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BOILER ACCEPTANCE TESTS

CENTRAL HEATING PLANT, CFB OTTAWA NORTH

ROCKLIFFE, ONTARIO

JANUARY 14-15, 1975

by

A.C.S. Hayden and R.G. Fouhse

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INTRODUCTION

At the request of G. MacDonald, Utilities Officer, CFB Ottawa-North, Department of National Defence, staff of the Canadian Combustion Research Laboratory conducted performance tests on Boiler Number 2 of the Central Heating Plant of CFB Ottawa North. This boiler had originally been stoker-fired and had been converted to be fired by either No. 4 fuel oil or natural gas. The purpose of the tests was to measure the performance of the new firing systems with respect to contract specifications.

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DESCRIPTION OF EQUIPMENT

The Central Heating Plant of CFB Ottawa North is equipped with four watertube boilers, numbered 1 to 4. Details of manufacturer and ratings are as follows:

Boiler No. 1:	John Inglis	400 HP
Boiler No. 2:	Foster Wheeler	3100 lbs of steam/hr
Boiler No. 3 and No. 4:	Waterous	3100 lbs of steam/hr

The boiler layout with the numbering system as used for the tests is shown in Figure 1.

Boilers No. 1, 3 and 4 are equipped with Peabody Compower steam atomizing oil burners and natural gas burners. Boiler No. 2, on which these tests were carried out, is equipped with a Todd steam atomizing oil burner, designed to burn fuel oil not heavier than No. 2, and a natural gas burner. Details of the equipment are presented in Appendix A.

Automatic control is provided by a Bailey pneumatic system, with air as the master. For each boiler, steam flow is measured, recorded and integrated by an orifice meter and oil flow is monitored by an integrating displacement meter. A single integrating displacement meter measures the natural gas flow to the Plant.

FUEL ANALYSIS

A sample of the fuel oil was taken by CCRL staff during the tests and submitted for analysis to the Petroleum and Gas Laboratory of the Energy Research Laboratories, Canada Centre for Mineral and Energy Technology (CANMET), Department of Energy, Mines and Resources, Ottawa. The results are shown in in Table 1.

The gas supplier, Trans Canada Pipelines Ltd., provided a representative analysis of the natural gas as burned during the tests. This analysis is presented in Table 2.

DESCRIPTION OF TESTS AND RESULTS

Because the contract chiefly involved conversion of the firing equipment to both oil and natural gas firing, the tests were primarily aimed at evaluating boiler performance, but they were also intended to measure overall burner efficiency, to determine the nature of any operational limitations and to establish whether or not the automatic controls were suitably calibrated. For the test, the master-air control was held on manual to obtain the desired load conditions. The fuel flow was allowed to follow on automatic control, in order that the tests would duplicate actual boiler performance conditions. All tests were conducted under stabilized conditions, at loads roughly corresponding to 20%, 66% and 100% of the maximum continuous rating of the boiler. Conditions governing the load and excess air settings, as well as comments on the flame obtained, are summarized in Table 3, for each test.

During the tests, operating data were recorded at fifteen minute intervals, using the Plant instruments, with the following exceptions. Flue gas was monitored continuously by means of infra-red analyzers for CO_2 and CO and a paramagnetic analyzer for oxygen. As a check on the Plant instruments, flue gas temperature was measured with a chromel-alumel, multi-junction averaging thermocouple and a portable potentiometer. The temperatures of the combustion air and the ambient air were measured with mercury thermometers.

The average data recorded for each test, along with the calculated results, are presented in Table 4. Tables 5 to 11 show the heat balances and calculations for tests 1 to 7, respectively, in the ASME Short Form format. Figure 2 presents the efficiency curves for the boiler, for both oil and natural gas firing. On oil firing, the efficiencies average about 82% and on natural gas firing, 78%.

After the constant load tests for each fuel, the boiler was allowed to run from low fire to full load on automatic in a very short period of time (less than ten minutes). On gas firing no problem occurred. However, on oil firing, when the boiler reached full load, the firing rate began to hunt, and the burner cut out. It was found that the governing cam had been cut in such a way that it had a lip at the top end, and once this point was exceeded, the

burner could not return to a lower firing rate. The contractor was made aware of this defect and, before CCRL staff left, reset stops on the controls to prevent this point from being reached. The actual load where this occured was at a somewhat higher firing rate than the full load test conducted by CCRL, so that the test results apply completely.

DISCUSSION AND CONCLUSIONS

The converted boiler offers consistently good performance on both oil and gas firing. In particular, the performance on oil firing can be considered to be somewhat above average for this type of equipment.

The boiler pressure meter located on the main panel should be recalibrated, as it is consistently reading some 5 psig low. Similarly, the flue gas temperature sensing and recording device should be checked, as it is grossly in error on the low side.

It is recommended that serious consideration be given to the purchase of an oxygen monitoring instrument to measure the oxygen concentration in the flue gas. This, in conjunction with accurate flue gas temperature measurements, can give a rapid determination of boiler efficiency. In particular, paramagnetic oxygen analyzers have been found by CCRL staff to give the best results.

From time to time, checks by Plant staff should be performed on the boiler to ensure that the stops set up by the contractor that firing rate can not increase beyond the smooth region of the burner control cam, where return to lower firing is impossible, as described previously.

In conclusion, it appears that the conversion of these boilers has been carried out in accordance with good industrial practice. The burners themselves are robust in design, provide good control over the flame shape, have an acceptable turn-down ratio, and result in satisfactory boiler efficiencies.

