Covanta Durham York Renewable Energy Limited Partnership.

Protocol for the

Measurement of Combustion Temperature

And the Development of Time and Temperature Correlations

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Contents

1 INTRODUCTION & OBJECTIVE

On June 28, 2011, the Durham York Energy Centre (DYEC) obtained a multimedia Certificate of Approval from the Ministry of the Environment (MOE) which is now referenced as Environmental Compliance Approval (ECA) No. **7306-8FDKNX.** This ECA requires that combustion gases be maintained at a minimum temperature of 1000°C for a residence time of one (1) second starting from the point where most of the combustion has been completed and the combustion temperature has been fully developed[1] and ending at the Target Location.[2] Subsequent to the issuance of the ECA, documentation was provided to the MOE which proposed to install and use Infraview™ brand infrared pyrometer (IP) temperature measurement instruments near (~ 2-3 m) the Target Location in lieu of roof top thermocouples which are ~ 11m above the Target Location. IP's are not only more reliable than thermocouples, but allow installation in the harsh environment very near the Target Location. Utilizing a nearby, reliable IP temperature provides an essentially direct measurement of 1-second temperature which is inherently more accurate than the relatively distant, unreliable roof top thermocouples. The MOE, following consultation with the Standards Development Branch, determined that this temperature monitoring approach and the IP system proposed by Covanta were acceptable and considered equivalent to thermocouple(s) as required in Schedule F of the ECA.[3]

Thus, the objective of this test protocol is to provide the detailed procedures for utilizing IP instruments to directly measure combustion gas temperatures and to develop a correlation[2] between the gas temperature at the one (1) second Target Location and the nearby temperature measured by the permanent plant IP. The plant IP located approximately 2-3 meters downstream of the one (1) second Target Location will be used to continuously demonstrate compliance with the *ECA*.

2 SUMMARY & CONCLUSIONS

2.1 Waste Firing

Residence time and temperature testing was performed on DYEC Boilers 1 and 2 on 9/20 thru 22/2015. Test data were obtained on each boiler at nominal boiler loads of 100% maximum continuous rating (MCR) and 80% MCR. Three (3), one (1) hour data sets were compiled for

[1] ECA condition 7. (2) (a)
[2] ECA condition 6. (2) (a) (ii)
[3] Email dated January 14, 2014 from Quynh Nguyen, P.Eng. Senior Review Engineer of the Air Approval Services Unit, Environmental Approvals Branch.

each boiler at each load for a total of six (6) data sets per boiler or twelve (12) total data sets. The data and results demonstrated full compliance with the ECA furnace residence time and temperature requirements.

From these 12 one-hour data sets, a single correlation of required residence time and temperature to the plant's continuous infra-red pyrometer (CIP) was developed to demonstrate on-going continuous compliance with the ECA requirements. The resulting correlation will be programmed into the plant's CEM system.

The correlation equation is as follows:

$$Correlated\ T_{1-sec}\text{°C} = T_{Cont\ IP} + 437 - 300 \times \left(\frac{W_{steam}}{33{,}640}\right)$$

Where:

$Correlated\ T_{1\text{-}sec}$	=	The estimated furnace temperature at the 1-second elevation used for continuous comparison to the ECA limit of 1000°C.
$T_{Cont\ IP}$=		Plant continuous IR pyrometer indication, °C
W_{steam} =		Boiler steam flow, kg/hr
33,640 =		Boiler MCR steam flow, kg/hr

The result of the equation must be above 1000°C to demonstrate compliance with the ECA residence time and temperature requirement.

2.2 Prior to Waste Introduction

It was discovered during natural gas burner firing prior to waste introduction that the plant continuous infra-red pyrometer (CIP) was the most direct indication of furnace temperature. Therefore, it was determined that waste could not be introduced into the furnace until the raw plant CIP directly indicated 1000°C without any correlation.

3 TEST PROCEDURES & MODIFICATIONS

With the below described exceptions, the testing was performed in accordance with the June 2014 Residence Time and Temperature Protocol issued by Covanta and approved by the MOE.

3.1 Testing Prior to Waste Introduction

During preliminary testing and instrumentation checkout, it was discovered that when the auxiliary burner was in service, the location of the temporary test IR pyrometer (TIP) could not accurately measure or "see" the burner flame. The airflow from underneath the burner drew the flame up and out of the line of sight of the IR. It was also observed that the plant CIP

located directly above and across from the auxiliary burner provided an accurate and reliable indication of furnace temperature with the auxiliary burner in service. Therefore, no correlation testing was required for the condition of establishing a minimum furnace temperature prior to Waste introduction.

3.2 Boiler 100% MCR

Subsequent to approval of the test protocol, it was realized that the actual maximum continuous rating (MCR) steam flow for the boilers was 33,640 kg/hr per boiler and not 34,400 kg/hr. The Martin boiler design data sheet is included below for reference.

MARTIN GmbH für Umwelt- und Energietechnik	Date : 12-21-2010	Name : Nachreiner	Sheet : No. : 1	Doc. - No. : 00-050962-Q1100 V3
Project : Durham Our No. : 050 962	(refractory in 1-st pass) 100 % heat input, load point LP1=NOM Very low NOx design, medium fouled boiler condition			
BOILER DESIGN DATA	Units of measurement			
	US- units	Metric- units	US- units	Metric- units
Refuse throughput per unit	%	%	100,00	100,00
Refuse quantity per unit	lb/h	kg/h	20.025	9.083
Lower calorific value of refuse (LHV)	BTU/lb	kJ/kg	5.000	11.630
Higher calorific value of refuse (HHV)	BTU/lb	kJ/kg	5.589	13.000
Ash	%	%	15,92	15,92
Moisture	%	%	15,16	15,16
Combustible matter	%	%	68,92	68,92
Steam output, calcul.	lb/h	kg/h	75.618	34.300
, guarant.	lb/h	kg/h	74.163	33.640
Considered blow down	%	%	2,0	2,0

3.3 Reference Air Temperature and Air flows

Plant air flows were configured based on the Ontario "reference" temperature of 25°C rather than the 27°C that was assumed in the protocol. Therefore, all air flows are in Reference cubic meters per hour (Rm^3/h) at 25°C instead of Normal meters cubed per hour (Nm^3/h) at 0°C as stated in the protocol. The total air and IGR flows were temperature compensated in the DCS while the IGR flow was also pressure compensated.

3.4 Test Procedures

3.4.1 Test Duration, Steam Load

Testing on the combustion units was conducted during the days of 9/20-9/22, 2015. Test data were obtained at full load MSW firing rate (nominal 100% steam flow) and part load MSW firing rate (nominal 80% steam flow).

3.4.2 Test Runs/Boiler Stability

Each 1-hour data set was selected for stable operating conditions.

3.4.3 Sootblowing

Sootblowing was not performed during any test run.

4 DATA ANALYSIS & CALCULATIONS

4.1 Instrumentation and Data

4.1.1 Correlation DCS Data and Special Test Data

Data required for the correlation calculations consisted of boiler steam, total air, internal gas recycle (IGR) and seal air flows along with the plant continuous IP and the temporary test IP. Inlet air temperature and IGR temperatures were not required in the calculations because the total air and IGR flows were temperature compensated in the plant's distributed control system (DCS). The temporary infrared pyrometer, (TIP), installed on the side wall in an observation port near the auxiliary burner was the only special test instrumentation. All other data were from the plant's normal DCS.

Both the DCS data and the temporary, test IP data, which was logged on a separate data logger, were recorded at one (1) minute intervals during the test runs.

These data are summarized per boiler for each load in Tables 1A thru 1D.

National Institute of Standards & Technology (NIST) calibration certificates for the IP's used in the testing are included at the end of this report.

4.1.2 Plant Process Data

Other process data used to characterize boiler operation was also collected via the plant's DCS. These parameters were also recorded at one (1) minute intervals during the test runs. Averages of the process data for the test runs are summarized in Table 2.

4.2 Analytical Methodology

The calculations presented in the protocol use a method whereby a $T_{1\text{-sec}}$ temperature first had to be assumed, then calculated, then iterated until the assumed temperature and final result

were the same. Subsequently, another, more direct calculation methodology was brought to Covanta's attention whereby the iteration was not required and the temperature was calculated directly. Both methodologies arrive at the exact same result. The calculations presented in this report use the more direct methodology without the iteration.

Calculations for each run for each boiler and each load point with the methodology used are included as Tables 3 thru 6. The calculations for all twelve runs are summarized in Table 7.

Please refer to the protocol at the end of this report for nomenclature and detailed explanations of calculation steps.

4.3 Correlation

The protocol calculations ended with the following equation of minimum Continuous Temperature Monitor temperature required for compliance:

$$T_{UprIP\ min} = T_{UprIP} - (T_{1SEC} - 1000\text{°C})$$

Rearranging this equation;

$$1000\text{°C} - T_{UprIP\ min} = T_{1SEC} - T_{UprIP}$$

To simplify incorporation of this equation and a correlation into the CEM system, a correction factor, F_c is defined as:

$$F_c(\text{°C}) = 1000\text{°C} - T_{UprIP\ min}\text{°C}$$

Then,

$$F_c(\text{°C}) = T_{1\ SEC}\text{°C} - T_{UprIP}$$

A correlation was then developed using % steam load and F_c. A plot of the correction factor to be added to the plant's continuous IP versus % MCR steam load is shown as Figure 1. The six points at 100% load and the six points at 80% load were used to perform a linear regression and consequent correlation equation.

Once % steam flow is calculated, this correction factor can calculated and then added to the plant continuous IP indication to obtain the correlated $T_{1\text{-sec}}$ temperature.

$$Correlated\ T_{1SEC} = T_{Upr\ IP}\text{°C} + F_c$$

The correlated $T_{1\text{-sec}}$ temperature which is monitored and recorded in plant Continuous Emissions Monitoring System (CEMS) can then be compared to the minimum $T_{1\text{-sec}}$ limit of 1000°C.

The correlation of Fc to % MCR steam flow is graphically depicted below along with the linear regression equation.

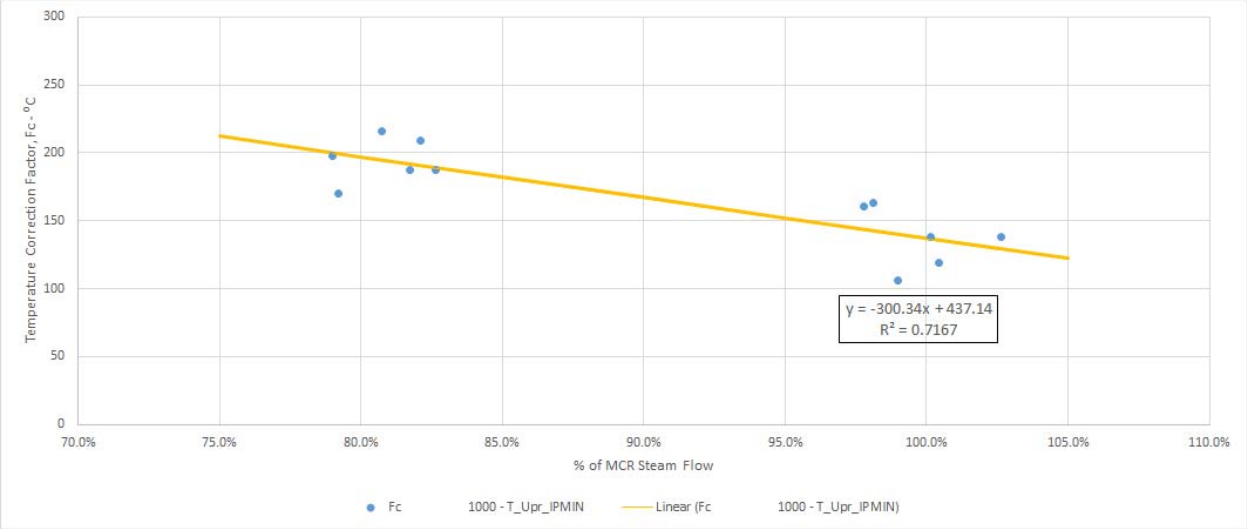


Figure 1

The following correlation equation will be programmed into each combustion units' CEMS to demonstrate on-going continuous compliance.

$$Correlated\ T_{1-sec} = T_{Cont\ IP} + 437 - 300 \times \left(\frac{W_{steam}}{33{,}640}\right)$$

Where:

$Correlated\ T_{1\text{-}sec}$ = The furnace temperature at the 1-second elevation used for comparison to the ECA limit of 1000°C.

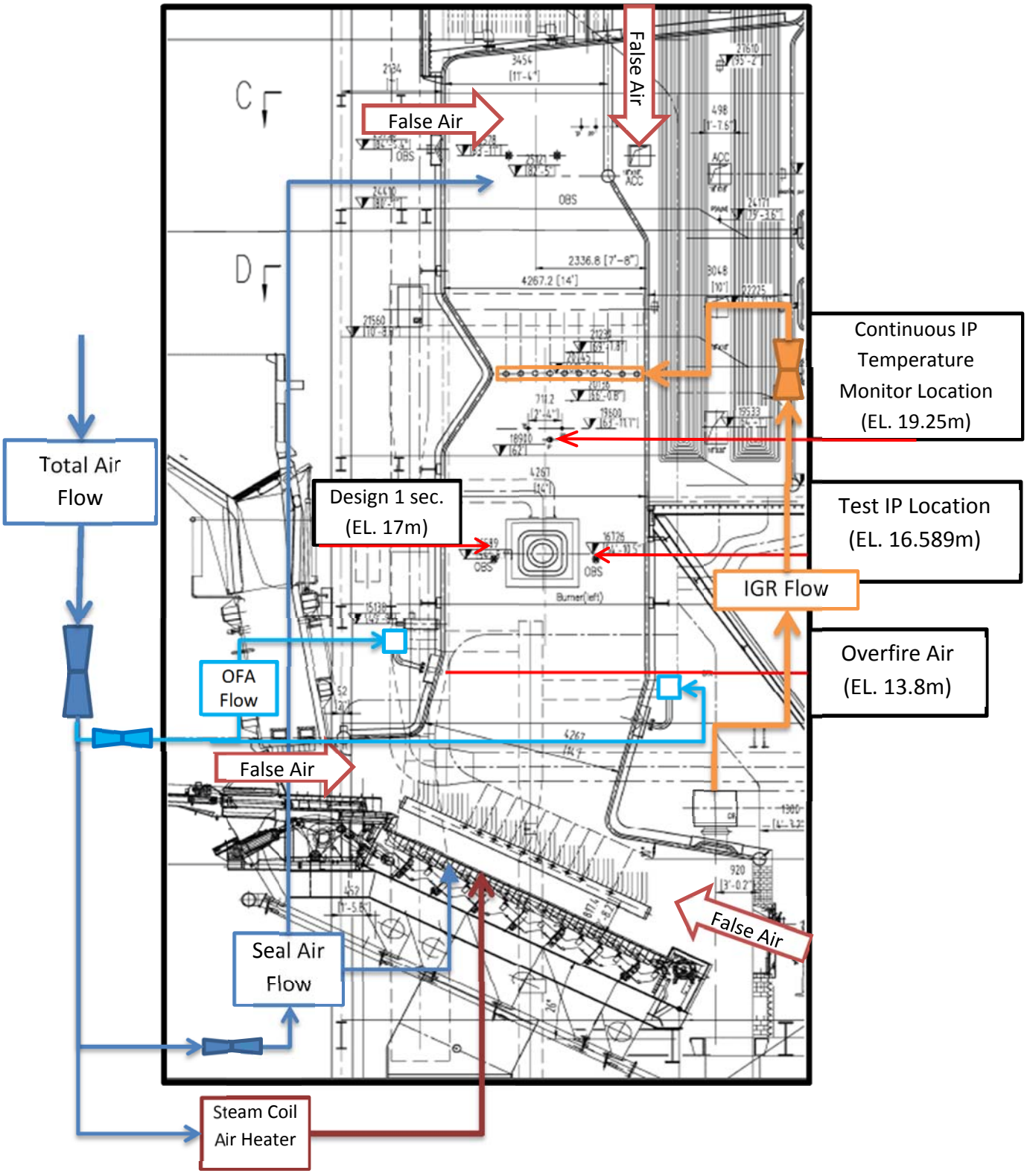
$T_{Cont\ IP}$= Plant continuous IR pyrometer indication, °C

W_{steam} = Boiler steam flow, kg/hr

33,640 = Boiler MCR steam flow, kg/hr

A test diagram of the furnace is included below for reference.

