

Post Overhaul Performance Assessment Test

Rajghat Power House

Unit 1 & 2 (2x67.5 MW)

of

Indraprastha Power Generation Company Limited

Report No. CenPEEP/08/S1

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Report Prepared by

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Rajghat Unit 1 & 2 'Unit Heat Rate' Test Report

1.0 Executive Summary

This is the final report with respect to Work Order No. 907 dated 06/08/2010 to NTPC Ltd. for Consultancy services for carrying out Post overhauling performance /efficiency tests to assess the operating Heat Rate of 2x67.5 MW units of Rajghat Power House (IPGCL). All the activities related to performance assessment tests have been completed & this report covers the test methodology, collected data and the test results.

A preliminary walk down of Rajghat Unit 1 & 2 was conducted on 13th Aug'10 for carrying out preparatory activities for the tests. Boiler & Turbine performance assessment tests were carried out in both the units on 17th Aug'10. Feed water flow in both units was measured by Ultrasonic Flow meter for accurate measurement and average of flow meter readings during the test period was used for Heat Rate computations.

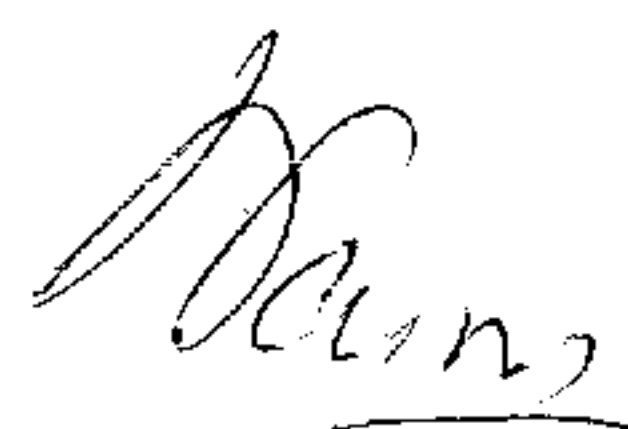
The Design, Operating Test values & Corrected values of Boiler Efficiency, Gross Turbine Cycle Heat Rate (GTCHR) and Unit Heat Rate for Unit 1 & 2 are summarized in the following Table.

	Unit 1*			Unit 2		
Description	Boiler Efficiency	GTCHR	Unit HR	Boiler Efficiency	GTCHR	Unit HR
Units	%	Kcal/kW hr	Kcal/kW hr	%	Kcal/kW hr	Kcal/kW hr
Design	86.6	2232	2577.4	86.6	2232	2577.4
Test	85.61	2611	3049.8	81.52	2625	3220.1

**Unit 1 HP heaters were out of service during the tests.*

The values tabulated above are based on 2 hour test conducted under stable conditions. The average operating Heat Rate for the units would be higher than the Test Heat Rate on account of following reasons.

- Parametric deviations (e.g. steam pressure & temperatures)
- Variations in coal quality
- Operation of soot blowers, Water/steam leakages, CBD/IBD operation
- Partial Loading, Unit startups / shutdowns
- Non standard operation (e.g. HP heaters not in service)
- Changes in ambient operating conditions (Ambient temp & CW inlet temp)
- Deterioration in equipment performance from an overhaul to next



2.0 Scope of Work

1. Assessment of Unit Heat Rate for 2X67.5 MW units
2. Boiler Efficiency Tests of two units
3. Gross Turbine Cycle Heat Rate (GTCHR) tests of two units using online parameters

Acknowledgements

We wish to put on record our thanks and appreciation to **Mr. R.K.Gaur, Managing Director - IPGCL, Mr. P.K.Ray, Director (Technical) – IPGCL, Mr. V.K.Metrey, GM (T), Mr. Pravin Gupta, AGM (Chemistry), Mr. R. Bansal, DGM (Mech) and Mr. S.M.Tangri, DGM (Operation)** for their continuous guidance & support. We want to thank **Mr. Harish Kumar, Manager (Boiler), Mr. Narendra Kumar, AM (I/C - Turbine) & Mr. Rajesh Chattarwal AM (MTP)**, for coordinating all the activities and to all the station engineers and station chemistry staff for their enthusiastic participation in conductance of the performance assessment tests.



3.0 Test Conditions

Performance Assessment Tests were carried out from 1100 to 1300 hours in Unit 1 and 1500 to 1700 hours in Unit 2 on 17th Aug'10. All the preparatory activities for the tests including fabrication and checking of test ports in gas ducts, parameter validation and checking etc. were carried out during unit walk down on 13th Aug'10. Details of requirements of test ports for the test and list of additional work to be carried out prior to test was discussed and provided to station engineers. A copy of Walk down report is enclosed as **Annexure I**.