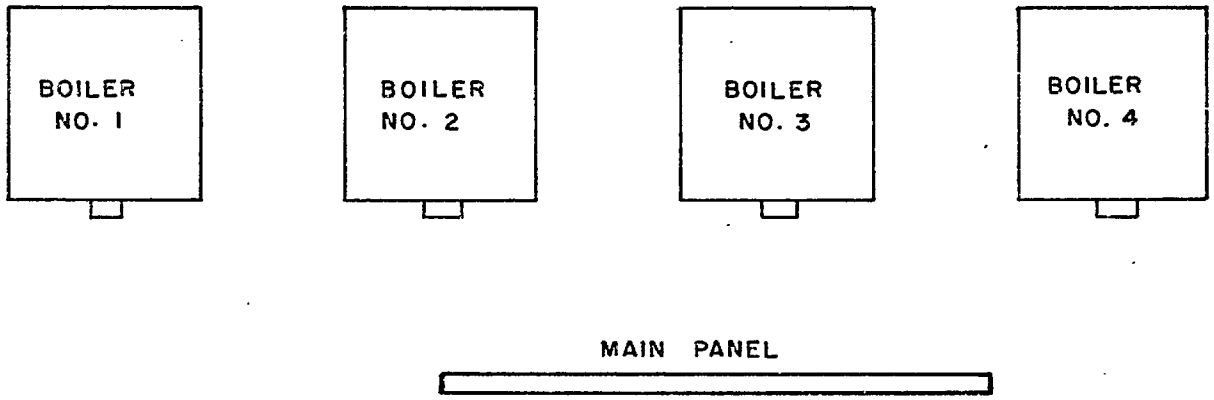

Figure 1. Boiler layout, CFB Ottawa North CHP

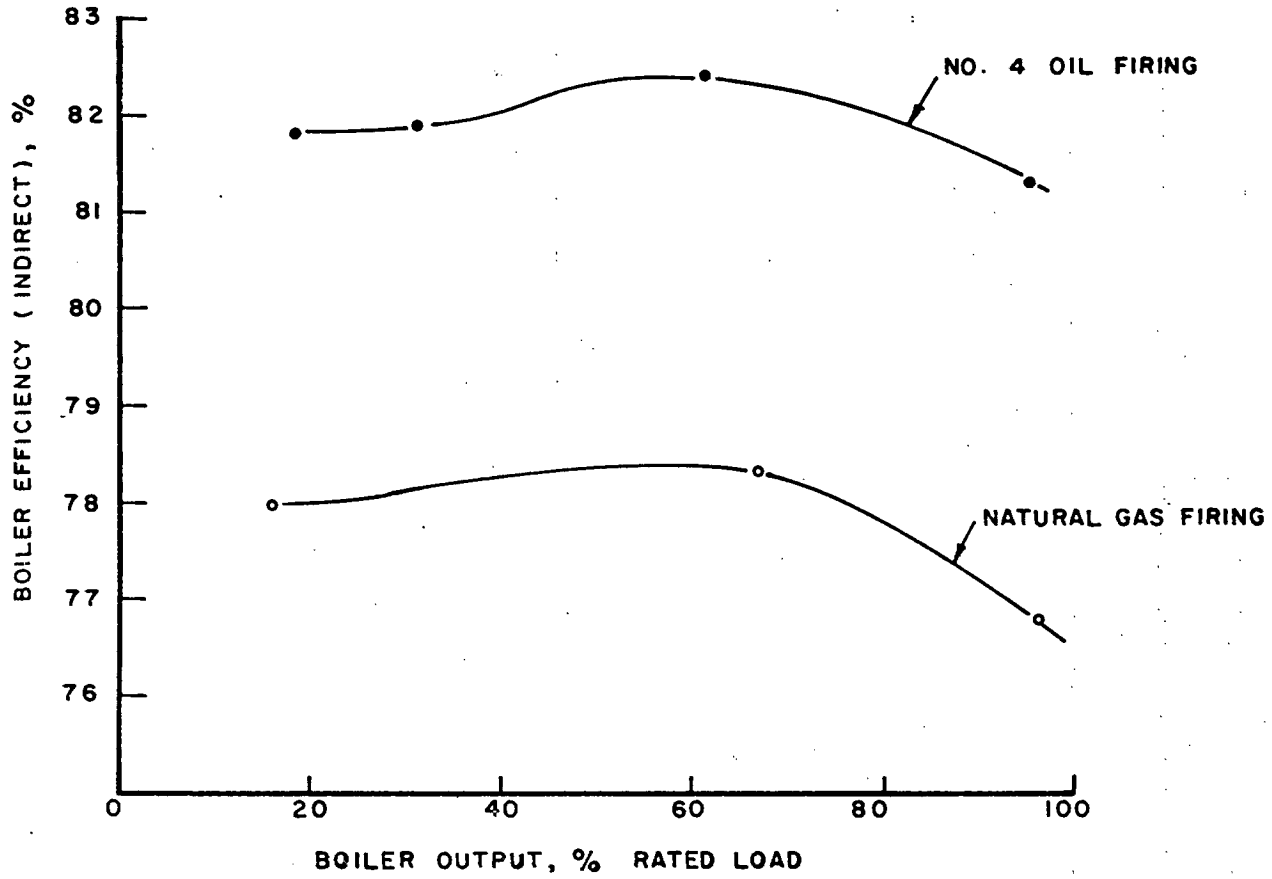

Figure 2. Boiler indirect efficiency versus output, Boiler No.2, CFB Ottawa North CHP

TABLE 1

Analysis[1/] of No. 4 Fuel Oil - CFB Ottawa North

Date:	January 15, 1975
Sample Number:	A004-75; 21-75
Specific Gravity, 60/60°F:	0.898
Viscosity at 122°F, cst:	10.21
Heat of Combustion, Btu/lb:	20,432
Carbon, % by weight:	86.37
Hydrogen, "	12.36
Nitrogen, "	0.11
Sulphur, "	1.14
Vanadium, ppm by weight:	107

[1/] *Analysis performed by the Petroleum and Gas Laboratory, Energy Research Laboratories, Canada Centre for Mineral and Energy Technology, Department of Energy, Mines and Resources, Ottawa.*

TABLE 2

Analysis[1/] of Natural Gas - CFB Ottawa North

Nitrogen, % by weight:	2.21
Carbon Dioxide, "	0.36
Methane, "	93.17
Ethane, "	4.14
Propane, "	0.15
Isobutane, "	0.01
N-butane, "	0.01
Total Sulphur, grains/100 ft^3:	0.15
Specific Gravity, 60/60°F:	0.588
Heat of Combustion, Btu/1000 ft^3:	1006

[1/] *Continuous analysis of natural gas supplied to Ottawa region by TransCanada Pipelines Ltd. over period January 13-17, 1975.*

TABLE 3

Summery of Test Conditions and Operating Limitations - Boiler No. 2

Test 1: 96% of rating. Natural gas firing. Air on manual, set at 100. Fuel on automatic. Good, clean, non luminous flame.

Test 2: 61% of rating. Natural gas firing. Air on manual, set at 55. Fuel on automatic. Good, clean, non luminous flame with some yellow traces at 10 o'clock.

Test 3: 16% of rating. Natural gas firing. Air on manual, set at 0. Fuel on automatic. Good flame with lazy yellow tips.

Test 4: 96% of rating. No. 4 oil firing. Air on manual set at 100. Fuel on automatic. Good, bright flame with no snow. Stack clear.

Test 5: 61% of rating. No. 4 oil firing. Air on manual, set at 55. Fuel on automatic. Good, bright flame. Stack clear.

Test 6: 31% of rating. No. 4 oil firing. Air on manual, set at 20. Fuel on automatic. Good, bright flame with some lazy tips. Stack clear.

Test 7: 18% of rating. No. 4 oil firing. Air on manual, set at 0. Fuel on automatic. Clean, lazy flame with little snow. Stack clear.

TABLE 4

Summary of Boiler Acceptance Test Data and Calculations - CFB Ottawa North - Boiler No. 2

Test No.	1	2	3	4	5	6	7
Fuel	Natural gas	Natural gas	Natural gas	No. 4 oil	No. 4 oil	No. 4 oil	No. 4 oil
Rated Capacity, k lb/hr	31	31	31	31	31	31	31
Date	14/1/75	14/1/75	14/1/75	15/1/75	15/1/75	15/1/75	15/1/75
Test Duration, hr	1	1	1	1	1	.5	.25
Steam Pressure, psig							
Drum, blr	132	130	125	126	124	121	121
Drum, panel	126	124	120	120	118	115	115
Header	126	126	125	120	120	120	120
Steam Flow, k lb/hr							
Indicated	29.0	20.6	4.9	30.1	19.7	9.9	5.3
Integrator	29.6	20.6	5.0	30.2	19.4	9.9	5.8
Corrected	29.75	20.70	5.0	29.60	19.01	9.70	5.68
% Rated Capacity	95.7	66.8	16.1	95.5	61.3	31.3	18.3
Air Flow, k lb/hr rel	28.0	20.0	5.1	28.6	20.6	12.9	6.4
Feedwater							
Temp., ^{o}F	216	216	217	217	202	204	212
Pressure, psig	165	168	170	160	161	166	166
Air Temperature, ^{o}F							
Ambient	74	75	75	72	74	75	75
Combustion	82	81	81	82	81	80	80
Flue Gas Temp., ^{o}F							
Panel	392	330	210	400	331	261	220
CCRL	607	517	353	633	535	435	370
F/D Control Setting	100	55	0	100	55	20	0

(cont'd)

TABLE 4 (cont'd)

Summary of Boiler Acceptance Test Data and Calculations - CFB Ottawa North - Boiler No. 2