4.4 Test Diagram



5 ATTACHMENTS

5.1 Data Used in Correlation

5.1.1 Boiler 1 – 100% MCR – Table 1A

5.1.2 Boiler 1 – 80% MCR – Table 1B

5.1.3 Boiler 2 – 100% MCR – Table 1C

5.1.4 Boiler 2 – 80% MCR – Table 1D

5.2 Summary of Plant Process Data – Table 2

5.3 Calculations

5.3.1 Boiler 1 – 100% MCR – Table 3

5.3.2 Boiler 1 – 80% MCR – Table 4

5.3.3 Boiler 2 – 100% MCR – Table 5

5.3.4 Boiler 2 – 80% MCR – Table 6

5.4 Data and Calculation Summary –All runs - Table 7

5.5 Correlation Graph and Linear Regression of Data – Figure 1

5.6 Calibration Certificates of Plant/Continuous and Test/Temporary IR's

Boiler	Date	Time	Data-logger	DCS Data				
			Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
A	9/22/2015 14:00	9/22/2015 14:59	1218.7	33294.9	1058.7	41476.7	2277.4	1868.3
V	9/22/2015 15:00	9/22/2015 15:59	1222.2	33781.8	1042.6	41310.3	2324.2	1837.1
G	9/22/2015 16:00	9/22/2015 16:59	1244.0	33682.6	1030.3	40970.2	2280.0	1820.7
1	22-Sep-15	14:00:00	1069.0	35,029	1062.98	41753.07	2606.56	1924.65
1	22-Sep-15	14:01:00	1051.7	34,075	1033.06	45505.10	2471.60	1881.90
1	22-Sep-15	14:02:00	1056.1	33,211	1013.50	41863.58	2155.24	1912.30
1	22-Sep-15	14:03:00	1087.7	33,192	1033.65	40977.93	2559.64	1907.83
1	22-Sep-15	14:04:00	1173.5	33,627	1039.45	42415.53	2076.75	1903.44
1	22-Sep-15	14:05:00	1254.7	32,896	1019.30	42069.17	2076.75	1898.95
1	22-Sep-15	14:06:00	1199.8	32,525	1048.05	41795.43	2179.56	1929.90
1	22-Sep-15	14:07:00	1203.6	31,955	1020.43	41079.52	2612.57	1901.61
1	22-Sep-15	14:08:00	1256.7	32,887	1030.75	41254.39	2511.83	1899.86
1	22-Sep-15	14:09:00	1222.8	33,410	1026.72	40488.98	2660.96	1931.62
1	22-Sep-15	14:10:00	1229.5	32,174	992.77	41217.97	2181.74	1863.84
1	22-Sep-15	14:11:00	1237.7	31,543	1035.42	41212.48	1975.50	1836.43
1	22-Sep-15	14:12:00	1230.6	30,655	1037.68	42170.82	2016.72	1798.17
1	22-Sep-15	14:13:00	1219.6	31,095	980.14	40651.93	1975.52	1802.04
1	22-Sep-15	14:14:00	1216.7	32,196	1012.91	41401.89	2182.17	1775.54
1	22-Sep-15	14:15:00	1214.6	31,183	1008.88	41084.11	2202.06	1778.29
1	22-Sep-15	14:16:00	1275.6	30,928	987.61	43813.97	2104.01	1784.06
1	22-Sep-15	14:17:00	1295.8	30,712	1006.57	41227.45	2352.34	1815.14
1	22-Sep-15	14:18:00	1311.4	31,599	1026.13	41227.45	1929.22	1838.24
1	22-Sep-15	14:19:00	1307.9	32,547	1106.76	41915.46	2259.55	1871.20
1	22-Sep-15	14:20:00	1304.2	33,069	1077.38	41029.23	2530.92	1901.61
1	22-Sep-15	14:21:00	1242.3	33,782	1107.95	41717.40	2259.25	1912.30
1	22-Sep-15	14:22:00	1192.1	35,037	1053.79	41045.68	2141.77	1944.74
1	22-Sep-15	14:23:00	1192.2	33,953	1075.71	41045.68	2529.89	1914.03
1	22-Sep-15	14:24:00	1084.8	33,901	1066.47	41001.09	2562.65	1912.30
1	22-Sep-15	14:25:00	1212.0	33,433	1053.20	40071.75	2371.71	1919.31
1	22-Sep-15	14:26:00	1200.7	33,410	1033.06	40967.68	2017.07	1851.08
1	22-Sep-15	14:27:00	1221.9	33,160	1023.87	40660.46	2660.39	1852.96
1	22-Sep-15	14:28:00	1213.1	32,890	1020.97	41111.95	2180.92	1820.70
1	22-Sep-15	14:29:00	1272.0	33,189	1012.37	41011.71	2015.70	1819.83
1	22-Sep-15	14:30:00	1288.0	34,731	1053.79	41137.74	2120.85	1837.29
1	22-Sep-15	14:31:00	1259.6	33,740	997.39	45332.41	2595.97	1776.43
1	22-Sep-15	14:32:00	1269.8	33,518	1037.68	41759.42	2512.45	1839.27
1	22-Sep-15	14:33:00	1237.4	33,842	1113.64	40974.45	2708.31	1901.61
1	22-Sep-15	14:34:00	1260.8	34,384	1059.60	40971.22	2059.63	1897.20
1	22-Sep-15	14:35:00	1236.7	34,247	1094.68	40857.81	2545.14	1927.36
1	22-Sep-15	14:36:00	1271.4	34,220	1074.53	40886.53	2121.65	1892.70
1	22-Sep-15	14:37:00	1195.5	34,100	1118.85	40961.16	2201.44	1892.70
1	22-Sep-15	14:38:00	1197.5	34,728	1117.67	40961.16	2630.03	1890.94
1	22-Sep-15	14:39:00	1201.5	33,906	1111.33	41098.66	2315.94	1914.03
1	22-Sep-15	14:40:00	1200.5	33,799	1078.56	41218.85	2080.17	1880.13
1	22-Sep-15	14:41:00	1236.1	33,379	1113.64	41191.30	2142.34	1880.13
1	22-Sep-15	14:42:00	1175.7	33,323	1116.00	40839.08	2511.96	1876.52
1	22-Sep-15	14:43:00	1143.3	33,315	1077.38	40719.70	2122.33	1907.83
1	22-Sep-15	14:44:00	1192.0	32,760	1047.51	40719.70	2060.44	1871.20
1	22-Sep-15	14:45:00	1164.3	32,781	1092.96	40719.70	2423.56	1841.93

			Data-logger	DCS Data				
Boiler	Date	Time	Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
1	22-Sep-15	14:46:00	1209.8	34,479	1067.65	43539.65	2409.08	1842.87
1	22-Sep-15	14:47:00	1170.6	33,734	1097.52	44948.54	2632.74	1840.13
1	22-Sep-15	14:48:00	1195.3	34,423	1105.58	42248.38	2161.03	1872.05
1	22-Sep-15	14:49:00	1179.1	34,454	1105.04	41931.66	2142.43	1833.67
1	22-Sep-15	14:50:00	1206.4	34,738	1116.00	42473.96	2443.54	1894.45
1	22-Sep-15	14:51:00	1242.7	34,731	1077.38	41042.68	1954.01	1885.59
1	22-Sep-15	14:52:00	1278.7	34,336	1137.82	41018.66	2102.39	1850.14
1	22-Sep-15	14:53:00	1254.9	33,929	1096.40	41440.70	2613.37	1886.43
1	22-Sep-15	14:54:00	1277.2	33,305	1069.32	41402.77	2595.54	1855.69
1	22-Sep-15	14:55:00	1274.9	33,185	1073.94	40718.63	2079.60	1844.67
1	22-Sep-15	14:56:00	1195.1	33,266	1061.85	40684.11	1908.12	1814.18
1	22-Sep-15	14:57:00	1278.6	33,371	1084.31	40684.11	2102.70	1840.13
1	22-Sep-15	14:58:00	1276.8	32,294	1046.27	41057.06	2058.32	1867.49
1	22-Sep-15	14:59:00	1301.8	33,416	1031.39	40270.40	1928.43	1836.43
1	22-Sep-15	15:00:00	1182.2	33,715	1073.94	41004.36	2079.05	1867.49
1	22-Sep-15	15:01:00	1240.6	34,074	1056.70	40494.39	2676.33	1868.42
1	22-Sep-15	15:02:00	1283.1	33,728	1022.69	43624.13	2545.71	1706.47
1	22-Sep-15	15:03:00	1189.2	33,300	1036.55	40981.15	2079.40	1803.88
1	22-Sep-15	15:04:00	1157.7	33,141	998.51	41004.16	1928.77	1804.75
1	22-Sep-15	15:05:00	1204.7	32,711	1044.61	41824.61	2441.83	1804.75
1	22-Sep-15	15:06:00	1163.5	33,284	996.26	40897.51	2709.22	1802.91
1	22-Sep-15	15:07:00	1187.3	33,085	974.98	40910.47	2016.49	1793.60
1	22-Sep-15	15:08:00	1227.9	32,580	1016.94	41401.71	2079.34	1812.27
1	22-Sep-15	15:09:00	1203.0	33,106	1016.40	40899.87	2596.57	1844.67
1	22-Sep-15	15:10:00	1240.8	32,223	1008.88	41055.66	2578.92	1840.13
1	22-Sep-15	15:11:00	1215.7	32,754	988.74	41127.81	2059.48	1838.24
1	22-Sep-15	15:12:00	1230.5	33,014	1033.06	41115.38	2160.43	1836.43
1	22-Sep-15	15:13:00	1238.0	33,244	1061.26	40803.39	2740.85	1863.84
1	22-Sep-15	15:14:00	1175.1	35,075	1068.19	40520.09	2333.53	1847.49
1	22-Sep-15	15:15:00	1173.8	33,768	1071.04	41192.31	2102.20	1780.34
1	22-Sep-15	15:16:00	1226.8	33,563	1019.30	41265.27	2628.30	1846.55
1	22-Sep-15	15:17:00	1169.5	33,303	1014.63	43709.07	2142.07	1783.08
1	22-Sep-15	15:18:00	1147.1	33,493	1015.28	41618.06	2141.11	1814.18
1	22-Sep-15	15:19:00	1159.9	31,938	1011.78	40776.35	2406.16	1813.31
1	22-Sep-15	15:20:00	1165.7	33,336	1018.66	40642.55	2544.72	1814.18
1	22-Sep-15	15:21:00	1228.3	32,834	1030.75	40666.05	2058.72	1846.55
1	22-Sep-15	15:22:00	1168.9	32,908	1068.19	41223.12	2120.33	1879.29
1	22-Sep-15	15:23:00	1153.2	33,409	1039.99	41249.98	2422.14	1879.29
1	22-Sep-15	15:24:00	1176.9	34,629	1032.52	40679.90	2544.71	1816.01
1	22-Sep-15	15:25:00	1238.7	33,433	1062.98	40890.07	2593.85	1846.55
1	22-Sep-15	15:26:00	1235.7	33,720	1029.62	40817.38	2611.18	1878.37
1	22-Sep-15	15:27:00	1230.2	34,239	1058.41	40962.32	2277.30	1846.55
1	22-Sep-15	15:28:00	1221.2	33,786	1033.65	41265.28	2120.12	1816.97
1	22-Sep-15	15:29:00	1205.9	33,766	998.51	40550.75	2527.32	1819.83
1	22-Sep-15	15:30:00	1186.7	32,873	1018.07	41320.18	2658.30	1851.08
1	22-Sep-15	15:31:00	1254.2	33,307	1016.40	41041.59	2293.93	1852.96
1	22-Sep-15	15:32:00	1233.0	34,677	1061.85	44299.16	2059.85	1783.08
1	22-Sep-15	15:33:00	1169.2	33,272	1067.65	41787.35	2404.93	1847.49
1	22-Sep-15	15:34:00	1215.5	33,267	1079.74	41575.55	2659.79	1847.49

			Data-logger	DCS Data				
Boiler	Date	Time	Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
1	22-Sep-15	15:35:00	1241.5	34,039	1073.35	40684.89	2200.99	1846.55
1	22-Sep-15	15:36:00	1190.0	33,590	1067.01	40634.34	2119.84	1849.29
1	22-Sep-15	15:37:00	1199.9	33,520	1027.36	41199.75	2120.63	1813.31
1	22-Sep-15	15:38:00	1189.4	32,764	1032.52	41194.03	2159.49	1811.31
1	22-Sep-15	15:39:00	1182.4	33,505	1041.12	41194.03	2676.55	1815.14
1	22-Sep-15	15:40:00	1234.2	34,923	1024.46	41087.37	2296.06	1817.84
1	22-Sep-15	15:41:00	1261.7	33,403	1016.94	41161.86	2078.26	1812.27
1	22-Sep-15	15:42:00	1276.0	33,669	1050.89	41135.61	2120.89	1833.67
1	22-Sep-15	15:43:00	1273.2	33,717	1077.38	41123.49	2708.89	1837.29
1	22-Sep-15	15:44:00	1294.9	33,925	1080.87	41742.65	2295.35	1869.26
1	22-Sep-15	15:45:00	1291.1	34,433	1073.94	41117.77	2120.91	1881.90
1	22-Sep-15	15:46:00	1228.6	34,549	1063.63	41255.76	2295.97	1846.55
1	22-Sep-15	15:47:00	1253.0	35,096	1032.52	44460.99	2596.68	1806.76
1	22-Sep-15	15:48:00	1258.5	36,672	1022.69	41154.52	2220.42	1809.47
1	22-Sep-15	15:49:00	1246.8	35,069	1048.05	41954.54	2016.96	1847.49
1	22-Sep-15	15:50:00	1177.6	35,169	1079.74	41321.65	2103.47	1879.29
1	22-Sep-15	15:51:00	1228.3	34,928	1075.07	40669.82	1886.86	1844.67
1	22-Sep-15	15:52:00	1290.4	34,868	1121.70	41429.33	2161.93	1875.59
1	22-Sep-15	15:53:00	1266.1	35,112	1103.92	41116.50	2143.43	1880.13
1	22-Sep-15	15:54:00	1276.4	35,115	1114.82	41473.53	2647.60	1878.37
1	22-Sep-15	15:55:00	1298.2	34,451	1044.02	41386.29	2647.53	1886.43
1	22-Sep-15	15:56:00	1267.6	34,267	1087.80	40633.67	2040.58	1854.75
1	22-Sep-15	15:57:00	1256.6	34,168	1028.49	41384.16	2203.69	1873.82
1	22-Sep-15	15:58:00	1285.2	33,955	1016.40	41455.48	2598.94	1892.70
1	22-Sep-15	15:59:00	1264.1	33,449	1001.95	41447.30	2649.01	1862.91
1	22-Sep-15	16:00:00	1277.6	33,448	988.20	40762.88	2182.99	1831.78
1	22-Sep-15	16:01:00	1261.5	33,670	984.17	40885.27	2202.92	1829.96
1	22-Sep-15	16:02:00	1250.2	33,654	966.93	44176.39	2633.66	1789.72
1	22-Sep-15	16:03:00	1246.0	33,364	1025.59	40870.80	2549.28	1813.31
1	22-Sep-15	16:04:00	1233.1	33,937	1041.12	41561.22	1977.83	1834.62
1	22-Sep-15	16:05:00	1185.4	34,151	1051.54	41855.36	2356.30	1834.62
1	22-Sep-15	16:06:00	1234.0	34,212	1024.46	41273.97	2618.96	1866.64
1	22-Sep-15	16:07:00	1269.5	34,282	1012.37	41151.19	2429.89	1831.78
1	22-Sep-15	16:08:00	1288.3	33,855	997.39	41091.64	2147.67	1850.14
1	22-Sep-15	16:09:00	1284.4	33,975	1036.55	41888.38	2621.09	1850.14
1	22-Sep-15	16:10:00	1257.2	33,739	1041.12	41050.71	2552.35	1860.28
1	22-Sep-15	16:11:00	1285.0	33,946	1031.93	41912.12	2165.86	1861.13
1	22-Sep-15	16:12:00	1212.4	34,284	1041.71	41183.98	2147.63	1834.62
1	22-Sep-15	16:13:00	1239.0	34,268	1037.68	41033.84	2357.49	1831.78
1	22-Sep-15	16:14:00	1196.9	33,908	1027.90	41382.55	2601.28	1832.81
1	22-Sep-15	16:15:00	1256.1	33,300	1012.91	41382.55	2186.37	1863.84
1	22-Sep-15	16:16:00	1256.8	33,133	1026.72	41225.35	2147.76	1852.11
1	22-Sep-15	16:17:00	1216.2	33,108	986.43	44052.93	2341.65	1735.94
1	22-Sep-15	16:18:00	1222.4	33,254	994.49	41227.80	2501.79	1830.83
1	22-Sep-15	16:19:00	1201.8	32,848	1014.04	41362.54	2147.08	1799.14
1	22-Sep-15	16:20:00	1231.1	33,003	1019.30	41683.03	2339.71	1818.79
1	22-Sep-15	16:21:00	1250.3	33,255	1027.36	41771.14	2413.68	1818.79
1	22-Sep-15	16:22:00	1245.8	33,420	1027.36	41216.98	2224.67	1835.48
1	22-Sep-15	16:23:00	1266.1	33,402	1020.43	41357.96	2501.98	1834.62