The capital overhaul of Unit – 1 was carried out from 18th April to 29th May'10 and capital overhaul of Unit – 2 was carried out from 13th Sept to 11th Nov'09. The details of major works carried out during the capital overhauls are attached in this report as **Annexure – II**.

Unit 1 HP heaters 1 & 2 were not in service due to suspected Tube leakage. So after detailed discussion with Operation & maintenance groups, it was decided to conduct the tests without HP heaters being in service in Unit 1.

The tests were conducted under the following conditions.

- a) Unit operation is kept steady for two hours prior to and during the tests.
- b) Tests conducted at rated load at nominal operating parameters to the extent possible.
- c) No furnace soot blowers or air heater soot blowers are operated during the test.
- d) Main Steam Pressure and Temperature are maintained as close as possible to the design values.
- e) Auxiliary PRDS steam flow is kept isolated for the unit being tested.
- f) Continuous blow down and Intermittent blow down is kept isolated and not operated during the test.
- g) Unit 1 HP heaters 1& 2 were not in service during the tests due to suspected tube leakage. Unit 2 all FW Heaters are kept in service with normal drip cascading.
- h) No mill changeover is done during the test and the test is conducted without any oil support.
- i) Economiser hopper de-ashing is not done during the test.
- j) Bottom hopper de-ashing is done prior to the test stabilisation period and thereafter immediately after the test.



4.0 Performance Assessment

4.1 Boiler Efficiency Tests - U1 & U2

4.1.1 General Description – Boiler

- a. Rajghat 2x67.5 MW boilers supplied by M/s BHEL are coal fired utility units supplying steam to 67.5 MW turbine.
- b. Boilers are of double drum natural circulation balanced draft with dry bottom.
- c. Boilers are of type VU 40 with bank tubes connecting the upper and lower drums.
- d. A plain tube economizer is provided for the feed water heating. The superheater consists platen superheater as stage-I in the radiant zone just above the furnace and the final superheater as stage-2 in the horizontal convection zone.
- e. Single stage desuperheater is provided for the temperature control of steam.
- f. Coal firing is by fixed tangential burners. Coal preparation is by 5 nos. of HP 703-P bowl mills.
- g. Secondary air is provided by two single stage axial reaction fans. Primary air is provided by five radial PA fans with hot PA system. Induced draught is created by two radial ID fans.
- h. Air pre-heating is done by one regenerative bisector Ljungstrom air heater.
- i. 22 nos. of wall blowers and 7 nos. of soot blowers were provided but are not being used. Only air heater soot blowers are operated once a day.
- j. Contract data sheet (3 nos.) for Rajghat Boilers are annexed as Annexure III.

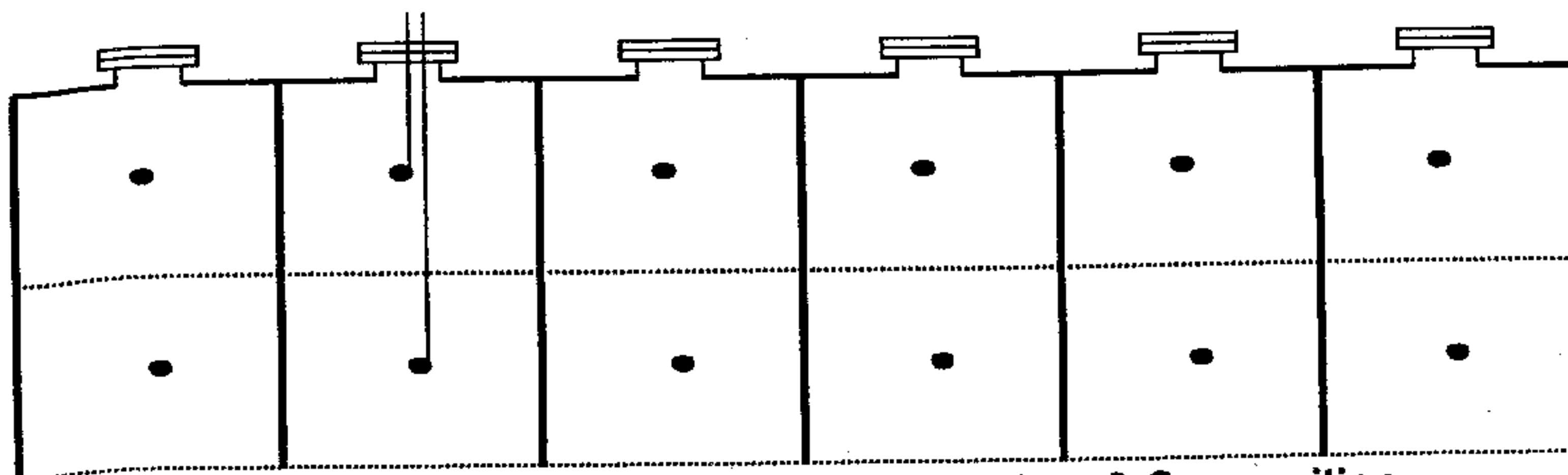
4.1.2 Test Set up & Measurements

The following field measurements & sampling were done simultaneously during the tests.