Test No.	1	2	3	4	5	6	7
Supply Gas							
Temp., ^{o}F	35	35	35				
Pressure, psig	37.5	38.0	38.0				
Gas Flow,							
Timed, sec/100 ft^3	36.8	56.8	233				
Integrator, ft^3/hr	9783	6200	1600				
Gas Burner Press., psig	2.05	1.05	0.20				
Oil Flow							
Temperature				106	106	106	106
Timed, sec/gal				16.73	25.15	49.49	92.2
Integrator, k lb/hr x 10				215.2	143.4	72.8	39.1
Burner Press., psig							
Oil				78	58	34	22
Steam				95	77	51	37
Pressure, in. W.C.							
Windbox	6.1	2.6	0	5.9	2.4	0.4	0
Furnace	0.6	-0.2	-0.5	-0.5	-0.12	-0.5	-0.5
Upstake	-0.45	-0.55	-0.53	-0.39	-0.50	-0.55	-0.55
Flue Gas Analysis							
CO_2, % by vol.	10.5	10.4	9.7	13.9	13.3	11.0	11.1
CO, "	.04	.03	.02	-	.03	.03	.03
O_2, "	1.93	1.93	3.60	2.51	3.50	6.0	5.8
Excess Air, %	8.85	8.87	18.26	12.61	18.52	36.79	35.07

(cont'd)

TABLE 4 (Cont'd)

Summary of Boiler Acceptance Test Data and Calculations - CFB Ottawa North - Boiler No. 2

Test No.	1	2	3	4	5	6	7
Total Heat Input, k Btu/hr	-	-	-	43970	29290	14874	7989
Total Heat Output, k Btu/hr	30040	20890	5040	29837	19445	9899	5750
Direct Efficiency, %	-	-	-	67.86	66.39	66.55	71.97
Heat Balance (Losses)							
Dry gas loss, %	9.52	7.98	5.35	10.21	8.76	8.20	6.64
Hydrogen loss, %	12.23	11.83	11.11	7.09	6.84	6.59	6.42
CO loss, %	0.12	0.09	0.07	-	0.10	0.12	0.12
Radiation loss, %	0.90	1.30	5.00	0.90	1.40	2.70	4.50
Unmeasured losses, %	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Total losses, %	23.27	21.70	22.03	18.70	17.60	18.11	18.18
Indirect Efficiency, %	76.73	78.30	77.97	81.30	82.40	81.89	81.82

TABLE 5

ASME TEST FORM FOR ABBREVIATED EFFICIENCY TEST

SUMMARY SHEET — PTC 4.1-a (1964)

TEST NO. 1 — BOILER NO. 2 — DATE 14/1/75

OWNER OF PLANT: DND — LOCATION: CFB Ottawa North

TEST CONDUCTED BY: A.C.S. Hayden, R.G. Fouhse — OBJECTIVE OF TEST: Acceptance — DURATION: 1 hr

BOILER, MAKE & TYPE: Foster Wheeler — RATED CAPACITY: 31,000 lb/hr

STOKER, TYPE & SIZE:

PULVERIZER, TYPE & SIZE: — BURNER, TYPE & SIZE: Todd

FUEL USED: Natural Gas — MINE: — COUNTY: — STATE: — SIZE AS FIRED:

PRESSURES & TEMPERATURES

1	STEAM PRESSURE IN BOILER DRUM	psia	146.7
2	STEAM PRESSURE AT ~~XXXXXXXXXX~~ HDR	psia	140.7
3	STEAM PRESSURE AT R. H. INLET	psia	
4	STEAM PRESSURE AT R. H. OUTLET	psia	
5	STEAM TEMPERATURE AT S. H. OUTLET	F	
6	STEAM TEMPERATURE AT R.H. INLET	F	
7	STEAM TEMPERATURE AT R.H. OUTLET	F	
8	WATER TEMP. ENTERING (~~XXXX~~) (BOILER)	F	216
9	STEAM QUALITY % MOISTURE OR P. P. M.		
10	AIR TEMP. AROUND BOILER (AMBIENT)	F	74
11	TEMP. AIR FOR COMBUSTION (This is Reference Temperature) †	F	82
12	TEMPERATURE OF FUEL	F	35
13	GAS TEMP. LEAVING (Boiler) (~~XXXXXXXXXX~~)	F	607
14	GAS TEMP. ENTERING AH (If conditions to be corrected to guarantee)	F	

UNIT QUANTITIES

15	ENTHALPY OF SAT. LIQUID (TOTAL HEAT)	Btu/lb	
16	ENTHALPY OF (SATURATED) (~~XXXXXXXXXX~~) STM.	Btu/lb	1193.7
17	ENTHALPY OF SAT. FEED TO (BOILER) (~~XXXX~~)	Btu/lb	184.1
18	ENTHALPY OF REHEATED STEAM R.H. INLET	Btu/lb	
19	ENTHALPY OF REHEATED STEAM R. H. OUTLET	Btu/lb	
20	HEAT ABS/LB OF STEAM (ITEM 16 – ITEM 17)	Btu/lb	1009.6
21	HEAT ABS/LB R.H. STEAM (ITEM 19 – ITEM 18)	Btu/lb	
22	DRY REFUSE (ASH PIT + FLY ASH) PER LB AS FIRED FUEL	lb/lb	
23	Btu PER LB IN REFUSE (WEIGHTED AVERAGE)	Btu/lb	
24	CARBON BURNED PER LB AS FIRED FUEL	lb/lb	.7203
25	DRY GAS PER LB AS FIRED FUEL BURNED	lb/lb	16.95

HOURLY QUANTITIES

26	ACTUAL WATER EVAPORATED	lb/hr	29750
27	REHEAT STEAM FLOW	lb/hr	
28	RATE OF FUEL FIRING (AS FIRED wt)	lb/hr	
29	TOTAL HEAT INPUT $\frac{(\text{Item 28} \times \text{Item 41})}{1000}$	kB/hr	
30	HEAT OUTPUT IN BLOW-DOWN WATER	kB/hr	
31	TOTAL HEAT OUTPUT $\frac{(\text{Item 26} \times \text{Item 20}) + (\text{Item 27} \times \text{Item 21}) + \text{Item 30}}{1000}$	kB/hr	30040

FLUE GAS ANAL. (BOILER) (ECON) (AIR HTR) OUTLET

32	CO_2	% VOL	10.5
33	O_2	% VOL	1.93
34	CO	% VOL	.04
35	N_2 (BY DIFFERENCE)	% VOL	87.57
36	EXCESS AIR	%	8.85

FUEL DATA

	COAL AS FIRED PROX. ANALYSIS	% wt		OIL	
37	MOISTURE		51	FLASH POINT F*	
38	VOL MATTER		52	Sp. Gravity Deg. API*	
39	FIXED CARBON		53	VISCOSITY AT SSU* BURNER SSF	
40	ASH		44	TOTAL HYDROGEN % wt	
	TOTAL		41	Btu per lb	
41	Btu per lb AS FIRED				
42	ASH SOFT TEMP.* ASTM METHOD			GAS	% VOL
	COAL OR OIL AS FIRED ULTIMATE ANALYSIS		54	CO	
43	CARBON		55	CH_4 METHANE	93.17
44	HYDROGEN		56	C_2H_6	4.14
45	OXYGEN		57	C_3H_8	0.15
46	NITROGEN		58	C_4H_{10}	0.02
47	SULPHUR		59	Nitrogen	2.21
40	ASH		60	CO_2	0.36
37	MOISTURE		61		
	TOTAL			TOTAL	100.0
	COAL PULVERIZATION			TOTAL HYDROGEN % wt	23.65
48	GRINDABILITY INDEX*		62	DENSITY 68 F ATM. PRESS.	.588
49	FINENESS % THRU 50 M*		63	Btu PER CU FT	1006
50	FINENESS % THRU 200 M*		41	Btu PER LB	22438
64	INPUT-OUTPUT EFFICIENCY OF UNIT % $\frac{\text{ITEM 31} \times 100}{\text{ITEM 29}}$				

HEAT LOSS EFFICIENCY

		Btu/lb A. F. FUEL	% of A. F. FUEL
65	HEAT LOSS DUE TO DRY GAS	2135.70	9.52
66	HEAT LOSS DUE TO MOISTURE IN FUEL		
67	HEAT LOSS DUE TO H_2O FROM COMB. OF H_2	2743.76	12.23
68	HEAT LOSS DUE TO CO	27.77	0.12
69	HEAT LOSS DUE TO RADIATION		0.90
70	UNMEASURED LOSSES		0.50
71	TOTAL		23.27
72	EFFICIENCY = (100 – Item 71)		76.73