			Data-logger	DCS Data				
Boiler	Date	Time	Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
1	22-Sep-15	16:24:00	1291.2	33,390	1041.12	41589.67	2125.90	1812.27
1	22-Sep-15	16:25:00	1268.4	33,390	1010.01	41317.81	2042.14	1843.73
1	22-Sep-15	16:26:00	1264.2	33,486	1030.75	41317.81	2376.01	1842.87
1	22-Sep-15	16:27:00	1246.6	33,402	1026.13	40577.84	2533.94	1787.86
1	22-Sep-15	16:28:00	1256.1	33,136	1042.84	41316.73	2223.39	1802.91
1	22-Sep-15	16:29:00	1242.2	33,041	1029.03	41038.98	1911.99	1769.74
1	22-Sep-15	16:30:00	1229.5	32,731	1025.00	41224.41	2356.66	1800.19
1	22-Sep-15	16:31:00	1210.3	32,645	1025.00	40958.09	2568.67	1800.19
1	22-Sep-15	16:32:00	1207.1	32,552	968.59	44334.88	2084.86	1741.84
1	22-Sep-15	16:33:00	1186.9	32,634	1061.85	41451.46	2107.89	1772.60
1	22-Sep-15	16:34:00	1154.2	32,724	1005.98	41341.66	2586.79	1821.66
1	22-Sep-15	16:35:00	1166.6	32,878	1056.70	41272.98	2570.79	1820.70
1	22-Sep-15	16:36:00	1261.5	32,863	1034.78	41271.42	1959.88	1816.01
1	22-Sep-15	16:37:00	1249.8	33,116	1067.65	40494.17	2359.68	1815.14
1	22-Sep-15	16:38:00	1253.7	32,993	1014.63	39656.55	2538.42	1755.40
1	22-Sep-15	16:39:00	1257.4	33,077	1032.52	39740.22	2045.81	1785.92
1	22-Sep-15	16:40:00	1230.4	33,077	1029.62	39824.85	1915.63	1785.92
1	22-Sep-15	16:41:00	1238.9	33,327	1034.78	39824.85	2486.09	1793.60
1	22-Sep-15	16:42:00	1260.3	33,409	1045.15	39108.56	2024.94	1811.31
1	22-Sep-15	16:43:00	1264.8	34,201	1062.44	39839.36	2005.08	1833.67
1	22-Sep-15	16:44:00	1240.1	34,769	1048.64	39839.36	2382.63	1862.91
1	22-Sep-15	16:45:00	1260.2	34,939	1041.71	39055.62	2325.74	1862.91
1	22-Sep-15	16:46:00	1264.4	35,206	1068.19	38971.82	2268.53	1894.45
1	22-Sep-15	16:47:00	1265.7	35,273	1003.19	41399.45	1938.45	1890.11
1	22-Sep-15	16:48:00	1251.7	35,268	1037.68	38207.00	2170.86	1922.93
1	22-Sep-15	16:49:00	1257.9	34,944	1035.96	38713.93	2005.79	1869.26
1	22-Sep-15	16:50:00	1233.9	34,592	1031.39	40198.08	2171.76	1835.48
1	22-Sep-15	16:51:00	1235.5	34,509	1035.42	40309.43	2192.57	1833.67
1	22-Sep-15	16:52:00	1254.9	34,147	1049.77	39672.18	2152.90	1833.67
1	22-Sep-15	16:53:00	1271.8	34,062	1061.26	40406.59	2153.76	1849.29
1	22-Sep-15	16:54:00	1254.1	33,976	1049.77	40131.45	2253.36	1836.43
1	22-Sep-15	16:55:00	1259.5	33,976	1080.87	40810.30	2192.99	1832.81
1	22-Sep-15	16:56:00	1274.1	33,976	1060.72	40797.63	2608.44	1734.03
1	22-Sep-15	16:57:00	1251.2	34,030	1020.43	41522.11	2542.72	1734.03
1	22-Sep-15	16:58:00	1233.1	33,853	1056.10	41522.11	2113.06	1734.03
1	22-Sep-15	16:59:00	1226.4	33,944	1052.08	41793.37	2153.55	1757.29
1	22-Sep-15	17:00:00	1257.4	33,955	1057.82	42286.64	2771.66	1761.15

			Data-logger	DCS Data				
Boiler	Date	Time	Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
A	9/20/2015 15:00	9/20/15 15:59:00	1140.4	26646.0	970.6	33295.4	2626.9	1797.4
V	9/20/2015 16:00	9/20/15 16:59:00	1227.2	27162.9	991.2	33460.9	2513.5	1779.9
G	9/20/2015 17:00	9/20/15 17:59:00	1200.6	26567.4	993.0	33117.8	2557.0	1830.2
1	20-Sep-15	15:00:00	1,158.6	26,531	966	34,497	2,423	1,751
1	20-Sep-15	15:01:00	1,157.2	26,705	954	34,468	2,796	1,775
1	20-Sep-15	15:02:00	1,226.1	26,807	971	34,933	2,795	1,739
1	20-Sep-15	15:03:00	1,167.4	27,154	1,042	35,461	2,909	1,769
1	20-Sep-15	15:04:00	1,148.0	27,412	1,041	34,899	2,424	1,755
1	20-Sep-15	15:05:00	1,166.8	27,583	1,031	34,899	2,463	1,775
1	20-Sep-15	15:06:00	1,143.6	28,105	1,015	34,891	2,499	1,805
1	20-Sep-15	15:07:00	1,175.7	28,491	1,007	34,554	2,644	1,823
1	20-Sep-15	15:08:00	1,201.3	28,685	1,071	34,448	3,003	1,856
1	20-Sep-15	15:09:00	1,208.5	28,873	1,015	34,403	2,462	1,877
1	20-Sep-15	15:10:00	1,166.5	29,060	1,020	34,405	2,442	1,877
1	20-Sep-15	15:11:00	1,198.4	28,723	1,019	34,497	2,463	1,821
1	20-Sep-15	15:12:00	1,190.9	28,443	1,019	34,514	2,534	1,856
1	20-Sep-15	15:13:00	1,151.7	28,087	961	33,813	2,403	1,839
1	20-Sep-15	15:14:00	1,101.4	27,480	937	33,792	2,383	1,838
1	20-Sep-15	15:15:00	1,131.6	26,907	969	34,151	2,553	1,848
1	20-Sep-15	15:16:00	1,111.3	26,429	944	33,624	2,423	1,847
1	20-Sep-15	15:17:00	1,140.5	26,262	958	33,634	2,383	1,856
1	20-Sep-15	15:18:00	1,187.5	25,933	974	32,979	3,108	1,853
1	20-Sep-15	15:19:00	1,179.6	25,849	993	33,114	2,746	1,853
1	20-Sep-15	15:20:00	1,161.3	26,022	973	33,114	2,810	1,823
1	20-Sep-15	15:21:00	1,129.3	26,130	1,001	32,488	2,828	1,834
1	20-Sep-15	15:22:00	1,164.9	26,401	978	32,725	2,843	1,834
1	20-Sep-15	15:23:00	1,161.1	26,821	974	33,427	2,794	1,841
1	20-Sep-15	15:24:00	1,136.8	27,249	925	32,849	2,921	1,847
1	20-Sep-15	15:25:00	1,171.8	27,334	934	33,266	2,875	1,846
1	20-Sep-15	15:26:00	1,180.9	27,290	977	32,504	2,657	1,813
1	20-Sep-15	15:27:00	1,158.7	27,019	931	32,573	2,774	1,817
1	20-Sep-15	15:28:00	1,089.6	26,760	930	32,340	2,688	1,845
1	20-Sep-15	15:29:00	1,073.7	26,513	959	33,048	2,774	1,781
1	20-Sep-15	15:30:00	1,070.8	25,984	940	33,214	2,419	1,754
1	20-Sep-15	15:31:00	1,059.3	25,528	967	33,092	2,417	1,760
1	20-Sep-15	15:32:00	1,123.6	25,010	947	32,366	2,398	1,729
1	20-Sep-15	15:33:00	1,132.1	24,575	921	33,038	2,259	1,730
1	20-Sep-15	15:34:00	1,183.1	24,611	883	32,791	2,635	1,696
1	20-Sep-15	15:35:00	1,124.9	24,133	916	32,782	2,456	1,726
1	20-Sep-15	15:36:00	1,104.9	25,128	958	32,631	2,616	1,693
1	20-Sep-15	15:37:00	1,120.7	25,705	967	33,006	2,801	1,726
1	20-Sep-15	15:38:00	1,129.5	25,644	963	32,849	2,581	1,771
1	20-Sep-15	15:39:00	1,127.5	26,054	943	32,849	2,769	1,765
1	20-Sep-15	15:40:00	1,118.5	26,142	932	33,053	2,394	1,739
1	20-Sep-15	15:41:00	1,078.7	26,311	927	33,031	2,394	1,769
1	20-Sep-15	15:42:00	1,147.3	26,493	952	32,981	2,596	1,721
1	20-Sep-15	15:43:00	1,123.6	27,124	1,009	33,107	2,818	1,751
1	20-Sep-15	15:44:00	1,089.4	27,723	989	33,294	2,880	1,780
1	20-Sep-15	15:45:00	1,133.8	28,069	970	33,918	2,452	1,735

			Data-logger	DCS Data				
Boiler	Date	Time	Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
1	20-Sep-15	15:46:00	1,118.5	28,086	1,002	33,372	2,336	1,800
1	20-Sep-15	15:47:00	1,079.3	28,086	989	33,475	2,432	1,802
1	20-Sep-15	15:48:00	1,103.4	27,671	987	33,279	2,276	1,837
1	20-Sep-15	15:49:00	1,089.8	27,113	997	32,400	2,880	1,856
1	20-Sep-15	15:50:00	1,114.0	26,679	1,005	32,275	2,849	1,834
1	20-Sep-15	15:51:00	1,146.7	26,082	956	32,244	2,578	1,862
1	20-Sep-15	15:52:00	1,142.7	25,735	959	32,060	2,430	1,825
1	20-Sep-15	15:53:00	1,086.5	25,906	966	32,137	2,897	1,850
1	20-Sep-15	15:54:00	1,210.7	25,342	950	32,137	2,896	1,820
1	20-Sep-15	15:55:00	1,219.6	25,173	961	32,715	2,412	1,757
1	20-Sep-15	15:56:00	1,086.1	25,264	939	31,945	2,829	1,770
1	20-Sep-15	15:57:00	1,141.2	25,276	947	32,594	2,893	1,769
1	20-Sep-15	15:58:00	1,129.0	25,444	953	32,437	2,794	1,795
1	20-Sep-15	15:59:00	1,149.2	25,612	946	32,347	2,408	1,729
1	20-Sep-15	16:00:00	1,205.7	25,778	959	33,108	2,609	1,761
1	20-Sep-15	16:01:00	1,225.2	26,120	961	32,782	2,369	1,766
1	20-Sep-15	16:02:00	1,201.7	26,120	948	32,760	2,330	1,766
1	20-Sep-15	16:03:00	1,189.1	26,120	958	33,572	2,209	1,766
1	20-Sep-15	16:04:00	1,219.2	26,629	965	32,883	2,387	1,755
1	20-Sep-15	16:05:00	1,224.9	26,750	941	32,938	2,903	1,787
1	20-Sep-15	16:06:00	1,187.4	26,750	951	32,846	2,446	1,783
1	20-Sep-15	16:07:00	1,175.9	26,610	971	33,207	2,572	1,748
1	20-Sep-15	16:08:00	1,244.4	26,591	969	33,222	2,516	1,748
1	20-Sep-15	16:09:00	1,239.8	26,667	958	33,393	2,757	1,744
1	20-Sep-15	16:10:00	1,238.5	26,749	990	33,500	2,638	1,728
1	20-Sep-15	16:11:00	1,199.5	27,103	1,001	33,313	2,549	1,747
1	20-Sep-15	16:12:00	1,155.7	27,453	987	32,960	2,364	1,754
1	20-Sep-15	16:13:00	1,149.9	27,558	1,000	32,959	2,285	1,754
1	20-Sep-15	16:14:00	1,103.4	27,839	1,047	33,721	2,493	1,761
1	20-Sep-15	16:15:00	1,179.0	27,942	1,001	33,524	2,402	1,774
1	20-Sep-15	16:16:00	1,139.3	27,695	1,008	33,929	2,265	1,794
1	20-Sep-15	16:17:00	1,199.9	27,522	1,015	33,134	2,285	1,769
1	20-Sep-15	16:18:00	1,222.4	27,461	982	33,823	2,345	1,771
1	20-Sep-15	16:19:00	1,264.5	27,270	982	33,820	2,549	1,801
1	20-Sep-15	16:20:00	1,247.9	27,012	1,020	33,792	2,365	1,801
1	20-Sep-15	16:21:00	1,285.1	26,823	986	33,688	2,947	1,794
1	20-Sep-15	16:22:00	1,245.8	26,725	973	33,177	2,757	1,789
1	20-Sep-15	16:23:00	1,266.6	26,894	961	33,472	2,673	1,793
1	20-Sep-15	16:24:00	1,255.8	26,727	964	33,547	2,345	1,784
1	20-Sep-15	16:25:00	1,259.6	26,737	1,022	33,547	2,548	1,785
1	20-Sep-15	16:26:00	1,232.3	26,992	1,051	33,627	2,804	1,795
1	20-Sep-15	16:27:00	1,244.4	27,161	1,039	33,507	2,361	1,771
1	20-Sep-15	16:28:00	1,242.6	27,152	973	33,637	2,283	1,803
1	20-Sep-15	16:29:00	1,240.2	27,235	972	33,469	2,343	1,771
1	20-Sep-15	16:30:00	1,247.1	27,291	1,000	32,794	2,263	1,771
1	20-Sep-15	16:31:00	1,214.4	27,291	975	33,592	2,816	1,794
1	20-Sep-15	16:32:00	1,245.2	27,092	949	33,376	2,400	1,766
1	20-Sep-15	16:33:00	1,245.7	27,360	950	33,376	2,801	1,798
1	20-Sep-15	16:34:00	1,280.8	27,367	980	33,434	2,846	1,776

