas	10.87	*m3/m3*	*0%,0C,wet*	
	8.86	*m3/m3*	*0%,0C,dry*	
GasConditions				
OXYGEN	10.4	%		
TEMP	184	C		

FLUE GAS CONDITIONS			FLUE GAS VOLUMES	
MOISTURE	TEMPERATURE	OXYGEN	m3/s	m3/h
DRY	0	0	0.034	121
WET	0	0	0.04	149
WATER	0	0	0.01	27
DRY	0	10.4	0.07	240
WET	0	10.4	0.07	267
DRY	184	10.4	0.11	402
WET	**184**	**10.4**	**0.12**	**448**

	ppm	mg/m3@ stack O2	mg/m3@3 %	kg/h
NOx	75	153.75	261.08	**36.88**
CO	10	12.5	21.23	**3.00**

BOILER	**Water Heater (ref: DEE 281)**
MAKE	**State**
MODEL	**SBE 80500 NEUK**
AGE	**N/A**
BURNER	**atmospheric**
FUEL	**Nat. Gas**

From Steam

heatoutput	0.100	MW		
efficiency	78	%		
Heatinput	0.128	MW		
From Burner				
burner	0.128	MW(MJ/s)		
cv gas	*38 5*	*MJ/m3*		
gas flow	0.003	m3/s	11.99	m3/h
flue gas volume/m3gas	10.87	*m3/m3*	*0%,0C,wet*	
	8.86	*m3/m3*	*0%,0C,dry*	
GasConditions				
OXYGEN	18.1	%		
TEMP	78	C		

FLUE GAS CONDITIONS			FLUE GAS VOLUMES	
MOISTURE	TEMPERATURE	OXYGEN	m3/s	m3/h
DRY	0	0	0.030	106
WET	0	0	0.04	130
WATER	0	0	0.01	24
DRY	0	18.1	0.21	769
WET	0	18.1	0.22	793
DRY	78	18.1	0.27	989
WET	**78**	**18.1**	**0.28**	**1020**

	ppm	mg/m3@ stack O2	mg/m3@3 %	g/h
NOx	21	43.05	267.21	**33**
CO	3	3.75	23.28	**3**

FARMERS BOY LTD - DEESIDE

BOILER	**Office space heating**
MAKE	**Ideal**
MODEL	**Mexico Super 2**
AGE	**n/a**
BURNER	**atmospheric**
FUEL	**Nat. Gas**

heatoutput	0.029	MW		
efficiency	80	%		
Heatinput	0.036	MW		
From Burner				
burner	0.036	MW(MJ/s)		
cv gas	*38.500*	*MJ/m3*		
gas flow	0.001	m3/s	3.39	m3/h
flue gas volume/m3gas	10.87	*m3/m3*	*0%,0C,wet*	
	8.86	*m3/m3*	*0%,0C,dry*	
GasConditions				
OXYGEN	9.7	%		
TEMP	230	C		

FLUE GAS CONDITIONS MOISTURE	EMPERATUR	OXYGEN	FLUE GAS VOLUMES m3/s	m3/h
DRY	0	0	0.008	30
WET	0	0	0.01	37
WATER	0	0	0.00	7
DRY	0	9.7	0.02	56
WET	0	9.7	0.02	63
DRY	230	9.7	0.03	103
WET	**230**	**9.7**	**0.03**	**115**

	ppm	mg/m3@ stack O2	mg/m3@3%	g/h
NOx	69	141	225	**7.89**
CO	42	53	84	**2.93**

FARMERS BOY LTD - DEESIDE

BOILER	**First Floor office boiler**
MAKE	**Worcester**
MODEL	**28i Junior (Combi)**
AGE	**2008**
BURNER	**atmospheric**
FUEL	**Nat. Gas**

heatoutput	0.028	MW	
efficiency	80	%	
Heatinput	0.035	MW	
From Burner			
burner	0.035	MW(MJ/s)	
cv gas	*38.500*	*MJ/m3*	
gas flow	0.001	m3/s	3.27 m3/h
flue gas volume/m3gas	10.87	*m3/m3*	*0%,0C,wet*
	8.86	*m3/m3*	*0%,0C,dry*
GasConditions			
OXYGEN	9.2	%	
TEMP	200	C	

FLUE GAS CONDITIONS MOISTURE	EMPERATUR	OXYGEN	FLUE GAS VOLUMES m3/s	m3/h
DRY	0	0	0.008	29
WET	0	0	0.01	36
WATER	0	0	0.00	7
DRY	0	9.2	0.01	52
WET	0	9.2	0.02	58
DRY	200	9.2	0.02	89
WET	**200**	**9.2**	**0.03**	**101**

	ppm	mg/m3@ stack O2	mg/m3@3%	g/h
NOx	43	88.15	134.47	**5**
CO	12	15	22.88	**1**