* Not Required for Efficiency Testing

† For Point of Measurement See Par. 7.2.8.1-PTC 4.1-1964

TABLE 6

SUMMARY SHEET

ASME TEST FORM FOR ABBREVIATED EFFICIENCY TEST

PTC 4.1-a (1964)

		TEST NO. 2	BOILER NO. 2 DATE 14/1/75
OWNER OF PLANT	DND	LOCATION	CFB Ottawa North
TEST CONDUCTED BY	A.C.S. Hayden, R.G. Fouhse	OBJECTIVE OF TEST	Acceptance DURATION 1 hr
BOILER, MAKE & TYPE	Foster Wheeler		RATED CAPACITY 31,000 lb/hr
STOKER, TYPE & SIZE			
PULVERIZER, TYPE & SIZE			BURNER, TYPE & SIZE Todd
FUEL USED	Natural Gas MINE	COUNTY	STATE SIZE AS FIRED

PRESSURES & TEMPERATURES

1	STEAM PRESSURE IN BOILER DRUM	psia	144.7
2	STEAM PRESSURE AT ~~XXXXXXXXXXX~~ HDR	psia	138.7
3	STEAM PRESSURE AT R. H. INLET	psia	
4	STEAM PRESSURE AT R. H. OUTLET	psia	
5	STEAM TEMPERATURE AT S. H. OUTLET	F	
6	STEAM TEMPERATURE AT R.H. INLET	F	
7	STEAM TEMPERATURE AT R.H. OUTLET	F	
8	WATER TEMP. ENTERING ~~(ECON)~~ (BOILER)	F	216
9	STEAM QUALITY % MOISTURE OR P. P. M.		
10	AIR TEMP. AROUND BOILER (AMBIENT)	F	75
11	TEMP. AIR FOR COMBUSTION (This is Reference Temperature) †	F	81
12	TEMPERATURE OF FUEL	F	35
13	GAS TEMP. LEAVING (Boiler) ~~(ECON) (AIR HTR)~~	F	517
14	GAS TEMP. ENTERING AH (If conditions to be corrected to guarantee)	F	

UNIT QUANTITIES

15	ENTHALPY OF SAT. LIQUID (TOTAL HEAT)	Btu/lb	
16	ENTHALPY OF (SATURATED) ~~(SUPERHEATED)~~ STM.	Btu/lb	1193.5
17	ENTHALPY OF SAT. FEED TO (BOILER) ~~(ECON)~~	Btu/lb	184.1
18	ENTHALPY OF REHEATED STEAM R.H. INLET	Btu/lb	
19	ENTHALPY OF REHEATED STEAM R. H. OUTLET	Btu/lb	
20	HEAT ABS/LB OF STEAM (ITEM 16 – ITEM 17)	Btu/lb	1009.4
21	HEAT ABS/LB R.H. STEAM (ITEM 19 – ITEM 18)	Btu/lb	
22	DRY REFUSE (ASH PIT + FLY ASH) PER LB AS FIRED FUEL	lb/lb	
23	Btu PER LB IN REFUSE (WEIGHTED AVERAGE)	Btu/lb	
24	CARBON BURNED PER LB AS FIRED FUEL	lb/lb	.7203
25	DRY GAS PER LB AS FIRED FUEL BURNED	lb/lb	17.11

HOURLY QUANTITIES

26	ACTUAL WATER EVAPORATED	lb/hr	20700
27	REHEAT STEAM FLOW	lb/hr	
28	RATE OF FUEL FIRING (AS FIRED wt)	lb/hr	
29	TOTAL HEAT INPUT $\frac{(\text{Item 28} \times \text{Item 41})}{1000}$	kB/hr	
30	HEAT OUTPUT IN BLOW-DOWN WATER	kB/hr	
31	TOTAL HEAT OUTPUT $\frac{(\text{Item 26} \times \text{Item 20}) + (\text{Item 27} \times \text{Item 21}) + \text{Item 30}}{1000}$	kB/hr	20890

FLUE GAS ANAL.. (BOILER) (ECON) (AIR HTR) OUTLET

32	CO_2	% VOL	10.4
33	O_2	% VOL	1.93
34	CO	% VOL	.03
35	N_2 (BY DIFFERENCE)	% VOL	87.64
36	EXCESS AIR	%	8.87

FUEL DATA

	COAL AS FIRED PROX. ANALYSIS	% wt
37	MOISTURE	
38	VOL MATTER	
39	FIXED CARBON	
40	ASH	
	TOTAL	
41	Btu per lb AS FIRED	
42	ASH SOFT TEMP.* ASTM METHOD	
	COAL OR OIL AS FIRED ULTIMATE ANALYSIS	
43	CARBON	
44	HYDROGEN	
45	OXYGEN	
46	NITROGEN	
47	SULPHUR	
40	ASH	
37	MOISTURE	
	TOTAL	

	COAL PULVERIZATION	
48	GRINDABILITY INDEX*	
49	FINENESS % THRU 50 M*	
50	FINENESS % THRU 200 M*	

	OIL	
51	FLASH POINT F*	
52	Sp. Gravity Deg. API*	
53	VISCOSITY AT SSU* BURNER SSF	
44	TOTAL HYDROGEN % wt	
41	Btu per lb	

	GAS	% VOL
54	CO	
55	CH_4 METHANE	93.17
56	C_2H_6	4.14
57	C_3H_8	0.15
58	C_2H_{10}	0.02
59	N_2 Nitrogen	2.21
60	CO_2	0.36
61	H_2 HYDROGEN	
	TOTAL	100.0
	TOTAL HYDROGEN % wt	23.65
62	DENSITY 68 F ATM. PRESS.	.588
63	Btu PER CU FT	1006
41	Btu PER LB	22438

64 INPUT-OUTPUT EFFICIENCY OF UNIT % $\frac{\text{ITEM 31} \times 100}{\text{ITEM 29}}$

HEAT LOSS EFFICIENCY

		Btu/lb A. F. FUEL	% of A. F. FUEL
65	HEAT LOSS DUE TO DRY GAS	1790.39	7.98
66	HEAT LOSS DUE TO MOISTURE IN FUEL		
67	HEAT LOSS DUE TO H_2O FROM COMB. OF H_2	2654.96	11.83
68	HEAT LOSS DUE TO CO	21.05	0.09
69	HEAT LOSS DUE TO RADIATION		1.30
70	UNMEASURED LOSSES		0.50
71	TOTAL		21.70
72	EFFICIENCY = (100 – Item 71)		78.30

* Not Required for Efficiency Testing

† For Point of Measurement See Par. 7.2.8.1-PTC 4.1-1964

TABLE 7

ASME TEST FORM FOR ABBREVIATED EFFICIENCY TEST

SUMMARY SHEET

PTC 4.1-a (1964)

TEST NO. 3 BOILER NO. 2 DATE 14/1/75

OWNER OF PLANT DND LOCATION CFB Ottawa North

TEST CONDUCTED BY A.C.S. Hayden, R.G. Fouhse OBJECTIVE OF TEST Acceptance DURATION 1 hr