			Data-logger	DCS Data				
Boiler	Date	Time	Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
1	20-Sep-15	16:35:00	1,270.0	27,726	974	33,337	2,863	1,776
1	20-Sep-15	16:36:00	1,271.9	27,624	981	33,337	2,415	1,786
1	20-Sep-15	16:37:00	1,283.8	27,519	968	34,252	2,800	1,757
1	20-Sep-15	16:38:00	1,275.4	27,599	1,055	33,501	2,341	1,788
1	20-Sep-15	16:39:00	1,260.0	27,599	1,034	33,634	2,614	1,754
1	20-Sep-15	16:40:00	1,248.0	27,383	997	33,762	2,321	1,784
1	20-Sep-15	16:41:00	1,241.5	27,124	1,027	33,762	2,830	1,791
1	20-Sep-15	16:42:00	1,243.8	26,958	1,033	33,052	2,733	1,792
1	20-Sep-15	16:43:00	1,220.0	26,785	990	33,109	2,280	1,788
1	20-Sep-15	16:44:00	1,203.3	26,523	984	33,296	2,376	1,784
1	20-Sep-15	16:45:00	1,185.4	26,523	974	33,377	2,845	1,784
1	20-Sep-15	16:46:00	1,237.6	26,216	981	32,914	2,613	1,785
1	20-Sep-15	16:47:00	1,182.9	26,155	1,006	33,426	2,340	1,774
1	20-Sep-15	16:48:00	1,253.7	26,903	1,064	33,867	2,781	1,805
1	20-Sep-15	16:49:00	1,254.2	27,757	1,069	33,816	2,301	1,808
1	20-Sep-15	16:50:00	1,234.3	28,121	1,016	34,451	2,543	1,781
1	20-Sep-15	16:51:00	1,273.2	28,510	985	33,767	2,749	1,790
1	20-Sep-15	16:52:00	1,270.3	28,687	1,009	34,411	2,472	1,785
1	20-Sep-15	16:53:00	1,266.4	28,517	966	34,167	1,959	1,788
1	20-Sep-15	16:54:00	1,233.7	28,434	972	33,987	2,319	1,822
1	20-Sep-15	16:55:00	1,197.6	28,349	999	33,631	2,732	1,821
1	20-Sep-15	16:56:00	1,196.7	27,898	992	33,496	2,339	1,790
1	20-Sep-15	16:57:00	1,172.3	27,347	1,007	33,574	2,765	1,792
1	20-Sep-15	16:58:00	1,200.3	26,727	1,012	33,527	2,339	1,822
1	20-Sep-15	16:59:00	1,234.6	26,206	969	32,777	2,319	1,787
1	20-Sep-15	17:00:00	1,271.1	25,787	990	32,821	2,765	1,800
1	20-Sep-15	17:01:00	1,235.0	25,997	1,064	33,578	2,199	1,794
1	20-Sep-15	17:02:00	1,196.9	26,446	972	33,255	2,436	1,811
1	20-Sep-15	17:03:00	1,149.7	26,809	974	34,069	2,597	1,824
1	20-Sep-15	17:04:00	1,168.9	27,161	1,017	33,384	2,766	1,791
1	20-Sep-15	17:05:00	1,184.6	27,500	948	33,481	2,357	1,800
1	20-Sep-15	17:06:00	1,148.9	27,672	1,030	33,785	2,939	1,783
1	20-Sep-15	17:07:00	1,191.3	27,858	999	33,886	2,731	1,814
1	20-Sep-15	17:08:00	1,190.3	28,079	975	33,798	2,507	1,802
1	20-Sep-15	17:09:00	1,173.0	28,090	988	33,669	2,613	1,799
1	20-Sep-15	17:10:00	1,143.5	27,741	1,008	33,393	2,238	1,830
1	20-Sep-15	17:11:00	1,124.2	27,195	969	33,482	2,468	1,830
1	20-Sep-15	17:12:00	1,149.5	26,689	993	33,571	2,762	1,827
1	20-Sep-15	17:13:00	1,227.5	26,086	992	33,650	2,355	1,827
1	20-Sep-15	17:14:00	1,241.2	25,659	1,070	32,929	2,375	1,794
1	20-Sep-15	17:15:00	1,257.7	25,855	1,052	32,946	2,727	1,801
1	20-Sep-15	17:16:00	1,245.1	26,297	1,039	33,125	2,431	1,794
1	20-Sep-15	17:17:00	1,280.2	26,822	1,015	33,440	2,432	1,799
1	20-Sep-15	17:18:00	1,231.5	27,418	1,019	34,213	2,809	1,811
1	20-Sep-15	17:19:00	1,172.6	27,837	1,019	34,093	2,355	1,815
1	20-Sep-15	17:20:00	1,066.0	27,919	1,028	33,906	2,776	1,785
1	20-Sep-15	17:21:00	1,120.2	27,916	1,039	33,843	2,355	1,784
1	20-Sep-15	17:22:00	1,126.1	27,835	1,028	34,034	2,762	1,816
1	20-Sep-15	17:23:00	1,142.1	27,778	1,044	33,351	2,825	1,808

			Data-logger	DCS Data				
Boiler	Date	Time	Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
1	20-Sep-15	17:24:00	1,113.9	27,604	971	33,745	2,316	1,795
1	20-Sep-15	17:25:00	1,179.0	26,931	898	34,472	2,760	1,797
1	20-Sep-15	17:26:00	1,198.9	26,327	998	33,058	2,371	1,810
1	20-Sep-15	17:27:00	1,178.1	25,731	940	33,067	2,572	1,779
1	20-Sep-15	17:28:00	1,190.5	25,239	986	32,906	2,807	1,885
1	20-Sep-15	17:29:00	1,219.1	24,895	982	32,885	2,313	1,853
1	20-Sep-15	17:30:00	1,233.4	24,801	1,014	33,774	2,805	1,821
1	20-Sep-15	17:31:00	1,215.1	24,734	971	33,559	2,388	1,823
1	20-Sep-15	17:32:00	1,209.9	24,955	980	33,997	2,427	1,835
1	20-Sep-15	17:33:00	1,250.0	25,168	967	33,509	2,835	1,840
1	20-Sep-15	17:34:00	1,260.0	25,631	983	33,509	2,404	1,853
1	20-Sep-15	17:35:00	1,218.2	26,318	995	33,487	2,230	1,868
1	20-Sep-15	17:36:00	1,246.0	26,795	976	34,177	2,770	1,838
1	20-Sep-15	17:37:00	1,239.3	26,981	939	33,259	2,347	1,836
1	20-Sep-15	17:38:00	1,274.5	27,155	1,031	33,331	2,801	1,874
1	20-Sep-15	17:39:00	1,290.4	27,237	980	33,276	2,531	1,864
1	20-Sep-15	17:40:00	1,262.4	27,405	954	32,650	2,441	1,872
1	20-Sep-15	17:41:00	1,243.4	27,221	961	32,626	2,801	1,849
1	20-Sep-15	17:42:00	1,230.5	26,865	957	33,293	2,329	1,857
1	20-Sep-15	17:43:00	1,196.2	26,519	979	32,644	2,736	1,867
1	20-Sep-15	17:44:00	1,181.9	25,972	1,013	32,829	2,513	1,872
1	20-Sep-15	17:45:00	1,226.1	25,711	992	32,157	2,344	1,847
1	20-Sep-15	17:46:00	1,134.2	25,531	1,007	32,238	2,783	1,879
1	20-Sep-15	17:47:00	1,188.8	25,428	1,015	32,155	2,344	1,859
1	20-Sep-15	17:48:00	1,235.9	25,430	1,048	32,228	2,765	1,860
1	20-Sep-15	17:49:00	1,224.9	25,804	1,054	32,303	2,797	1,863
1	20-Sep-15	17:50:00	1,229.8	26,141	1,022	32,416	2,343	1,858
1	20-Sep-15	17:51:00	1,154.4	26,441	931	32,045	2,814	1,869
1	20-Sep-15	17:52:00	1,202.6	26,694	931	32,394	2,326	1,838
1	20-Sep-15	17:53:00	1,212.5	26,518	929	31,668	2,344	1,852
1	20-Sep-15	17:54:00	1,225.2	26,437	945	32,085	2,860	1,825
1	20-Sep-15	17:55:00	1,161.5	26,888	966	32,085	2,305	1,856
1	20-Sep-15	17:56:00	1,174.6	26,888	974	32,085	2,667	1,850
1	20-Sep-15	17:57:00	1,173.4	26,729	1,019	32,085	2,562	1,830
1	20-Sep-15	17:58:00	1,208.7	26,365	1,012	31,632	2,287	1,861
1	20-Sep-15	17:59:00	1,217.9	26,111	989	31,741	2,796	1,831

Boiler	Date	Time	Data-logger	DCS Data				
			Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
A	9/22/15 1:00:00	9/22/15 1:59:00	1,241.9	33,012	988.9	45,172	7,124	1,608
V	9/22/15 2:00:00	9/22/15 2:59:00	1,219.8	34,528	1,004.0	46,412	7,347	1,584
G	9/22/15 3:00:00	9/22/15 3:59:00	1,222.7	32,895	969.9	46,142	7,327	1,574
2	22-Sep-15	1:00:00	1,108.0	33,221	1,014	45,381	7,144	1,636
2	22-Sep-15	1:01:00	1,222.9	32,417	979	45,568	6,810	1,591
2	22-Sep-15	1:02:00	1,224.2	31,935	1,002	45,595	6,745	1,516
2	22-Sep-15	1:03:00	1,250.8	31,501	1,021	44,903	6,803	1,578
2	22-Sep-15	1:04:00	1,209.4	30,998	988	47,928	7,090	1,509
2	22-Sep-15	1:05:00	1,230.2	30,892	995	44,668	7,149	1,582
2	22-Sep-15	1:06:00	1,247.7	31,590	996	43,999	7,326	1,511
2	22-Sep-15	1:07:00	1,282.9	31,062	964	44,734	6,939	1,545
2	22-Sep-15	1:08:00	1,227.6	31,519	937	44,756	7,039	1,605
2	22-Sep-15	1:09:00	1,114.6	32,170	992	44,670	7,086	1,639
2	22-Sep-15	1:10:00	1,068.4	32,314	1,026	44,670	6,919	1,615
2	22-Sep-15	1:11:00	1,028.6	32,331	1,035	44,406	7,156	1,615
2	22-Sep-15	1:12:00	1,044.7	32,626	1,011	44,406	7,176	1,610
2	22-Sep-15	1:13:00	1,092.9	33,161	1,038	44,214	7,002	1,640
2	22-Sep-15	1:14:00	1,144.1	32,973	991	44,910	7,285	1,639
2	22-Sep-15	1:15:00	1,134.9	32,826	1,036	44,916	7,095	1,626
2	22-Sep-15	1:16:00	1,188.6	32,998	1,040	45,333	6,808	1,648
2	22-Sep-15	1:17:00	1,189.9	32,469	1,010	44,637	7,129	1,647
2	22-Sep-15	1:18:00	1,269.4	32,765	943	44,457	7,151	1,637
2	22-Sep-15	1:19:00	1,273.4	32,701	952	47,210	7,253	1,577
2	22-Sep-15	1:20:00	1,273.7	32,523	981	45,261	7,002	1,613
2	22-Sep-15	1:21:00	1,275.5	32,550	969	45,324	6,985	1,630
2	22-Sep-15	1:22:00	1,280.1	32,629	979	45,090	7,162	1,630
2	22-Sep-15	1:23:00	1,274.1	32,698	980	45,543	7,051	1,625
2	22-Sep-15	1:24:00	1,260.1	32,995	962	44,854	7,051	1,615
2	22-Sep-15	1:25:00	1,229.5	33,229	1,011	45,204	7,006	1,642
2	22-Sep-15	1:26:00	1,245.7	33,223	1,001	45,019	7,043	1,646
2	22-Sep-15	1:27:00	1,279.6	32,971	950	45,079	7,163	1,614
2	22-Sep-15	1:28:00	1,256.9	32,871	934	45,062	7,288	1,613
2	22-Sep-15	1:29:00	1,205.4	32,628	967	44,602	7,005	1,617
2	22-Sep-15	1:30:00	1,200.9	32,398	983	45,276	7,161	1,641
2	22-Sep-15	1:31:00	1,231.1	32,499	979	45,011	7,175	1,617
2	22-Sep-15	1:32:00	1,277.0	32,603	1,009	44,716	7,180	1,622
2	22-Sep-15	1:33:00	1,249.1	32,958	1,027	44,659	7,055	1,630
2	22-Sep-15	1:34:00	1,247.1	33,378	965	47,599	7,112	1,569
2	22-Sep-15	1:35:00	1,271.1	33,178	965	45,210	6,729	1,610
2	22-Sep-15	1:36:00	1,278.1	33,468	1,009	45,217	7,276	1,626
2	22-Sep-15	1:37:00	1,205.1	33,485	1,006	45,287	7,294	1,630
2	22-Sep-15	1:38:00	1,187.3	33,298	966	44,237	7,272	1,567
2	22-Sep-15	1:39:00	1,243.9	33,149	919	44,497	7,272	1,590
2	22-Sep-15	1:40:00	1,318.5	33,492	1,006	45,283	7,054	1,559
2	22-Sep-15	1:41:00	1,325.6	33,462	971	44,957	7,193	1,590
2	22-Sep-15	1:42:00	1,308.4	33,794	949	44,779	7,233	1,590
2	22-Sep-15	1:43:00	1,327.7	34,076	972	44,805	7,227	1,621
2	22-Sep-15	1:44:00	1,305.5	34,503	994	44,805	6,695	1,663
2	22-Sep-15	1:45:00	1,312.8	34,679	952	45,064	6,895	1,625

Boiler	Date	Time	Data-logger	DCS Data				
			Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
2	22-Sep-15	1:46:00	1,292.5	34,664	985	44,944	7,038	1,649
2	22-Sep-15	1:47:00	1,251.2	34,655	995	45,030	7,432	1,622
2	22-Sep-15	1:48:00	1,241.8	34,574	1,005	44,840	7,405	1,593
2	22-Sep-15	1:49:00	1,267.8	34,284	964	47,454	7,226	1,584
2	22-Sep-15	1:50:00	1,350.1	34,102	999	45,141	7,355	1,580
2	22-Sep-15	1:51:00	1,333.4	33,794	1,017	45,820	7,025	1,616
2	22-Sep-15	1:52:00	1,293.6	33,803	1,071	45,866	7,306	1,650
2	22-Sep-15	1:53:00	1,274.5	33,348	1,016	45,455	7,495	1,617
2	22-Sep-15	1:54:00	1,339.9	33,245	967	45,151	7,232	1,646
2	22-Sep-15	1:55:00	1,327.2	33,078	976	44,751	7,207	1,608
2	22-Sep-15	1:56:00	1,314.5	33,202	961	45,545	7,202	1,599
2	22-Sep-15	1:57:00	1,297.8	33,615	982	45,642	7,426	1,600
2	22-Sep-15	1:58:00	1,249.5	33,497	1,013	45,645	7,108	1,597
2	22-Sep-15	1:59:00	1,257.6	33,649	1,005	45,244	7,308	1,562
2	22-Sep-15	2:00:00	1,245.5	33,510	966	46,043	7,330	1,596
2	22-Sep-15	2:01:00	1,258.5	32,798	942	45,980	6,919	1,528
2	22-Sep-15	2:02:00	1,268.0	33,065	969	46,409	7,152	1,561
2	22-Sep-15	2:03:00	1,306.7	33,343	983	45,689	7,610	1,598
2	22-Sep-15	2:04:00	1,277.5	34,033	972	48,891	7,333	1,566
2	22-Sep-15	2:05:00	1,297.0	34,200	981	46,095	7,434	1,618
2	22-Sep-15	2:06:00	1,286.2	34,291	994	45,959	7,233	1,619
2	22-Sep-15	2:07:00	1,263.5	34,127	1,007	45,607	7,226	1,581
2	22-Sep-15	2:08:00	1,220.3	34,037	1,004	45,766	7,378	1,621
2	22-Sep-15	2:09:00	1,300.1	33,784	991	45,186	7,308	1,590
2	22-Sep-15	2:10:00	1,267.4	33,705	960	44,906	7,504	1,628
2	22-Sep-15	2:11:00	1,256.2	33,241	929	44,928	7,650	1,582
2	22-Sep-15	2:12:00	1,242.6	33,721	1,000	45,254	7,157	1,573
2	22-Sep-15	2:13:00	1,269.9	33,547	996	45,446	7,339	1,603
2	22-Sep-15	2:14:00	1,272.4	33,452	984	45,446	7,314	1,601
2	22-Sep-15	2:15:00	1,254.9	32,295	936	46,089	7,288	1,501
2	22-Sep-15	2:16:00	1,264.1	32,449	906	45,223	7,471	1,543
2	22-Sep-15	2:17:00	1,251.4	32,236	968	45,992	7,278	1,506
2	22-Sep-15	2:18:00	1,222.8	31,935	995	45,086	7,292	1,343
2	22-Sep-15	2:19:00	1,193.5	31,912	980	49,609	7,257	1,410
2	22-Sep-15	2:20:00	1,218.1	32,010	968	46,680	7,381	1,466
2	22-Sep-15	2:21:00	1,242.2	32,082	972	45,911	7,321	1,501
2	22-Sep-15	2:22:00	1,260.0	32,051	923	44,977	7,127	1,536
2	22-Sep-15	2:23:00	1,275.3	32,347	978	45,689	7,360	1,536
2	22-Sep-15	2:24:00	1,250.9	32,297	933	45,885	7,534	1,535
2	22-Sep-15	2:25:00	1,250.4	32,355	947	45,638	7,277	1,525
2	22-Sep-15	2:26:00	1,265.2	32,856	930	45,738	7,252	1,497
2	22-Sep-15	2:27:00	1,305.3	33,311	994	46,944	7,431	1,436
2	22-Sep-15	2:28:00	1,237.3	34,025	1,044	47,139	7,415	1,506
2	22-Sep-15	2:29:00	1,285.1	34,057	1,047	46,385	7,223	1,561
2	22-Sep-15	2:30:00	1,258.6	34,407	977	46,288	7,436	1,565
2	22-Sep-15	2:31:00	1,253.2	34,507	973	45,638	7,241	1,600
2	22-Sep-15	2:32:00	1,287.7	34,507	943	45,490	7,286	1,612
2	22-Sep-15	2:33:00	1,288.8	34,899	995	46,748	6,972	1,562
2	22-Sep-15	2:34:00	1,208.2	35,358	1,022	50,002	7,637	1,561

Boiler	Date	Time	Data-logger	DCS Data				
			Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
2	22-Sep-15	2:35:00	1,120.3	35,358	1,034	46,772	7,316	1,629
2	22-Sep-15	2:36:00	1,198.8	35,358	1,002	45,912	7,482	1,596
2	22-Sep-15	2:37:00	1,168.9	35,790	1,048	46,604	7,274	1,627
2	22-Sep-15	2:38:00	1,203.4	35,957	1,047	45,858	7,460	1,615
2	22-Sep-15	2:39:00	1,225.4	36,231	1,077	46,452	7,254	1,602
2	22-Sep-15	2:40:00	1,201.6	36,398	1,041	46,525	7,432	1,642
2	22-Sep-15	2:41:00	1,272.1	37,029	1,144	46,525	7,460	1,665
2	22-Sep-15	2:42:00	1,217.2	37,773	1,080	47,215	7,285	1,630
2	22-Sep-15	2:43:00	1,244.3	37,943	1,068	47,215	7,466	1,664
2	22-Sep-15	2:44:00	1,152.9	37,935	1,054	47,215	7,279	1,659
2	22-Sep-15	2:45:00	1,097.9	37,567	998	46,108	7,456	1,658
2	22-Sep-15	2:46:00	1,097.4	37,024	1,016	46,362	7,253	1,627
2	22-Sep-15	2:47:00	1,109.0	36,671	1,022	46,895	7,471	1,595
2	22-Sep-15	2:48:00	1,211.5	36,664	1,066	47,022	7,492	1,624
2	22-Sep-15	2:49:00	1,117.3	36,645	1,081	49,221	7,298	1,626
2	22-Sep-15	2:50:00	1,175.9	36,469	1,021	46,989	7,386	1,625
2	22-Sep-15	2:51:00	1,162.0	36,207	1,002	47,178	7,074	1,653
2	22-Sep-15	2:52:00	1,160.5	35,938	1,081	47,141	7,391	1,663
2	22-Sep-15	2:53:00	1,172.6	35,729	1,055	46,843	7,341	1,665
2	22-Sep-15	2:54:00	1,180.9	35,278	1,058	46,057	7,504	1,635
2	22-Sep-15	2:55:00	1,115.0	34,945	1,067	46,450	7,478	1,630
2	22-Sep-15	2:56:00	1,126.3	34,991	1,052	47,218	7,327	1,636
2	22-Sep-15	2:57:00	1,136.7	35,351	1,048	46,836	7,492	1,627
2	22-Sep-15	2:58:00	1,112.2	34,880	995	46,611	7,309	1,633
2	22-Sep-15	2:59:00	1,100.4	34,769	979	46,721	7,492	1,627
2	22-Sep-15	3:00:00	1,134.0	34,592	997	46,721	7,645	1,662
2	22-Sep-15	3:01:00	1,080.2	34,710	1,003	46,034	7,629	1,661
2	22-Sep-15	3:02:00	1,216.7	33,656	978	45,546	7,444	1,658
2	22-Sep-15	3:03:00	1,253.3	33,288	986	45,546	7,158	1,624
2	22-Sep-15	3:04:00	1,162.8	33,127	995	48,455	7,490	1,532
2	22-Sep-15	3:05:00	1,256.5	32,762	984	46,049	7,083	1,579
2	22-Sep-15	3:06:00	1,297.7	31,994	988	46,365	7,227	1,574
2	22-Sep-15	3:07:00	1,268.6	32,547	982	46,270	7,211	1,584
2	22-Sep-15	3:08:00	1,300.1	32,144	945	46,270	7,688	1,588
2	22-Sep-15	3:09:00	1,316.6	32,420	959	46,645	7,480	1,617
2	22-Sep-15	3:10:00	1,322.9	32,896	991	45,864	7,352	1,627
2	22-Sep-15	3:11:00	1,290.2	33,581	990	46,656	7,190	1,627
2	22-Sep-15	3:12:00	1,230.6	33,579	966	46,552	7,551	1,659
2	22-Sep-15	3:13:00	1,112.6	33,559	936	45,907	7,196	1,659
2	22-Sep-15	3:14:00	1,078.8	33,357	987	45,537	7,340	1,570
2	22-Sep-15	3:15:00	1,177.2	33,237	1,005	45,917	7,357	1,640
2	22-Sep-15	3:16:00	1,205.0	33,383	995	45,097	7,159	1,604
2	22-Sep-15	3:17:00	1,264.8	33,035	942	45,097	7,163	1,607
2	22-Sep-15	3:18:00	1,310.3	32,648	973	44,896	6,993	1,567
2	22-Sep-15	3:19:00	1,252.4	32,810	951	48,284	7,154	1,527
2	22-Sep-15	3:20:00	1,243.9	33,274	952	45,730	7,189	1,582
2	22-Sep-15	3:21:00	1,239.5	32,735	932	46,009	7,312	1,609
2	22-Sep-15	3:22:00	1,283.7	33,523	937	45,942	7,101	1,639
2	22-Sep-15	3:23:00	1,257.9	33,314	981	45,867	7,299	1,643

Boiler	Date	Time	Data-logger	DCS Data				
			Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
2	22-Sep-15	3:24:00	1,266.7	33,519	994	45,844	7,278	1,649
2	22-Sep-15	3:25:00	1,074.1	33,722	972	45,465	7,182	1,652
2	22-Sep-15	3:26:00	1,096.4	33,522	963	45,335	7,322	1,652
2	22-Sep-15	3:27:00	1,100.7	33,014	920	47,965	7,566	1,547
2	22-Sep-15	3:28:00	1,194.8	32,636	946	48,102	7,081	1,560
2	22-Sep-15	3:29:00	1,194.8	32,865	985	45,893	7,009	1,532
2	22-Sep-15	3:30:00	1,190.7	32,660	972	45,900	7,195	1,590
2	22-Sep-15	3:31:00	1,183.6	31,813	957	45,841	7,429	1,494
2	22-Sep-15	3:32:00	1,229.3	31,993	975	45,439	7,487	1,465
2	22-Sep-15	3:33:00	1,190.2	31,748	961	45,457	7,254	1,540
2	22-Sep-15	3:34:00	1,213.0	32,110	939	45,466	7,278	1,532
2	22-Sep-15	3:35:00	1,233.8	32,031	975	45,202	7,284	1,558
2	22-Sep-15	3:36:00	1,218.9	31,877	943	44,883	7,069	1,495
2	22-Sep-15	3:37:00	1,206.6	31,975	943	45,242	7,413	1,502
2	22-Sep-15	3:38:00	1,140.8	32,242	916	45,255	6,985	1,560
2	22-Sep-15	3:39:00	1,255.6	32,202	924	45,157	7,475	1,487
2	22-Sep-15	3:40:00	1,284.1	32,166	919	45,316	7,349	1,489
2	22-Sep-15	3:41:00	1,291.8	32,611	953	45,989	7,278	1,450
2	22-Sep-15	3:42:00	1,295.3	33,122	978	46,679	7,341	1,480
2	22-Sep-15	3:43:00	1,339.6	33,362	972	48,932	6,966	1,473
2	22-Sep-15	3:44:00	1,242.7	33,577	981	46,599	7,691	1,541
2	22-Sep-15	3:45:00	1,241.3	33,852	1,018	45,897	7,444	1,572
2	22-Sep-15	3:46:00	1,241.0	33,811	1,007	46,658	7,574	1,612
2	22-Sep-15	3:47:00	1,218.7	33,523	1,022	45,987	6,998	1,635
2	22-Sep-15	3:48:00	1,220.1	33,172	985	45,987	7,196	1,620
2	22-Sep-15	3:49:00	1,187.6	32,971	1,046	45,987	7,340	1,588
2	22-Sep-15	3:50:00	1,212.5	32,797	1,002	46,412	7,789	1,588
2	22-Sep-15	3:51:00	1,290.9	32,703	945	46,266	7,405	1,585
2	22-Sep-15	3:52:00	1,255.1	32,628	996	45,591	7,533	1,608
2	22-Sep-15	3:53:00	1,236.9	32,647	1,026	46,287	7,349	1,612
2	22-Sep-15	3:54:00	1,223.4	32,554	999	46,105	7,535	1,551
2	22-Sep-15	3:55:00	1,231.4	32,556	923	45,939	7,364	1,551
2	22-Sep-15	3:56:00	1,214.2	32,472	915	46,336	7,554	1,546
2	22-Sep-15	3:57:00	1,211.0	32,388	946	46,086	7,327	1,481
2	22-Sep-15	3:58:00	1,188.9	32,388	958	49,124	7,528	1,482
2	22-Sep-15	3:59:00	1,191.7	32,333	962	46,650	7,366	1,504
2	22-Sep-15	4:00:00	1,198.5	32,437	970	46,184	7,731	1,577

Boiler	Date	Time	Data-logger	DCS Data				
			Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
A	9/20/15 9:00 PM	9/20/15 9:59 PM	1179.2	27802.0	954.2	40082.3	5863.0	1631.2
V	9/20/15 10:00 PM	9/20/15 10:59 PM	1159.9	27496.5	950.5	38415.5	5496.2	1641.1
G	9/20/15 11:00 PM	9/20/15 11:59 PM	1182.8	27621.0	943.6	38257.7	5485.0	1678.6
2	20-Sep-15	21:00:00	1,139.7	27,834	975	40,510	6,400	1,690
2	20-Sep-15	21:01:00	1,150.9	27,501	1,005	40,592	6,304	1,656
2	20-Sep-15	21:02:00	1,054.7	27,613	957	43,868	5,695	1,616
2	20-Sep-15	21:03:00	1,109.7	27,391	975	40,956	6,063	1,580
2	20-Sep-15	21:04:00	1,154.9	26,524	959	40,879	6,279	1,564
2	20-Sep-15	21:05:00	1,129.6	27,112	945	40,355	5,996	1,629
2	20-Sep-15	21:06:00	1,135.3	27,030	972	40,891	5,904	1,627
2	20-Sep-15	21:07:00	1,156.6	26,936	953	40,754	6,285	1,596
2	20-Sep-15	21:08:00	1,164.8	27,265	924	40,305	6,195	1,652
2	20-Sep-15	21:09:00	1,179.7	27,270	934	41,716	5,805	1,651
2	20-Sep-15	21:10:00	1,179.1	27,528	972	40,870	5,644	1,678
2	20-Sep-15	21:11:00	1,159.8	27,804	965	41,027	6,326	1,665
2	20-Sep-15	21:12:00	1,164.0	28,208	957	41,097	6,295	1,674
2	20-Sep-15	21:13:00	1,175.0	27,711	962	41,042	5,860	1,678
2	20-Sep-15	21:14:00	1,186.7	27,523	914	40,280	5,567	1,706
2	20-Sep-15	21:15:00	1,221.3	27,955	961	40,501	6,147	1,661
2	20-Sep-15	21:16:00	1,239.6	27,792	961	40,461	5,901	1,661
2	20-Sep-15	21:17:00	1,241.6	27,726	981	43,586	5,835	1,607
2	20-Sep-15	21:18:00	1,185.8	27,600	923	40,184	6,267	1,643
2	20-Sep-15	21:19:00	1,221.9	28,183	950	40,546	5,880	1,632
2	20-Sep-15	21:20:00	1,193.8	27,639	946	40,743	5,777	1,651
2	20-Sep-15	21:21:00	1,214.1	27,794	972	40,887	5,728	1,653
2	20-Sep-15	21:22:00	1,203.0	28,539	983	40,206	6,317	1,682
2	20-Sep-15	21:23:00	1,227.7	28,462	996	39,749	5,959	1,706
2	20-Sep-15	21:24:00	1,218.0	28,355	1,017	39,756	5,791	1,700
2	20-Sep-15	21:25:00	1,217.7	28,166	1,012	39,912	6,010	1,717
2	20-Sep-15	21:26:00	1,213.2	28,255	1,012	39,522	5,544	1,689
2	20-Sep-15	21:27:00	1,189.1	27,952	962	39,713	5,510	1,652
2	20-Sep-15	21:28:00	1,212.1	27,873	946	39,549	5,565	1,649
2	20-Sep-15	21:29:00	1,193.0	27,709	941	39,782	5,808	1,649
2	20-Sep-15	21:30:00	1,193.3	27,879	908	39,961	5,572	1,616
2	20-Sep-15	21:31:00	1,168.1	27,250	911	40,186	5,750	1,615
2	20-Sep-15	21:32:00	1,208.9	27,402	908	43,665	5,966	1,545
2	20-Sep-15	21:33:00	1,192.8	27,389	896	39,959	5,964	1,657
2	20-Sep-15	21:34:00	1,188.3	27,416	931	39,889	5,991	1,590
2	20-Sep-15	21:35:00	1,166.9	27,418	967	39,297	5,689	1,627
2	20-Sep-15	21:36:00	1,148.3	27,364	929	40,004	5,681	1,627
2	20-Sep-15	21:37:00	1,229.8	27,564	904	39,647	5,482	1,628
2	20-Sep-15	21:38:00	1,119.1	27,663	953	39,600	5,920	1,697
2	20-Sep-15	21:39:00	1,205.3	27,585	918	39,136	5,993	1,664
2	20-Sep-15	21:40:00	1,165.2	27,502	981	39,832	5,858	1,624
2	20-Sep-15	21:41:00	1,152.6	27,340	959	39,092	5,560	1,605
2	20-Sep-15	21:42:00	1,149.7	27,335	982	39,017	5,491	1,632
2	20-Sep-15	21:43:00	1,116.2	27,333	947	38,607	5,918	1,629
2	20-Sep-15	21:44:00	1,151.5	27,296	926	39,298	5,890	1,560
2	20-Sep-15	21:45:00	1,162.1	27,210	911	38,658	5,910	1,598