BOILER, MAKE & TYPE Foster Wheeler RATED CAPACITY 31,000 lb/hr

STOKER, TYPE & SIZE

PULVERIZER, TYPE & SIZE BURNER, TYPE & SIZE Todd

FUEL USED Natural Gas MINE COUNTY STATE SIZE AS FIRED

PRESSURES & TEMPERATURES

1	STEAM PRESSURE IN BOILER DRUM	psia	139.7
2	STEAM PRESSURE AT ~~S. H. OUTLET~~ HDR	psia	134.7
3	STEAM PRESSURE AT R. H. INLET	psia	
4	STEAM PRESSURE AT R. H. OUTLET	psia	
5	STEAM TEMPERATURE AT S. H. OUTLET	F	
6	STEAM TEMPERATURE AT R.H. INLET	F	
7	STEAM TEMPERATURE AT R.H. OUTLET	F	
8	WATER TEMP. ENTERING ~~(ECON.)~~ (BOILER)	F	217
9	STEAM QUALITY % MOISTURE OR P.P.M.		
10	AIR TEMP. AROUND BOILER (AMBIENT)	F	75
11	TEMP. AIR FOR COMBUSTION (This is Reference Temperature) †	F	81
12	TEMPERATURE OF FUEL	F	35
13	GAS TEMP. LEAVING (Boiler) ~~(ECON) (AIR HTR)~~	F	353
14	GAS TEMP. ENTERING AH (If conditions to be corrected to guarantee)	F	

UNIT QUANTITIES

15	ENTHALPY OF SAT. LIQUID (TOTAL HEAT)	Btu/lb	
16	ENTHALPY OF (SATURATED) ~~(SUPERHEATED)~~ STM.	Btu/lb	1193.0
17	ENTHALPY OF SAT. FEED TO (BOILER) ~~(ECON.)~~	Btu/lb	185.1
18	ENTHALPY OF REHEATED STEAM R.H. INLET	Btu/lb	
19	ENTHALPY OF REHEATED STEAM R. H. OUTLET	Btu/lb	
20	HEAT ABS/LB OF STEAM (ITEM 16 – ITEM 17)	Btu/lb	1007.9
21	HEAT ABS/LB R.H. STEAM (ITEM 19 – ITEM 18)	Btu/lb	
22	DRY REFUSE (ASH PIT + FLY ASH) PER LB AS FIRED FUEL	lb/lb	
23	Btu PER LB IN REFUSE (WEIGHTED AVERAGE)	Btu/lb	
24	CARBON BURNED PER LB AS FIRED FUEL	lb/lb	.7203
25	DRY GAS PER LB AS FIRED FUEL BURNED	lb/lb	18.34

HOURLY QUANTITIES

26	ACTUAL WATER EVAPORATED	lb/hr	5000
27	REHEAT STEAM FLOW	lb/hr	
28	RATE OF FUEL FIRING (AS FIRED wt)	lb/hr	
29	TOTAL HEAT INPUT $\frac{(\text{Item } 28 \times \text{Item } 41)}{1000}$	kB/hr	
30	HEAT OUTPUT IN BLOW-DOWN WATER	kB/hr	
31	TOTAL HEAT OUTPUT $\frac{(\text{Item } 26 \times \text{Item } 20) + (\text{Item } 27 \times \text{Item } 21) + \text{Item } 30}{1000}$	kB/hr	5040

FLUE GAS ANAL. (BOILER) (ECON) (AIR HTR) OUTLET

32	CO_2	% VOL	9.7
33	O_2	% VOL	3.6
34	CO	% VOL	.02
35	N_2 (BY DIFFERENCE)	% VOL	86.68
36	EXCESS AIR	%	18.26

FUEL DATA

	COAL AS FIRED PROX. ANALYSIS	% wt	
37	MOISTURE		
38	VOL MATTER		
39	FIXED CARBON		
40	ASH		
	TOTAL		
41	Btu per lb AS FIRED		
42	ASH SOFT TEMP.* ASTM METHOD		
	COAL OR OIL AS FIRED ULTIMATE ANALYSIS		
43	CARBON		
44	HYDROGEN		
45	OXYGEN		
46	NITROGEN		
47	SULPHUR		
40	ASH		
37	MOISTURE		
	TOTAL		
	COAL PULVERIZATION		
48	GRINDABILITY INDEX*		
49	FINENESS % THRU 50 M*		
50	FINENESS % THRU 200 M*		
64	INPUT-OUTPUT EFFICIENCY OF UNIT %	ITEM 31 × 100 / ITEM 29	

51	OIL FLASH POINT F*		
52	Sp. Gravity		
53	VISCOSITY AT SSU* BURNER SSF		
44	TOTAL HYDROGEN % wt		
41	Btu per lb		
	GAS		% VOL
54	CO		
55	CH_4 METHANE		93.17
56	C_2H_6		4.14
57	C_3H_8		0.15
58	C_4H_{10}		0.02
59	N_2 Nitrogen		2.21
60	CO_2		0.36
61	H_2 HYDROGEN		
	TOTAL		100.00
	TOTAL HYDROGEN % wt		23.65
62	DENSITY 68 F ATM. PRESS.		.588
63	Btu PER CU FT		1006
41	Btu PER LB		

HEAT LOSS EFFICIENCY

		Btu/lb A. F. FUEL	% of A. F. FUEL
65	HEAT LOSS DUE TO DRY GAS	1197.24	5.35
66	HEAT LOSS DUE TO MOISTURE IN FUEL		
67	HEAT LOSS DUE TO H_2O FROM COMB. OF H_2	2492.60	11.11
68	HEAT LOSS DUE TO CO	15.06	0.07
69	HEAT LOSS DUE TO RADIATION		5.00
70	UNMEASURED LOSSES		0.50
71	TOTAL		22.03
72	EFFICIENCY = (100 – Item 71)		77.97

* Not Required for Efficiency Testing

† For Point of Measurement See Par. 7.2.8.1-PTC 4.1-1964

TABLE 8

ASME TEST FORM FOR ABBREVIATED EFFICIENCY TEST

SUMMARY SHEET — PTC 4.1-a (1964)

		TEST NO. 4	BOILER NO. 2 DATE 15/1/75
OWNER OF PLANT	DND	LOCATION	CFB Ottawa North
TEST CONDUCTED BY	A.C.S. Hayden, R.G. Fouhse	OBJECTIVE OF TEST	Acceptance DURATION 1 hr
BOILER, MAKE & TYPE	Foster Wheeler		RATED CAPACITY 31,000 lb/hr
STOKER, TYPE & SIZE			
PULVERIZER, TYPE & SIZE			BURNER, TYPE & SIZE Todd
FUEL USED	No. 4 fuel oil MINE	COUNTY	STATE SIZE AS FIRED

PRESSURES & TEMPERATURES

1	STEAM PRESSURE IN BOILER DRUM	psia	140.7
2	STEAM PRESSURE AT ~~XXXOUTXXX~~ HDR	psia	134.7
3	STEAM PRESSURE AT R. H. INLET	psia	
4	STEAM PRESSURE AT R. H. OUTLET	psia	
5	STEAM TEMPERATURE AT S. H. OUTLET	F	
6	STEAM TEMPERATURE AT R.H. INLET	F	
7	STEAM TEMPERATURE AT R.H. OUTLET	F	
8	WATER TEMP. ENTERING (~~XXXX~~) (BOILER)	F	217
9	STEAM QUALITY % MOISTURE OR P.P.M.		
10	AIR TEMP. AROUND BOILER (AMBIENT)	F	72
11	TEMP. AIR FOR COMBUSTION (This is Reference Temperature) †	F	82
12	TEMPERATURE OF FUEL	F	106
13	GAS TEMP. LEAVING (Boiler) (~~ECON.~~) ~~AIR HTR~~	F	633
14	GAS TEMP. ENTERING AH (If conditions to be corrected to guarantee)	F	

UNIT QUANTITIES

15	ENTHALPY OF SAT. LIQUID (TOTAL HEAT)	Btu/lb	
16	ENTHALPY OF (SATURATED) ~~(SUPERHEATED)~~ STM.	Btu/lb	1193.1
17	ENTHALPY OF SAT. FEED TO (BOILER) (~~XXXX~~)	Btu/lb	185.1
18	ENTHALPY OF REHEATED STEAM R.H. INLET	Btu/lb	
19	ENTHALPY OF REHEATED STEAM R. H. OUTLET	Btu/lb	
20	HEAT ABS/LB OF STEAM (ITEM 16 – ITEM 17)	Btu/lb	1008.0
21	HEAT ABS/LB R.H. STEAM (ITEM 19 – ITEM 18)	Btu/lb	
22	DRY REFUSE (ASH PIT + FLY ASH) PER LB AS FIRED FUEL	lb/lb	
23	Btu PER LB IN REFUSE (WEIGHTED AVERAGE)	Btu/lb	
24	CARBON BURNED PER LB AS FIRED FUEL	lb/lb	.8637
25	DRY GAS PER LB AS FIRED FUEL BURNED	lb/lb	15.78