Boiler	Date	Time	Data-logger	DCS Data				
			Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
2	20-Sep-15	21:46:00	1,135.4	27,481	932	38,538	5,678	1,535
2	20-Sep-15	21:47:00	1,166.7	27,470	933	41,827	5,462	1,503
2	20-Sep-15	21:48:00	1,200.8	27,648	966	37,509	6,073	1,551
2	20-Sep-15	21:49:00	1,190.6	27,989	943	39,394	5,880	1,568
2	20-Sep-15	21:50:00	1,172.5	28,249	1,009	38,696	5,517	1,593
2	20-Sep-15	21:51:00	1,113.1	28,585	968	38,296	5,953	1,593
2	20-Sep-15	21:52:00	1,174.1	29,069	967	39,117	5,957	1,593
2	20-Sep-15	21:53:00	1,190.7	29,034	986	39,117	5,447	1,564
2	20-Sep-15	21:54:00	1,277.3	28,783	991	39,828	5,969	1,580
2	20-Sep-15	21:55:00	1,252.3	29,065	942	39,592	5,650	1,612
2	20-Sep-15	21:56:00	1,218.6	28,846	954	39,428	5,433	1,650
2	20-Sep-15	21:57:00	1,203.8	28,725	947	39,488	5,894	1,647
2	20-Sep-15	21:58:00	1,145.3	28,522	941	39,337	5,962	1,682
2	20-Sep-15	21:59:00	1,159.1	28,462	910	38,687	5,614	1,678
2	20-Sep-15	22:00:00	1,207.8	27,936	915	39,284	5,645	1,677
2	20-Sep-15	22:01:00	1,202.7	28,065	915	39,298	5,343	1,677
2	20-Sep-15	22:02:00	1,201.9	27,967	955	42,259	5,949	1,653
2	20-Sep-15	22:03:00	1,185.3	28,638	948	39,021	5,861	1,730
2	20-Sep-15	22:04:00	1,128.4	28,194	961	39,021	5,941	1,731
2	20-Sep-15	22:05:00	1,155.0	28,149	1,004	38,624	5,549	1,713
2	20-Sep-15	22:06:00	1,212.3	27,872	937	38,476	5,656	1,683
2	20-Sep-15	22:07:00	1,236.5	28,355	990	38,891	5,413	1,681
2	20-Sep-15	22:08:00	1,212.0	28,381	951	39,100	5,662	1,713
2	20-Sep-15	22:09:00	1,168.0	28,329	927	38,393	5,865	1,706
2	20-Sep-15	22:10:00	1,149.3	28,095	914	38,728	5,357	1,712
2	20-Sep-15	22:11:00	1,106.7	28,171	942	38,210	5,324	1,712
2	20-Sep-15	22:12:00	1,118.2	27,827	901	38,300	5,833	1,678
2	20-Sep-15	22:13:00	1,116.7	27,573	986	38,676	5,871	1,678
2	20-Sep-15	22:14:00	1,122.0	27,582	988	37,948	5,320	1,678
2	20-Sep-15	22:15:00	1,162.0	27,497	937	37,993	5,379	1,692
2	20-Sep-15	22:16:00	1,107.7	27,055	944	37,814	5,804	1,661
2	20-Sep-15	22:17:00	1,107.6	26,831	923	41,254	5,574	1,527
2	20-Sep-15	22:18:00	1,078.1	26,959	882	38,099	5,455	1,581
2	20-Sep-15	22:19:00	1,138.9	26,812	893	38,023	5,701	1,575
2	20-Sep-15	22:20:00	1,136.6	26,728	923	38,510	5,896	1,606
2	20-Sep-15	22:21:00	1,132.1	26,335	909	37,793	5,479	1,601
2	20-Sep-15	22:22:00	1,205.9	26,080	912	37,776	5,231	1,598
2	20-Sep-15	22:23:00	1,158.2	26,092	931	38,672	5,800	1,560
2	20-Sep-15	22:24:00	1,165.2	26,510	960	38,032	5,745	1,470
2	20-Sep-15	22:25:00	1,152.5	26,195	955	38,642	5,580	1,517
2	20-Sep-15	22:26:00	1,215.5	26,125	897	37,588	5,191	1,451
2	20-Sep-15	22:27:00	1,229.4	26,211	942	36,697	5,227	1,481
2	20-Sep-15	22:28:00	1,115.2	26,622	958	38,383	5,776	1,414
2	20-Sep-15	22:29:00	1,060.8	27,152	931	38,471	5,737	1,469
2	20-Sep-15	22:30:00	1,070.1	27,702	1,004	38,223	5,178	1,504
2	20-Sep-15	22:31:00	1,124.9	28,278	960	38,978	5,427	1,568
2	20-Sep-15	22:32:00	1,179.4	28,667	979	41,618	5,321	1,532
2	20-Sep-15	22:33:00	1,107.3	28,690	1,005	38,920	5,269	1,607
2	20-Sep-15	22:34:00	1,109.4	28,771	979	38,926	5,034	1,602

Boiler	Date	Time	Data-logger	DCS Data				
			Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
2	20-Sep-15	22:35:00	1,174.2	28,983	983	38,739	5,336	1,605
2	20-Sep-15	22:36:00	1,193.1	29,427	987	38,615	5,734	1,639
2	20-Sep-15	22:37:00	1,145.1	28,901	987	38,471	5,775	1,681
2	20-Sep-15	22:38:00	1,154.5	29,137	992	37,807	5,209	1,715
2	20-Sep-15	22:39:00	1,176.7	28,656	946	37,813	5,213	1,708
2	20-Sep-15	22:40:00	1,170.9	28,441	984	37,849	5,797	1,737
2	20-Sep-15	22:41:00	1,185.3	27,847	988	37,957	5,742	1,737
2	20-Sep-15	22:42:00	1,164.8	27,708	1,010	37,190	5,697	1,718
2	20-Sep-15	22:43:00	1,215.1	27,512	962	37,632	5,232	1,683
2	20-Sep-15	22:44:00	1,123.5	27,719	979	37,772	5,164	1,710
2	20-Sep-15	22:45:00	1,160.8	27,552	956	37,998	5,703	1,715
2	20-Sep-15	22:46:00	1,219.2	27,540	984	37,469	5,745	1,696
2	20-Sep-15	22:47:00	1,242.2	27,417	987	40,710	4,450	1,620
2	20-Sep-15	22:48:00	1,206.5	27,245	943	38,311	5,163	1,658
2	20-Sep-15	22:49:00	1,218.3	26,931	935	38,265	5,199	1,692
2	20-Sep-15	22:50:00	1,203.9	27,002	937	38,339	5,758	1,688
2	20-Sep-15	22:51:00	1,212.2	26,826	972	38,283	5,760	1,689
2	20-Sep-15	22:52:00	1,175.0	27,000	982	37,540	5,081	1,730
2	20-Sep-15	22:53:00	1,132.4	26,788	981	37,557	5,008	1,694
2	20-Sep-15	22:54:00	1,176.8	26,679	912	38,340	5,445	1,653
2	20-Sep-15	22:55:00	1,127.8	26,507	947	37,844	5,897	1,648
2	20-Sep-15	22:56:00	1,155.9	26,501	935	37,194	5,310	1,644
2	20-Sep-15	22:57:00	1,131.7	26,408	896	37,606	5,105	1,678
2	20-Sep-15	22:58:00	1,115.1	26,352	907	37,526	5,148	1,649
2	20-Sep-15	22:59:00	1,135.1	26,265	882	37,461	5,708	1,649
2	20-Sep-15	23:00:00	1,152.1	26,250	927	37,296	5,659	1,681
2	20-Sep-15	23:01:00	1,182.4	26,419	927	37,203	5,395	1,675
2	20-Sep-15	23:02:00	1,189.2	26,682	895	40,370	4,892	1,609
2	20-Sep-15	23:03:00	1,134.6	27,135	924	37,777	5,026	1,669
2	20-Sep-15	23:04:00	1,126.4	26,954	912	38,094	5,643	1,700
2	20-Sep-15	23:05:00	1,123.6	26,947	908	37,813	5,572	1,663
2	20-Sep-15	23:06:00	1,127.0	27,444	909	37,555	5,294	1,667
2	20-Sep-15	23:07:00	1,172.6	27,048	918	37,555	5,675	1,637
2	20-Sep-15	23:08:00	1,216.3	27,198	914	37,636	5,694	1,651
2	20-Sep-15	23:09:00	1,218.5	27,084	923	37,364	5,659	1,657
2	20-Sep-15	23:10:00	1,243.0	26,941	912	37,216	5,740	1,658
2	20-Sep-15	23:11:00	1,228.6	27,300	948	38,065	5,095	1,690
2	20-Sep-15	23:12:00	1,250.7	27,235	949	37,820	5,041	1,707
2	20-Sep-15	23:13:00	1,234.5	27,116	972	37,572	5,488	1,650
2	20-Sep-15	23:14:00	1,240.6	27,350	952	37,709	5,433	1,684
2	20-Sep-15	23:15:00	1,264.8	27,550	939	37,897	5,693	1,682
2	20-Sep-15	23:16:00	1,228.0	27,997	946	38,625	5,113	1,652
2	20-Sep-15	23:17:00	1,229.4	26,570	929	40,944	5,170	1,652
2	20-Sep-15	23:18:00	1,251.0	27,884	955	38,380	5,470	1,670
2	20-Sep-15	23:19:00	1,226.6	27,898	967	37,694	5,706	1,710
2	20-Sep-15	23:20:00	1,223.2	27,840	969	38,450	5,423	1,673
2	20-Sep-15	23:21:00	1,274.8	28,791	945	38,365	5,164	1,645
2	20-Sep-15	23:22:00	1,290.9	28,174	963	37,556	5,299	1,675
2	20-Sep-15	23:23:00	1,278.1	28,043	932	37,857	5,952	1,687

Boiler	Date	Time	Data-logger	DCS Data				
			Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr
	Start	*End*	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL
2	20-Sep-15	23:24:00	1,268.7	27,732	947	38,756	5,793	1,690
2	20-Sep-15	23:25:00	1,219.4	27,650	922	38,064	5,741	1,685
2	20-Sep-15	23:26:00	1,221.5	27,972	952	37,697	5,265	1,681
2	20-Sep-15	23:27:00	1,189.5	28,156	933	37,697	5,141	1,706
2	20-Sep-15	23:28:00	1,214.3	27,736	938	37,601	5,875	1,672
2	20-Sep-15	23:29:00	1,182.8	27,736	989	37,638	5,795	1,710
2	20-Sep-15	23:30:00	1,228.7	27,700	992	37,536	5,161	1,710
2	20-Sep-15	23:31:00	1,142.0	28,153	938	38,037	5,266	1,726
2	20-Sep-15	23:32:00	1,155.1	28,474	1,005	40,956	5,866	1,626
2	20-Sep-15	23:33:00	1,161.9	28,495	967	38,488	5,764	1,691
2	20-Sep-15	23:34:00	1,183.3	28,891	995	38,264	5,437	1,710
2	20-Sep-15	23:35:00	1,166.5	28,364	932	38,531	5,268	1,713
2	20-Sep-15	23:36:00	1,167.3	28,172	965	38,134	5,111	1,678
2	20-Sep-15	23:37:00	1,170.1	27,769	950	38,244	5,963	1,708
2	20-Sep-15	23:38:00	1,208.0	27,832	983	37,973	5,716	1,717
2	20-Sep-15	23:39:00	1,184.0	28,109	980	37,916	5,215	1,718
2	20-Sep-15	23:40:00	1,166.0	27,771	978	39,472	5,160	1,686
2	20-Sep-15	23:41:00	1,199.1	27,775	972	37,972	5,549	1,696
2	20-Sep-15	23:42:00	1,162.0	28,468	911	37,959	5,931	1,694
2	20-Sep-15	23:43:00	1,114.5	27,709	938	38,113	5,838	1,730
2	20-Sep-15	23:44:00	1,132.2	28,019	938	38,099	5,187	1,702
2	20-Sep-15	23:45:00	1,164.8	27,405	903	37,896	5,168	1,673
2	20-Sep-15	23:46:00	1,104.4	27,070	930	38,532	5,614	1,648
2	20-Sep-15	23:47:00	1,141.6	26,869	939	41,584	5,360	1,613
2	20-Sep-15	23:48:00	1,112.3	26,777	908	38,840	5,524	1,674
2	20-Sep-15	23:49:00	1,125.7	26,934	926	38,583	5,146	1,636
2	20-Sep-15	23:50:00	1,133.2	27,863	941	38,246	5,565	1,669
2	20-Sep-15	23:51:00	1,160.9	27,415	911	38,960	5,700	1,671
2	20-Sep-15	23:52:00	1,111.6	27,396	941	38,528	5,908	1,640
2	20-Sep-15	23:53:00	1,119.6	27,523	918	38,131	5,310	1,671
2	20-Sep-15	23:54:00	1,108.7	27,726	943	37,986	5,092	1,705
2	20-Sep-15	23:55:00	1,098.1	27,772	935	38,123	5,753	1,673
2	20-Sep-15	23:56:00	1,109.8	27,391	952	38,097	5,884	1,674
2	20-Sep-15	23:57:00	1,197.0	27,734	984	38,775	5,800	1,669
2	20-Sep-15	23:58:00	1,155.6	28,525	988	38,562	5,183	1,700
2	20-Sep-15	23:59:00	1,179.5	28,326	943	38,660	5,758	1,706
2	21-Sep-15	0:00:00	1,202.8	28,310	1,006	39,046	5,942	1,706