HOURLY QUANTITIES

26	ACTUAL WATER EVAPORATED	lb/hr	29600
27	REHEAT STEAM FLOW	lb/hr	
28	RATE OF FUEL FIRING (AS FIRED wt)	lb/hr	2152
29	TOTAL HEAT INPUT $\frac{(\text{Item 28} \times \text{Item 41})}{1000}$	kB/hr	43970
30	HEAT OUTPUT IN BLOW-DOWN WATER	kB/hr	
31	TOTAL HEAT OUTPUT $\frac{(\text{Item 26} \times \text{Item 20}) + (\text{Item 27} \times \text{Item 21}) + \text{Item 30}}{1000}$	kB/hr	29837

FLUE GAS ANAL. (BOILER) (ECON) (AIR HTR) OUTLET

32	CO_2	% VOL	13.9
33	O_2	% VOL	2.51
34	CO	% VOL	–
35	N_2 (BY DIFFERENCE)	% VOL	83.59
36	EXCESS AIR	%	12.61

FUEL DATA

	COAL AS FIRED PROX. ANALYSIS	% wt
37	MOISTURE	
38	VOL MATTER	
39	FIXED CARBON	
40	ASH	
	TOTAL	
41	Btu per lb AS FIRED	
42	ASH SOFT TEMP.* ASTM METHOD	
	COAL OR OIL AS FIRED ULTIMATE ANALYSIS	
43	CARBON	86.37
44	HYDROGEN	12.36
45	OXYGEN	–
46	NITROGEN	0.11
47	SULPHUR	1.14
40	ASH	0.02
37	MOISTURE	–
	TOTAL	100.0
	COAL PULVERIZATION	
48	GRINDABILITY INDEX*	
49	FINENESS % THRU 50 M*	
50	FINENESS % THRU 200 M*	

	OIL	
51	FLASH POINT F*	
52	Sp. Gravity	0.898
53	VISCOSITY AT SSU* BURNER SSF	
44	TOTAL HYDROGEN % wt	12.32
41	Btu per lb	20432
	GAS	% VOL
54	CO	
55	CH_4 METHANE	
56		
57		
58		
59		
60	CO_2	
61	H_2 HYDROGEN	
	TOTAL	
	TOTAL HYDROGEN % wt	
62	DENSITY 68 F ATM. PRESS.	
63	Btu PER CU FT	
41	Btu PER LB	

64 INPUT-OUTPUT EFFICIENCY OF UNIT % $\frac{\text{ITEM 31} \times 100}{\text{ITEM 29}}$ = 67.86

	HEAT LOSS EFFICIENCY	Btu/lb A. F. FUEL	% of A. F. FUEL
65	HEAT LOSS DUE TO DRY GAS	2086.75	10.21
66	HEAT LOSS DUE TO MOISTURE IN FUEL		
67	HEAT LOSS DUE TO H_2O FROM COMB. OF H_2	1447.86	7.09
68	HEAT LOSS DUE TO CO	–	–
69	HEAT LOSS DUE TO RADIATION		0.90
70	UNMEASURED LOSSES		0.50
71	TOTAL		18.70
72	EFFICIENCY = (100 – Item 71)		81.30

* Not Required for Efficiency Testing

† For Point of Measurement See Par. 7.2.8.1-PTC 4.1-1964

ASME TEST FORM FOR ABBREVIATED EFFICIENCY TEST

SUMMARY SHEET

PTC 4.1-a (1964)

TEST NO. 5 BOILER NO. 2 DATE 15/1/75

OWNER OF PLANT DND LOCATION CFB Ottawa North

TEST CONDUCTED BY A.C.S. Hayden, R.G. Fouhse OBJECTIVE OF TEST Acceptance DURATION 1 hr

BOILER, MAKE & TYPE Foster Wheeler RATED CAPACITY 31,000 lb/hr

STOKER, TYPE & SIZE

PULVERIZER, TYPE & SIZE BURNER, TYPE & SIZE Todd

FUEL USED No. 4 fuel oil MINE COUNTY STATE SIZE AS FIRED

PRESSURES & TEMPERATURES

1	STEAM PRESSURE IN BOILER DRUM	psia	138.7
2	STEAM PRESSURE AT ~~XXXXXXXXX~~ HDR	psia	132.7
3	STEAM PRESSURE AT R. H. INLET	psia	
4	STEAM PRESSURE AT R. H. OUTLET	psia	
5	STEAM TEMPERATURE AT S. H. OUTLET	F	
6	STEAM TEMPERATURE AT R.H. INLET	F	
7	STEAM TEMPERATURE AT R.H. OUTLET	F	
8	WATER TEMP. ENTERING (~~ECON.~~) (BOILER)	F	202
9	STEAM QUALITY % MOISTURE OR P. P. M.		
10	AIR TEMP. AROUND BOILER (AMBIENT)	F	74
11	TEMP. AIR FOR COMBUSTION (This is Reference Temperature) †	F	81
12	TEMPERATURE OF FUEL	F	106
13	GAS TEMP. LEAVING (Boiler) ~~XXXXXXXXXX~~	F	535
14	GAS TEMP. ENTERING AH (If conditions to be corrected to guarantee)	F	

UNIT QUANTITIES

15	ENTHALPY OF SAT. LIQUID (TOTAL HEAT)	Btu/lb	
16	ENTHALPY OF (SATURATED) (~~XXXXXXXXXX~~) STM.	Btu/lb	1192.9
17	ENTHALPY OF SAT. FEED TO (BOILER) (~~XXXX~~)	Btu/lb	170.0
18	ENTHALPY OF REHEATED STEAM R.H. INLET	Btu/lb	
19	ENTHALPY OF REHEATED STEAM R. H. OUTLET	Btu/lb	
20	HEAT ABS/LB OF STEAM (ITEM 16 – ITEM 17)	Btu/lb	1022.9
21	HEAT ABS/LB R.H. STEAM (ITEM 19 – ITEM 18)	Btu/lb	
22	DRY REFUSE (ASH PIT + FLY ASH) PER LB AS FIRED FUEL	lb/lb	
23	Btu PER LB IN REFUSE (WEIGHTED AVERAGE)	Btu/lb	
24	CARBON BURNED PER LB AS FIRED FUEL	lb/lb	.8637
25	DRY GAS PER LB AS FIRED FUEL BURNED	lb/lb	16.42

HOURLY QUANTITIES

26	ACTUAL WATER EVAPORATED	lb/hr	19010
27	REHEAT STEAM FLOW	lb/hr	
28	RATE OF FUEL FIRING (AS FIRED wt)	lb/hr	1434
29	TOTAL HEAT INPUT $\frac{(\text{Item } 28 \times \text{Item } 41)}{1000}$	kB/hr	29290
30	HEAT OUTPUT IN BLOW-DOWN WATER	kB/hr	
31	TOTAL HEAT OUTPUT $\frac{(\text{Item } 26 \times \text{Item } 20) + (\text{Item } 27 \times \text{Item } 21) + \text{Item } 30}{1000}$	kB/hr	19445