Residence Time and Temperature Correlation
Proces Data Summary

Boiler	Start	End	Process Parameter	Roof Temperature 1	Roof Temperature 2	Roof Temperature 3	Roof Temperature Average	Heated Combustion Air Temperature	Ambient Air Temperature	Tertiary Gas Temperature	Main Steam Temperature	Main Steam Pressure	Economizer Exit Gas Temperature	Furnace Sidewall Temperature Left	Furnace Sidewall Temperature Right	Economizer Exit O2, wet
			Units	°C	°C	°C	°C	°C	°C	°C	°C	bar	°C	°C	°C	%
1	9/22/15 2:00 PM	9/22/15 2:59 PM		841	854	767	821	77.0	27.4	149	503	89.3	164.6	976	1004	8.0
1	9/22/15 3:00 PM	9/22/15 3:59 PM		842	851	760	818	77.4	28.2	149	497	89.3	164.2	939	939	8.6
1	9/22/15 4:00 PM	9/22/15 4:59 PM		846	860	764	824	78.7	29.0	146	501	89.3	161.1	952	952	9.2
			Average	**843**	**855**	**764**	**821**	**77.7**	**28.2**	**148**	**500**	**89.3**	**163.3**	**956**	**965**	**8.6**
1	9/20/15 3:00 PM	9/20/15 3:59 PM		762	755	686	734	75.4	25.3	111	488	89.0	161.5	849	1023	9.5
1	9/20/15 4:00 PM	9/20/15 4:59 PM		772	766	690	743	79.1	26.5	113	484	89.0	162.8	857	1037	9.1
1	9/20/15 5:00 PM	9/20/15 5:59 PM		779	772	698	750	82.1	27.2	119	475	89.0	163.0	885	1051	9.4
			Average	**771**	**764**	**691**	**742**	**78.9**	**26.3**	**115**	**482**	**89.0**	**162.4**	**864**	**1037**	**9.3**
2	9/22/15 1:00 AM	9/22/15 1:59 AM		797		682	740	64.5	23.2	125	500	89.3	164.4	981	BAD	7.7
2	9/22/15 2:00 AM	9/22/15 2:59 AM		796		687	741	64.1	23.1	130	498	89.3	166.4	950	867	7.8
2	9/22/15 3:00 AM	9/22/15 3:59 AM		785		675	730	64.0	23.2	123	496	89.3	166.2	942	BAD	9.0
			Average	**793**	BAD	**681**	**737**	**64.2**	**23.1**	**126**	**498**	**89.3**	**165.7**	**958**	**867**	**8.2**
2	9/20/15 9:00 PM	9/20/15 9:59 PM		743		647	695	66.0	25.4	116	482	89.0	164.9	871	1340	9.2
2	9/20/15 10:00 PM	9/20/15 10:59 PM		749		652	701	66.3	24.9	122	480	89.0	163.6	872	1168	8.2
2	9/20/15 11:00 PM	9/20/15 11:59 PM		756		662	709	66.1	24.4	127	482	88.9	163.9	872	1141	8.0
			Average	**749**		**654**	**702**	**66.1**	**24.9**	**122**	**481**	**89.0**	**164.1**	**872**	**1216**	**8.5**

	Date		22-Sep-15	22-Sep-15	22-Sep-15	
	Time	Start	2:00 PM	3:00 PM	4:00 PM	
	Time	End	2:59 PM	3:59 PM	4:59 PM	
	Units	Range Name	Value	Value	Value	
Constants			Run 1	Run 2	Run 3	
Elev of OFA ports	m	E_OFA	13.80	13.80	13.80	
Elev of Test IP	m	E_Lwr_IP	16.589	16.589	16.589	
Elev of Continuous IP	m	E_Upr_IP	19.25	19.25	19.25	
Combustion Constant	%	K_c	1.152	1.152	1.152	
Furnace Depth	m	furn_depth	4.267	4.267	4.267	
Furnace Width	m	furn_width	4.267	4.267	4.267	
Reference Air Temperature	°C	T_AIR_REF	25.0	25.0	25.0	
False Air Flow	Nm^3/h	Q_False_C	1.05	1.05	1.05	**Percent of Q_TOT**
Measured Inputs						
Test Infra-red Pyrometer (IP)	°C	T_Lwr_IP	**1218.7**	**1222.2**	**1244.0**	
Continuous Temperature IP	°C	T_Upr_IP	**1058.7**	**1042.6**	**1030.3**	
Total Air Flow	Rm^3/h	Q_TOT	**41,477**	**41,310**	**40,970**	
Seal Air Flow	Rm^3/h	Q_SEAL	**1,868**	**1,837**	**1,821**	
IGR Flow	Rm^3/h	Q_IGR	**2,277**	**2,324**	**2,280**	
Calculations						**Formulae**
Furnace Temperature Gradient	°C/m	∇T_per_m	60.1	67.5	80.3	(T_Lwr_IP-T_Upr_IP)/(E_Upr_IP-E_Lwr_IP)
Temperature at OFA Elev	°C	T_OFA	1386.4	1410.5	1468.1	T_Lwr_IP+∇T_per_m*(E_Lwr_IP-E_OFA)
		P	46470.479	46233.229	45882.29	(1.05*Q_TOT-Q_IGR-0.5*Q_SEAL)*K_c
		R	298.16	298.16	298.16	273.16+T_AIR_REF
Temperature at 1-sec elev.	°C	T_1SEC	***1165.0***	***1161.5***	***1168.0***	∇T_per_m/(furn_depth*furn_width*3600)*(P_/R_*273.16+P_*T_OFA/2/R_))/(1+∇T_per
Average 1-Second Zone Temp	°C	T_C avg	1275.7	1286.0	1318.0	(T_OFA+T_1SEC)/2
Average 1-Second Zone Flow	actual m3/hr	Q_C	241,397	241,760	244,860	(1.05*Q_TOT-Q_IGR-0.5*Q_SEAL)*K_c*(273.16+T_C avg)/(273.16+T_AIR_REF)
Average 1-Second Zone Velocity	actual m/sec	V_C	3.68	3.69	3.74	Q_C/(furn_depth*furn_width)/3600
1-second elevation	m	E_1SEC	17.48	17.49	17.54	E_OFA+V_C*1
Minimum Continous Monitored Temp.	°C	$T\_Upr\_IP_{MIN}$	893.8	881.1	862.3	T_Upr_IP-(T_1SEC-1000)
Correlation Correction Factor	°C	Fc	106.2	118.9	137.7	T_1SEC - T_Upr_IP

Notes: All measured air flows in DCS are "Referenced" to 25°C & 1013.25 mbar
Combustion zone flue gas flow assumes:
5% of Total air added as False/tramp air.
Only 50% of Seal air enters combustion zone.
No "Fresh" air enters VLN system.

	Units	Range Name	20-Sep-15 3:00 PM 3:59 PM Value Run 1	20-Sep-15 4:00 PM 4:59 PM Value Run 2	20-Sep-15 5:00 PM 5:59 PM Value Run 3	
Constants						
Elev of OFA ports	m	E_OFA	13.80	13.80	13.80	
Elev of Test IP	m	E_Lwr_IP	16.589	16.589	16.589	
Elev of Continuous IP	m	E_Upr_IP	19.25	19.25	19.25	
Combustion Constant	%	K_c	1.152	1.152	1.152	
Furnace Depth	m	furn_depth	4.267	4.267	4.267	
Furnace Width	m	furn_width	4.267	4.267	4.267	
Reference Air Temperature	°C	T_AIR_REF	25.0	25.0	25.0	
False Air Flow	Nm^3/h	Q_False_C	1.05	1.05	1.05	**Percent of Q_TOT**
Measured Inputs						
Test Infra-red Pyrometer (IP)	°C	T_Lwr_IP	**1140.4**	**1227.2**	**1200.6**	
Continuous Temperature IP	°C	T_Upr_IP	**970.6**	**991.2**	**993.0**	
Total Air Flow	Rm^3/h	Q_TOT	**33,295**	**33,461**	**33,118**	
Seal Air Flow	Rm^3/h	Q_SEAL	**1,797**	**1,780**	**1,830**	
IGR Flow	Rm^3/h	Q_IGR	**2,627**	**2,513**	**2,557**	
Calculations						**Formulae**
Furnace Temperature Gradient	°C/m	∇T_per_m	63.8	88.7	78.0	(T_Lwr_IP-T_Upr_IP)/(E_Upr_IP-E_Lwr_IP)
Temperature at OFA Elev	°C	T_OFA	1318.5	1474.5	1418.2	T_Lwr_IP+∇T_per_m*(E_Lwr_IP-E_OFA)
		P	36212.708	36553.563	36059.536	(1.05*Q_TOT-Q_IGR-0.5*Q_SEAL)*K_c
		R	298.16	298.16	298.16	273.16+T_AIR_REF
Temperature at 1-sec elev.	°C	T_1SEC	***1140.7***	***1206.8***	***1191.1***	∇T_per_m/(furn_depth*furn_width*3600)*(P_/R_*273.16+P_*T_OFA/2/R_))/(1+∇T_per_m/(furn_depth*furn_width*3600)*P_/(2*R_))
Average 1-Second Zone Temp	°C	T_C avg	1229.6	1340.7	1304.7	(T_OFA+T_1SEC)/2
Average 1-Second Zone Flow	actual m3/hr	Q_C	182,514	197,850	190,822	(1.05*Q_TOT-Q_IGR-0.5*Q_SEAL)*K_c*(273.16+T_C avg)/(273.16+T_AIR_REF)
Average 1-Second Zone Velocity	actual m/sec	V_C	2.78	3.02	2.91	Q_C/(furn_depth*furn_width)/3600
1-second elevation	m	E_1SEC	16.58	16.82	16.71	E_OFA+V_C*1
Minimum Continous Monitored Temp.	°C	$T\_Upr\_IP_{MIN}$	829.9	784.4	801.9	T_Upr_IP-(T_1SEC-1000)
Correlation Correction Factor	°C	Fc	170.1	215.6	198.1	T_1SEC - T_Upr_IP

Notes:
All measured air flows in DCS are "Referenced" to 25°C & 1013.25 mbar
Combustion zone flue gas flow assumes:
5% of Total air added as False/tramp air.
Only 50% of Seal air enters combustion zone.
No "Fresh" air enters VLN system.

	Date		22-Sep-15	22-Sep-15	22-Sep-15	
	Time	Start	1:00 AM	2:00 AM	3:00 AM	
	Time	End	1:59 AM	2:59 AM	3:59 AM	
	Units	Range Name	Value	Value	Value	
Constants			Run 1	Run 2	Run 3	
Elev of OFA ports	m	E_OFA	13.80	13.80	13.80	
Elev of Test IP	m	E_Lwr_IP	16.589	16.589	16.589	
Elev of Continuous IP	m	E_Upr_IP	19.25	19.25	19.25	
Combustion Constant	%	K_c	1.152	1.152	1.152	
Furnace Depth	m	furn_depth	4.267	4.267	4.267	
Furnace Width	m	furn_width	4.267	4.267	4.267	
Reference Air Temperature	°C	T_AIR_REF	25.0	25.0	25.0	
False Air Flow	Nm^3/h	Q_False_C	1.05	1.05	1.05	**Percent of Q_TOT**
Measured Inputs						
Test Infra-red Pyrometer (IP)	°C	T_Lwr_IP	**1241.9**	**1219.8**	**1222.7**	
Continuous Temperature IP	°C	T_Upr_IP	**988.9**	**1004.0**	**969.9**	
Total Air Flow	Rm^3/h	Q_TOT	**45,172**	**46,412**	**46,142**	
Seal Air Flow	Rm^3/h	Q_SEAL	**1,608**	**1,584**	**1,574**	
IGR Flow	Rm^3/h	Q_IGR	**7,124**	**7,347**	**7,327**	
Calculations						**Formulae**
Furnace Temperature Gradient	°C/m	∇T_per_m	95.1	81.1	95.0	(T_Lwr_IP-T_Upr_IP)/(E_Upr_IP-E_Lwr_IP)
Temperature at OFA Elev	°C	T_OFA	1507.1	1445.9	1487.7	T_Lwr_IP+∇T_per_m*(E_Lwr_IP-E_OFA)
		P	45507.05	46763.219	46465.982	(1.05*Q_TOT-Q_IGR-0.5*Q_SEAL)*K_c
		R	298.16	298.16	298.16	273.16+T_AIR_REF
Temperature at 1-sec elev.	°C	T_1SEC	***1152.2***	***1141.9***	***1130.3***	∇T_per_m/(furn_depth*furn_width*3600)*(P_/R_*273.16+P_*T_OFA/2/R_))/(1+∇T_per_m/(furn_depth*furn_width*3600)*P_/(2*R_))
Average 1-Second Zone Temp	°C	T_C avg	1329.7	1293.9	1309.0	(T_OFA+T_1SEC)/2
Average 1-Second Zone Flow	actual m3/hr	Q_C	244,632	245,772	246,571	(1.05*Q_TOT-Q_IGR-0.5*Q_SEAL)*K_c*(273.16+T_C avg)/(273.16+T_AIR_REF)
Average 1-Second Zone Velocity	actual m/sec	V_C	3.73	3.75	3.76	Q_C/(furn_depth*furn_width)/3600
1-second elevation	m	E_1SEC	17.53	17.55	17.56	E_OFA+V_C*1
Minimum Continous Monitored Temp.	°C	$T\_Upr\_IP_{MIN}$	836.7	862.1	839.6	T_Upr_IP-(T_1SEC-1000)
Correlation Correction Factor	°C	Fc	163.3	137.9	160.4	T_1SEC - T_Upr_IP

Notes:
All measured air flows in DCS are "Referenced" to 25°C & 1013.25 mbar
Combustion zone flue gas flow assumes:
5% of Total air added as False/tramp air.
Only 50% of Seal air enters combustion zone.
No "Fresh" air enters VLN system.

Sample Calculations

	Units	Range Name	20-Sep-15 9:00 PM 9:59 PM Value Run 1	20-Sep-15 10:00 PM 10:59 PM Value Run 2	20-Sep-15 11:00 PM 11:59 PM Value Run 3	
Constants						
Elev of OFA ports	m	E_OFA	13.80	13.80	13.80	
Elev of Test IP	m	E_Lwr_IP	16.589	16.589	16.589	
Elev of Continuous IP	m	E_Upr_IP	19.25	19.25	19.25	
Combustion Constant	%	K_c	1.152	1.152	1.152	
Furnace Depth	m	furn_depth	4.267	4.267	4.267	
Furnace Width	m	furn_width	4.267	4.267	4.267	
Reference Air Temperature	°C	T_AIR_REF	25.0	25.0	25.0	
False Air Flow	Nm^3/h	Q_False_C	1.05	1.05	1.05	**Percent of Q_TOT**
Measured Inputs						
Test Infra-red Pyrometer (IP)	°C	T_Lwr_IP	**1179.2**	**1159.9**	**1182.8**	
Continuous Temperature IP	°C	T_Upr_IP	**954.2**	**950.5**	**943.6**	
Total Air Flow	Rm^3/h	Q_TOT	**40,082**	**38,416**	**38,258**	
Seal Air Flow	Rm^3/h	Q_SEAL	**1,631**	**1,641**	**1,679**	
IGR Flow	Rm^3/h	Q_IGR	**5,863**	**5,496**	**5,485**	
Calculations						**Formulae**
Furnace Temperature Gradient	°C/m	∇T_per_m	84.5	78.7	89.9	(T_Lwr_IP-T_Upr_IP)/(E_Upr_IP-E_Lwr_IP)
Temperature at OFA Elev	°C	T_OFA	1414.9	1379.4	1433.4	T_Lwr_IP+∇T_per_m*(E_Lwr_IP-E_OFA)
		P	40789.808	39190.505	38990.921	(1.05*Q_TOT-Q_IGR-0.5*Q_SEAL)*K_c
		R	298.16	298.16	298.16	273.16+T_AIR_REF
Temperature at 1-sec elev.	°C	T_1SEC	***1141.3***	***1137.7***	***1152.6***	∇T_per_m/(furn_depth*furn_width*3600)*(P_/R_*273.16+P_*T_OFA/2/R_))/(1+∇T_per_m/(furn_depth*furn_width*3600)*P_/(2*R_))
Average 1-Second Zone Temp	°C	T_C avg	1278.1	1258.5	1293.0	(T_OFA+T_1SEC)/2
Average 1-Second Zone Flow	actual m3/hr	Q_C	212,220	201,329	204,813	(1.05*Q_TOT-Q_IGR-0.5*Q_SEAL)*K_c*(273.16+T_C avg)/(273.16+T_AIR_REF)
Average 1-Second Zone Velocity	actual m/sec	V_C	3.24	3.07	3.12	Q_C/(furn_depth*furn_width)/3600
1-second elevation	m	E_1SEC	17.04	16.87	16.92	E_OFA+V_C*1
Minimum Continous Monitored Temp.	°C	$T\_Upr\_IP_{MIN}$	813.0	812.8	791.0	T_Upr_IP-(T_1SEC-1000)
Correlation Correction Factor	°C	Fc	187.0	187.2	209.0	T_1SEC - T_Upr_IP

Notes:
All measured air flows in DCS are "Referenced" to 25°C & 1013.25 mbar
Combustion zone flue gas flow assumes:
5% of Total air added as False/tramp air.
Only 50% of Seal air enters combustion zone.
No "Fresh" air enters VLN system.