FLUE GAS ANAL. (BOILER) (ECON) (AIR HTR) OUTLET

32	CO_2	% VOL	13.3
33	O_2	% VOL	3.50
34	CO	% VOL	.03
35	N_2 (BY DIFFERENCE)	% VOL	83.17
36	EXCESS AIR	%	18.52

FUEL DATA

	COAL AS FIRED PROX. ANALYSIS	% wt		OIL	
37	MOISTURE		51	FLASH POINT F*	
38	VOL MATTER		52	Sp. Gravity	0.898
39	FIXED CARBON		53	VISCOSITY AT SSU* BURNER SSF	
40	ASH		44	TOTAL HYDROGEN % wt	12.32
	TOTAL		41	Btu per lb	20432
41	Btu per lb AS FIRED				
42	ASH SOFT. TEMP.* ASTM METHOD			GAS	% VOL
	COAL OR OIL AS FIRED ULTIMATE ANALYSIS		54	CO	
43	CARBON	86.37	55	CH_4 METHANE	
44	HYDROGEN	12.36	56		
45	OXYGEN	–	57		
46	NITROGEN	0.11	58		
47	SULPHUR	1.14	59		
40	ASH	0.02	60	CO_2	
37	MOISTURE		61	H_2 HYDROGEN	
	TOTAL	100.0		TOTAL	
	COAL PULVERIZATION			TOTAL HYDROGEN % wt	
48	GRINDABILITY INDEX*		62	DENSITY 68 F ATM. PRESS.	
49	FINENESS % THRU 50 M*		63	Btu PER CU FT	
50	FINENESS % THRU 200 M*		41	Btu PER LB	
64	INPUT-OUTPUT EFFICIENCY OF UNIT %	ITEM 31 × 100 / ITEM 29	66.39		

	HEAT LOSS EFFICIENCY	Btu/lb A. F. FUEL	% of A. F. FUEL
65	HEAT LOSS DUE TO DRY GAS	1789.12	8.76
66	HEAT LOSS DUE TO MOISTURE IN FUEL		
67	HEAT LOSS DUE TO H_2O FROM COMB. OF H_2	1397.03	6.84
68	HEAT LOSS DUE TO CO	19.75	0.10
69	HEAT LOSS DUE TO RADIATION		1.40
70	UNMEASURED LOSSES		0.50
71	TOTAL		17.60
72	EFFICIENCY = (100 – Item 71)		82.40

* Not Required for Efficiency Testing

† For Point of Measurement See Par. 7.2.8.1-PTC 4.1-1964

TABLE 10

SUMMARY SHEET

ASME TEST FORM FOR ABBREVIATED EFFICIENCY TEST

PTC 4.1-a (1964)

TEST NO. 6 BOILER NO. 2 DATE 15/1/75

OWNER OF PLANT DND LOCATION CFB Ottawa North

TEST CONDUCTED BY A.C.S. Hayden, R.G. Fouhse OBJECTIVE OF TEST Acceptance DURATION .5 hr

BOILER, MAKE & TYPE Foster Wheeler RATED CAPACITY 31,000 lb/hr

STOKER, TYPE & SIZE

PULVERIZER, TYPE & SIZE BURNER, TYPE & SIZE Todd

FUEL USED No. 4 fuel oil MINE COUNTY STATE SIZE AS FIRED

PRESSURES & TEMPERATURES

1	STEAM PRESSURE IN BOILER DRUM	psia	135.7
2	STEAM PRESSURE AT ~~XXXXXXXXX~~	psia	129.7
3	STEAM PRESSURE AT R. H. INLET	psia	
4	STEAM PRESSURE AT R. H. OUTLET	psia	
5	STEAM TEMPERATURE AT S. H. OUTLET	F	
6	STEAM TEMPERATURE AT R.H. INLET	F	
7	STEAM TEMPERATURE AT R.H. OUTLET	F	
8	WATER TEMP. ENTERING (~~XXXX~~) (BOILER)	F	204
9	STEAM QUALITY % MOISTURE OR P.P.M.		
10	AIR TEMP. AROUND BOILER (AMBIENT)	F	75
11	TEMP. AIR FOR COMBUSTION (This is Reference Temperature) †	F	80
12	TEMPERATURE OF FUEL	F	106
13	GAS TEMP. LEAVING (Boiler) (~~XXXX~~ (~~XXXX~~)	F	435
14	GAS TEMP. ENTERING AH (If conditions to be corrected to guarantee)	F	

UNIT QUANTITIES

15	ENTHALPY OF SAT. LIQUID (TOTAL HEAT)	Btu/lb	
16	ENTHALPY OF (SATURATED) (~~SUPERHEATED~~) STM.	Btu/lb	1192.5
17	ENTHALPY OF SAT. FEED TO (BOILER) (~~XXXX~~)	Btu/lb	172.0
18	ENTHALPY OF REHEATED STEAM R.H. INLET	Btu/lb	
19	ENTHALPY OF REHEATED STEAM R. H. OUTLET	Btu/lb	
20	HEAT ABS/LB OF STEAM (ITEM 16 – ITEM 17)	Btu/lb	1020.5
21	HEAT ABS/LB R.H. STEAM (ITEM 19 – ITEM 18)	Btu/lb	
22	DRY REFUSE (ASH PIT + FLY ASH) PER LB AS FIRED FUEL	lb/lb	
23	Btu PER LB IN REFUSE (WEIGHTED AVERAGE)	Btu/lb	
24	CARBON BURNED PER LB AS FIRED FUEL	lb/lb	.8637
25	DRY GAS PER LB AS FIRED FUEL BURNED	lb/lb	19.67

HOURLY QUANTITIES

26	ACTUAL WATER EVAPORATED	lb/hr	9700
27	REHEAT STEAM FLOW	lb/hr	
28	RATE OF FUEL FIRING (AS FIRED wt)	lb/hr	728
29	TOTAL HEAT INPUT $\frac{(\text{Item 28} \times \text{Item 41})}{1000}$	kB/hr	14874
30	HEAT OUTPUT IN BLOW-DOWN WATER	kB/hr	
31	TOTAL HEAT OUTPUT $\frac{(\text{Item 26} \times \text{Item 20}) + (\text{Item 27} \times \text{Item 21}) + \text{Item 30}}{1000}$	kB/hr	9899

FLUE GAS ANAL. (BOILER) (ECON) (AIR HTR) OUTLET

32	CO_2	% VOL	11.0
33	O_2	% VOL	6.0
34	CO	% VOL	0.03
35	N_2 (BY DIFFERENCE)	% VOL	82.97
36	EXCESS AIR	%	36.79

FUEL DATA

	COAL AS FIRED PROX. ANALYSIS	% wt		OIL			
37	MOISTURE		51	FLASH POINT F*			
38	VOL MATTER		52	Sp. Gravity	0.998		
39	FIXED CARBON		53	VISCOSITY AT SSU* BURNER SSF			
40	ASH		44	TOTAL HYDROGEN % wt	12.36		
	TOTAL		41	Btu per lb	20432		
41	Btu per lb AS FIRED						
42	ASH SOFT TEMP.* ASTM METHOD			GAS	% VOL		
	COAL OR OIL AS FIRED ULTIMATE ANALYSIS		54	CO			
43	CARBON	86.37	55	CH_4 METHANE			
44	HYDROGEN	12.36	56	C_2H_2 ACETYLENE			
45	OXYGEN	–	57	C_2H_4 ETHYLENE			
46	NITROGEN	0.11	58	C_2H_6 ETHANE			
47	SULPHUR	1.14	59	H_2S			
40	ASH	0.02	60	CO_2			
37	MOISTURE	–	61	H_2 HYDROGEN			
	TOTAL	100.0		TOTAL			
	COAL PULVERIZATION			TOTAL HYDROGEN % wt			
48	GRINDABILITY INDEX*		62	DENSITY 68 F ATM. PRESS.			
49	FINENESS % THRU 50 M*		63	Btu PER CU FT			
50	FINENESS % THRU 200 M*		41	Btu PER LB			
64	INPUT-OUTPUT EFFICIENCY OF UNIT %	$\frac{\text{ITEM 31} \times 100}{\text{ITEM 29}}$	66.55				