Residence Time and Temperature Correlation Summary

			Data-logger	DCS Data						CALCULATIONS											
			Test IP	Steam Flow	Cont. Temp. IP	Total Air Flow	IGR Flow	Seal Air Flow	% MCR	Furnace Temperature Gradient	Temperature at OFA Elev			Temperature at 1-sec elev.	Average 1-Second Zone Temp	Average 1-Second Zone Flow	Average 1-Second Zone Velocity	1-second elevation	Minimum Continous Monitored Temp.		
			°C	kg/hr	°C	Rm3/hr	Rm3/hr	Rm3/hr	33,640	°C/m	°C			°C	°C	actual m3/hr	actual m/sec	m	°C		
Boiler	Start	End	T_Lwr_IP		T_Upr_IP	Q_TOT	Q_IGR	Q_SEAL		∇T_per_m	T_OFA	P	R	T_1SEC	T_C avg	Q_C	V_C	E_1SEC	$T\_Upr\_IP_{MIN}$	T_1SEC_{min}	$Fc = 1000 - T\_Upr\_IP_{MIN}$
1	9/22/15 2:00 PM	9/22/15 2:59 PM	1,219	33,295	1,059	41,477	2,277	1,868	**99.0%**	60.121	1386.4	46470	298.16	1165.0	1275.7	241397	3.68	17.483	893.8	1000.0	**106.2**
1	9/22/15 3:00 PM	9/22/15 3:59 PM	1,222	33,782	1,043	41,310	2,324	1,837	**100.4%**	67.504	1410.5	46233	298.16	1161.5	1286.0	241760	3.69	17.488	881.1	1000.0	**118.9**
1	9/22/15 4:00 PM	9/22/15 4:59 PM	1,244	33,683	1,030	40,970	2,280	1,821	**100.1%**	80.335	1468.1	45882	298.16	1168.0	1318.0	244860	3.74	17.536	862.3	1000.0	**137.7**
1	9/20/15 3:00 PM	9/20/15 3:59 PM	1,140	26,646	971	33,295	2,627	1,797	**79.2%**	63.833	1318.5	36213	298.16	1140.7	1229.6	182514	2.78	16.585	829.9	1000.0	**170.1**
1	9/20/15 4:00 PM	9/20/15 4:59 PM	1,227	27,163	991	33,461	2,513	1,780	**80.7%**	88.683	1474.5	36554	298.16	1206.8	1340.7	197850	3.02	16.818	784.4	1000.0	**215.6**
1	9/20/15 5:00 PM	9/20/15 5:59 PM	1,201	26,567	993	33,118	2,557	1,830	**79.0%**	78.013	1418.2	36060	298.16	1191.1	1304.7	190822	2.91	16.711	801.9	1000.0	**198.1**
AVG	9/22/15 1:00 AM	9/22/15 1:59 AM	1,242	33,012	989	45,172	7,124	1,608	**98.1%**	95.083	1507.1	45507	298.16	1152.2	1329.7	244632	3.73	17.532	836.7	1000.0	**163.3**
AVG	9/22/15 2:00 AM	9/22/15 2:59 AM	1,220	34,528	1,004	46,412	7,347	1,584	**102.6%**	81.074	1445.9	46763	298.16	1141.9	1293.9	245772	3.75	17.550	862.1	1000.0	**137.9**
AVG	9/22/15 3:00 AM	9/22/15 3:59 AM	1,223	32,895	970	46,142	7,327	1,574	**97.8%**	95.016	1487.7	46466	298.16	1130.3	1309.0	246571	3.76	17.562	839.6	1000.0	**160.4**
2	9/20/2015 21:00	9/20/2015 21:59	1,179	27,802	954	40,082	5,863	1,631	**82.6%**	84.531	1414.9	40790	298.16	1141.3	1278.1	212220	3.24	17.038	813.0	1000.0	**187.0**
2	9/20/2015 22:00	9/20/2015 22:59	1,160	27,496	951	38,416	5,496	1,641	**81.7%**	78.687	1379.4	39191	298.16	1137.7	1258.5	201329	3.07	16.872	812.8	1000.0	**187.2**
2	9/20/2015 23:00	9/20/2015 23:59	1,183	27,621	944	38,258	5,485	1,679	**82.1%**	89.873	1433.4	38991	298.16	1152.6	1293.0	204813	3.12	16.925	791.0	1000.0	**209.0**

TABLE 7

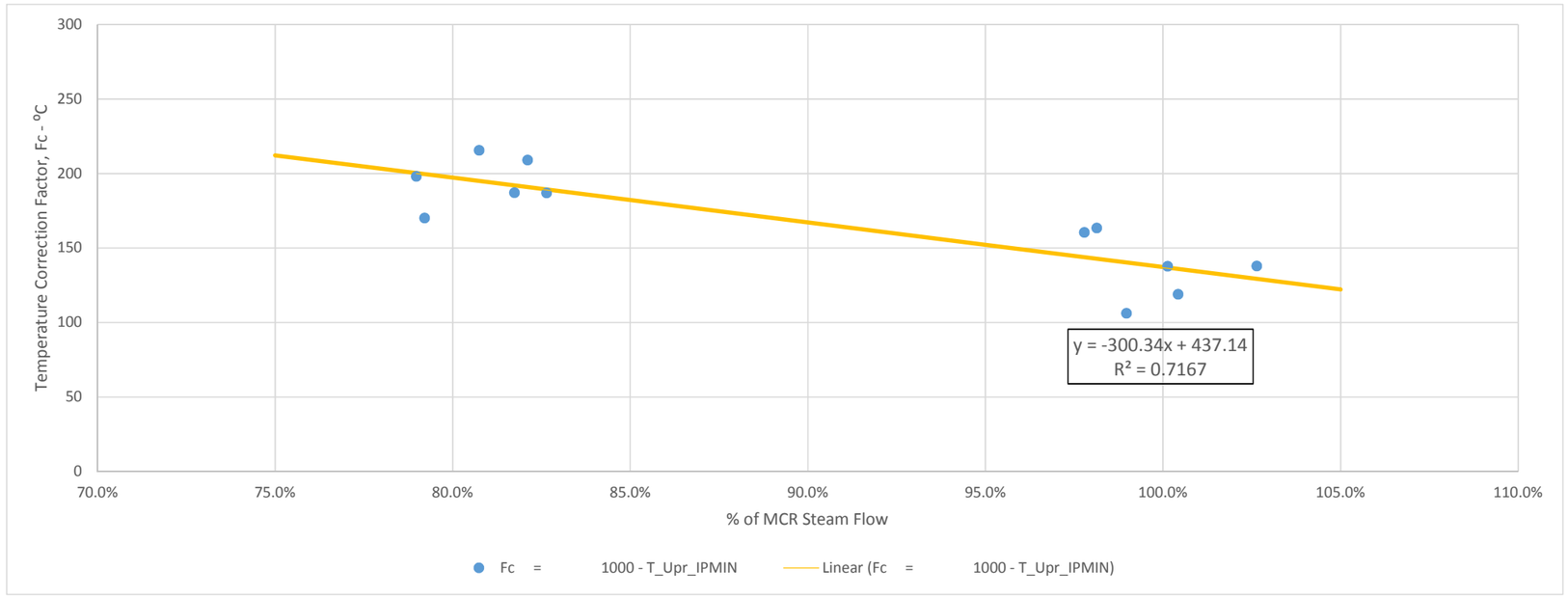


Figure 1

5.6.1 Test IP BOILER 1 Serial Number 704003

JNT Technical Services Inc.
85 Industrial Avenue, Little Ferry, New Jersey U.S.A. 07643

NIST Calibration Certificate

Description:	2-WIRE INFRARED TRANSMITTER	Certificate Number:	72720-704003-100714
Manufacturer:	JNT Technical Services Inc.		
Model:	F38TXSF4SF	Date of Calibration:	07 October 2014
Serial Number:	704003	Date Due:	07 October 2015
Customer Name:	Covanta, Morristown	Procedure Name:	NIST Manual Specifications

The instrument identified above was calibrated in accordance with applicable procedures. Its calibration processes are ISO-9001 controlled and are designed to certify that the instrument was within its published specifications at the time of calibration.
The measurement standards and instruments used during the calibration of this instrument are traceable to the United States National Institute of Standards and Technology (NIST), other reputable National Institutes, natural physical constants, consensus standards, or by ratio type measurements.
All measurements are made at point of reading on an N.I.S.T. Calibrated Black Body, and a 32°F Cold Bath, if applicable.

Technician: 15071 Standards# 11670, 11840

Unit Under Test

Model:	F38TXSF4SF	Range: 250 to 3000°F
Function:	Infrared Thermometer	121 to 1649°C

MEASURED VALUES			
As Found		As Left	
°C	°F	°C	°F
269.4	516.9	266.5	511.7
739.2	1362.6	748.8	1379.8
1184.0	2163.2	1200.0	2192.0

NOMINAL VALUES and LIMITS					
Nominal		Lower		Upper	
°C	°F	°C	°F	°C	°F
265.0	509.0	262.4	504.2	267.7	513.8
750.0	1382.0	742.5	1368.5	757.5	1395.5
1200.0	2192.0	1188.0	2170.4	1212.0	2213.6

5.6.2 TEST IP BOILER 2 Serial Number 122250

JNT Technical Services Inc.
85 Industrial Avenue, Little Ferry, New Jersey U.S.A. 07643

N.I.S.T.
Calibration Certificate

Description:	2-WIRE INFRARED TRANSMITTER	Certificate Number:	110112-12250-100714
Manufacturer:	JNT Technical Services Inc.		
Model:	F38TXSF4SF	Date of Calibration:	07 October 2014
Serial Number:	12250	Date Due:	07 October 2015
Customer Name:	Covanta, Tulsa	Procedure Name:	NIST Manual Specifications

The instrument identified above was calibrated in accordance with applicable procedures. Its calibration processes are ISO-9001 controlled and are designed to certify that the instrument was within its published specifications at the time of calibration.
The measurement standards and instruments used during the calibration of this instrument are traceable to the United States National Institute of Standards and Technology (NIST), other reputable National Institutes, natural physical constants, consensus standards, or by ratio type measurements.
All measurements are made at point of reading on an N.I.S.T. Calibrated Black Body, and a 32°F Cold Bath, if applicable.

Technician: 4561		Standards# 11670, 11840
Unit Under Test		
Model:	F38TXSF4SF	Range: 250 to 3000°F
Function:	Infrared Thermometer	121 to 1649°C

MEASURED VALUES			
As Found		As Left	
°C	°F	°C	°F
268.3	514.9	261.7	503.1
736.1	1357.0	747.8	1378.0
1180.0	2156.0	1199.0	2190.2

NOMINAL VALUES and LIMITS					
Nominal		Lower		Upper	
°C	°F	°C	°F	°C	°F
261.6	502.9	259.0	498.2	264.2	507.6
750.0	1382.0	742.5	1368.5	757.5	1395.5
1200.0	2192.0	1188.0	2170.4	1212.0	2213.6

5.6.3 PLANT CIP BOILER 1 Serial number 506261

JNT Technical Services Inc.
85 Industrial Avenue, Little Ferry, New Jersey U.S.A. 07643

NIST Calibration Certificate

Description:	2-WIRE INFRARED TRANSMITTER	Certificate Number:	56 0047- 506261
Manufacturer:	JNT Technical Services Inc.		
Model:	F38TXSF4SF	Date of Calibration:	27 July 2015
Serial Number:	506261	Date Due:	28 July 2016
Customer Name:	Covanta Durham York PO # DURYK-0000000124	Procedure Name:	NIST Manual Specifications

The instrument identified above was calibrated in accordance with applicable procedures. Its calibration processes are ISO-9001 controlled and are designed to certify that the instrument was within its published specifications at the time of calibration.
The measurement standards and instruments used during the calibration of this instrument are traceable to the United States National Institute of Standards and Technology (NIST), other reputable National Institutes, natural physical constants, consensus standards, or by ratio type measurements.
All measurements are made at point of reading on an N.I.S.T. Calibrated Black Body, and a 32°F Cold Bath, if applicable.

Technician: MR — Standards# 11670, 11840

Unit Under Test

Model:	F38TXSF4SF	Range: 250 to 3000°F
Function:	Infrared Thermometer	121 to 1649°C

MEASURED VALUES			
As Found		As Left	
°C	°F	°C	°F
	510		514
	1361		1360
	2194		2193

NOMINAL VALUES and LIMITS					
Nominal		Lower		Upper	
°C	°F	°C	°F	°C	°F
265.4	509.7	262.7	504.9	268.1	514.5
747.0	1376.6	739.5	1363.2	754.5	1390.0
1203.0	2197.4	1191.0	2175.7	1215.0	2219.1

5.6.4 PLANT CIP BOILER 2 Serial Number 506262

JNT Technical Services Inc.
85 Industrial Avenue, Little Ferry, New Jersey U.S.A. 07643

NIST Calibration Certificate

Description:	2-WIRE INFRARED TRANSMITTER	Certificate Number:	56 0048- 506262
Manufacturer:	JNT Technical Services Inc.		
Model:	F38TXSF4SF	Date of Calibration:	27 July 2015
Serial Number:	506262	Date Due:	28 July 2016
Customer Name:	Covanta Durham York PO # DURYK-0000000124	Procedure Name:	NIST Manual Specifications

The instrument identified above was calibrated in accordance with applicable procedures. Its calibration processes are ISO-9001 controlled and are designed to certify that the instrument was within its published specifications at the time of calibration.
The measurement standards and instruments used during the calibration of this instrument are traceable to the United States National Institute of Standards and Technology (NIST), other reputable National Institutes, natural physical constants, consensus standards, or by ratio type measurements.
All measurements are made at point of reading on an N.I.S.T. Calibrated Black Body, and a 32°F Cold Bath, if applicable.

Technician: MR — Standards# 11670, 11840

Unit Under Test

Model:	F38TXSF4SF	Range: 250 to 3000°F
Function:	Infrared Thermometer	121 to 1649°C

MEASURED VALUES			
As Found		As Left	
°C	°F	°C	°F
	510		511
	1361		1363
	2194		2194

NOMINAL VALUES and LIMITS					
Nominal		Lower		Upper	
°C	°F	°C	°F	°C	°F
265.4	509.7	262.7	504.9	268.1	514.5
747.0	1376.6	739.5	1363.2	754.5	1390.0
1203.0	2197.4	1191.0	2175.7	1215.0	2219.1