	HEAT LOSS EFFICIENCY	Btu/lb A. F. FUEL	% of A. F. FUEL
65	HEAT LOSS DUE TO DRY GAS	1675.88	8.20
66	HEAT LOSS DUE TO MOISTURE IN FUEL		
67	HEAT LOSS DUE TO H_2O FROM COMB. OF H_2	1345.96	6.59
68	HEAT LOSS DUE TO CO	23.87	0.12
69	HEAT LOSS DUE TO RADIATION		2.70
70	UNMEASURED LOSSES		0.50
71	TOTAL		18.11
72	EFFICIENCY = (100 – Item 71)		81.89

* Not Required for Efficiency Testing

† For Point of Measurement See Par. 7.2.8.1-PTC 4.1-1964

TABLE 11

ASME TEST FORM FOR ABBREVIATED EFFICIENCY TEST

SUMMARY SHEET — PTC 4.1-a (1964)

		TEST NO. 7	BOILER NO. 2 DATE 15/1/75
OWNER OF PLANT	DND	LOCATION	CFB Ottawa North
TEST CONDUCTED BY	A.C.S. Hayden, R.G. Fouhse	OBJECTIVE OF TEST	Acceptance DURATION .25Hr
BOILER, MAKE & TYPE	Foster Wheeler		RATED CAPACITY 31,000 lb/hr
STOKER, TYPE & SIZE			
PULVERIZER, TYPE & SIZE			BURNER, TYPE & SIZE Todd
FUEL USED	No. 4 fuel oil MINE	COUNTY	STATE SIZE AS FIRED

PRESSURES & TEMPERATURES

1	STEAM PRESSURE IN BOILER DRUM	psia	135.7
2	STEAM PRESSURE AT ~~XXXXXXXXX~~ HDR	psia	129.7
3	STEAM PRESSURE AT R. H. INLET	psia	
4	STEAM PRESSURE AT R. H. OUTLET	psia	
5	STEAM TEMPERATURE AT S. H. OUTLET	F	
6	STEAM TEMPERATURE AT R.H. INLET	F	
7	STEAM TEMPERATURE AT R.H. OUTLET	F	
8	WATER TEMP. ENTERING (~~ECON.~~) (BOILER)	F	212
9	STEAM QUALITY % MOISTURE OR P.P.M.		
10	AIR TEMP. AROUND BOILER (AMBIENT)	F	75
11	TEMP. AIR FOR COMBUSTION (This is Reference Temperature) †	F	80
12	TEMPERATURE OF FUEL	F	106
13	GAS TEMP. LEAVING (Boiler) ~~(Econ.) (Air Htr.)~~	F	370
14	GAS TEMP. ENTERING AH (If conditions to be corrected to guarantee)	F	

UNIT QUANTITIES

15	ENTHALPY OF SAT. LIQUID (TOTAL HEAT)	Btu/lb	
16	ENTHALPY OF (SATURATED) (~~SUPERHEATED~~) STM.	Btu/lb	11925
17	ENTHALPY OF SAT. FEED TO (BOILER) (~~ECON~~)	Btu/lb	180.1
18	ENTHALPY OF REHEATED STEAM R.H. INLET	Btu/lb	
19	ENTHALPY OF REHEATED STEAM R. H. OUTLET	Btu/lb	
20	HEAT ABS/LB OF STEAM (ITEM 16 – ITEM 17)	Btu/lb	1012.4
21	HEAT ABS/LB R.H. STEAM (ITEM 19 – ITEM 18)	Btu/lb	
22	DRY REFUSE (ASH PIT + FLY ASH) PER LB AS FIRED FUEL	lb/lb	
23	Btu PER LB IN REFUSE (WEIGHTED AVERAGE)	Btu/lb	
24	CARBON BURNED PER LB AS FIRED FUEL	lb/lb	.8637
25	DRY GAS PER LB AS FIRED FUEL BURNED	lb/lb	19.50

HOURLY QUANTITIES

26	ACTUAL WATER EVAPORATED	lb/hr	5680
27	REHEAT STEAM FLOW	lb/hr	
28	RATE OF FUEL FIRING (AS FIRED wt)	lb/hr	391
29	TOTAL HEAT INPUT $\frac{(\text{Item 28} \times \text{Item 41})}{1000}$	kB/hr	7989
30	HEAT OUTPUT IN BLOW-DOWN WATER	kB/hr	
31	TOTAL HEAT OUTPUT $\frac{(\text{Item 26} \times \text{Item 20}) + (\text{Item 27} \times \text{Item 21}) + \text{Item 30}}{1000}$	kB/hr	5750

FLUE GAS ANAL. (BOILER) (ECON) (AIR HTR) OUTLET

32	CO_2	% VOL	11.1
33	O_2	% VOL	5.8
34	CO	% VOL	.03
35	N_2 (BY DIFFERENCE)	% VOL	83.07
36	EXCESS AIR	%	35.07

FUEL DATA

	COAL AS FIRED PROX. ANALYSIS	% wt		OIL	
37	MOISTURE		51	FLASH POINT F*	
38	VOL MATTER		52	Sp. Gravity	0.898
39	FIXED CARBON		53	VISCOSITY AT SSU* BURNER SSF	
40	ASH		44	TOTAL HYDROGEN % wt	12.32
	TOTAL		41	Btu per lb	20432
41	Btu per lb AS FIRED				
42	ASH SOFT TEMP.* ASTM METHOD			GAS	% VOL
	COAL OR OIL AS FIRED ULTIMATE ANALYSIS		54	CO	
43	CARBON	86.37	55	CH_4 METHANE	
44	HYDROGEN	12.36	56	C_2H_2 ACETYLENE	
45	OXYGEN	–	57	C_2H_4 ETHYLENE	
46	NITROGEN	0.11	58	C_2H_6 ETHANE	
47	SULPHUR	1.14	59	H_2S	
40	ASH	0.02	60	CO_2	
37	MOISTURE	–	61	H_2 HYDROGEN	
	TOTAL	100.0		TOTAL	
	COAL PULVERIZATION			TOTAL HYDROGEN % wt	
48	GRINDABILITY INDEX*		62	DENSITY 68 F ATM. PRESS.	
49	FINENESS % THRU 50 M*		63	Btu PER CU FT	
50	FINENESS % THRU 200 M*		41	Btu PER LB	
64	INPUT-OUTPUT EFFICIENCY OF UNIT %	$\frac{\text{ITEM 31} \times 100}{\text{ITEM 29}}$	71.97		

HEAT LOSS EFFICIENCY

		Btu/lb A. F. FUEL	% of A. F. FUEL
65	HEAT LOSS DUE TO DRY GAS	1357.20	6.64
66	HEAT LOSS DUE TO MOISTURE IN FUEL		
67	HEAT LOSS DUE TO H_2O FROM COMB. OF H_2	1312.50	6.42
68	HEAT LOSS DUE TO CO	23.65	0.12
69	HEAT LOSS DUE TO RADIATION		4.50
70	UNMEASURED LOSSES		0.50
71	TOTAL		18.18
72	EFFICIENCY = (100 – Item 71)		81.82

* Not Required for Efficiency Testing

† For Point of Measurement See Par. 7.2.8.1-PTC 4.1-1964

APPENDIX A

BOILER AND BURNER SPECIFICATIONS

1. Boilers:

No. 1:	Inglis, Type VL, 400 HP
No. 2:	Foster Wheeler, 31,000 lb/hr
No. 3 & No. 4:	Waterous, 31,000 lb/hr

2. Burners:

No. 1: 2 parallel Compower oil/gas burners

No. 2: Todd D18, Number 197354

Input Btu: min 5.5 MM, max 31 MM

Natural gas and No. 4 oil

Inlet gas: 10 psig	Steam atomized oil burner
Manifold gas: 3 psig	Oil pressure: 100 psig
Max gas I/P: 8750 CFM	Max oil I/P: 2100 lb/hr

No. 3 & No. 4: Single Compower oil/gas burner