- **Air Heater Inlet & Outlet:**

Flue Gas composition & temperatures were measured at Air heater inlet and outlet with a 12 point (6X2) grid measurement. Gas composition & temperatures were measured at 2 different lengths in each of the six ports in each gas duct at air heater inlet and outlet as shown in the following sketch. Single tube probes with calibrated 'K' type MI thermocouples were used for gas composition & temperature measurement.





Sampling Points for Flue Gas Temperature & Composition

At both Air heater inlet and outlet locations, flue gas samples were drawn by a vacuum pump from the test grid probes and sent to a portable gas analyzer through a gas conditioning system. Gas-conditioning system consists of a wash bottle, partially filled with water for cleaning the gas sample, a condenser to condense the water vapor out of the gas sample and a desiccant filter to remove any water vapor that got through the condenser.

- **Raw Coal Sampling & Analysis**

Incremental raw coal samples were collected from feeder inlet chutes of all the running feeders and a composite sample was prepared for conducting proximate analysis and GCV (as-fired).

The samples were collected by staff of station Chemistry group. One sample was sealed for determination of total moisture. The coal analysis was carried out at Station Chemical labs by chemistry group.

- **Flyash & Bottom ash sampling**

Incremental ash samples were collected from first row of ESP hoppers, separately from left & right side and a composite sample prepared for left and right side hoppers.

Bottom ash samples were collected during de-ashing after completion of the test from the discharge in ash pit.

The unburnt carbon analysis for fly ash and bottom ash was carried out at Station Chemical labs by chemistry group

- **Ambient Temperatures:**

Dry and wet bulb temperatures were measured using a motorized Psychrometer at the beginning & end of the test. Average of the two values was used for test computations.

- **Control room parameters**

Manual readings of all available parameters in control room were taken and are enclosed as Annexure IV.

4.1.3 Boiler Test Results

Boiler tests were carried out from 1100 to 1300 hours and 1500 to 1700 hrs in Units 1 & 2 on 17th Aug'10. Unit 1 Boiler test was conducted without HP heaters in service and Unit 2 Boiler test was conducted with all HP heaters in service. The operating and corrected efficiency losses in the two tests are tabulated below.

Boiler Efficiency Test Report

Station: Rajghat
Unit: 1

Report date: 26.08.10
Test Date: 17.08.10

Test Conditions

1	Unit Load	MW	88	4	Coal Flow	T/hr	—
2	Steam Flow	T/hr	252	5	Mills in service	Nos.	BCD
3	Air flow	T/hr	256	6	FW inlet temperature	C	150

Flue Gas analysis

Avg. Air Temperatures

1	AH Inlet O ₂ L/R (UCB)	%	3.1	7	Design air inlet temp	C	40
2	AH Inlet O ₂ L/R (Local)	%	4.1	8	Dry Bulb Temperature	C	34.5
3	AH outlet Avg. O ₂	%	5.95	9	Wet Bulb Temperature	C	28.5
4	AH outlet Avg. CO ₂	%	13.05	10	AH Air inlet Temp	C	30
5	AH outlet Avg. CO	ppm	0	11	AH Air outlet Temp	C	292
6	AH Gas O/L Temp (UCB)	C	138	12	AH Gas O/L Temp (Grid)	C	141.2

Coal - Proximate Analysis

Unburnt C in ashes

1	Moisture	%	18.46	6	Unburnt C in bottom ash	%	4.1
2	Ash	%	32.93	7	Unburnt C in fly ash	%	0.885
3	Volatile Matter	%	20.87				
4	Fixed Carbon	%	27.73				
5	GCV	kcal/kg	3363				

Boiler Efficiency

S.N	Heat Losses (%)		U2 PG Test Value (1991)		Current Test	
			Test Value	Test Corrected to Design conditions	Test Value	Test Corrected to Design conditions
1	Dry Gas Loss	%	5.204	4.94	5.13	4.95
2	Loss due to Unburnt Carbon	%	1.983	1.78	1.02	0.87
3	Loss due to moisture in fuel	%	0.839	1.47	3.41	1.46
4	Loss due to Hydrogen in Fuel	%	3.703	3.176	3.94	3.15
5	Loss due to Carbon monoxide	%	0	0	0.00	0.00
6	Loss due to moisture in air	%	0.888	0.256	0.20	0.11
7	Sensible Heat Loss - Fly Ash	%	0.192	0.167	0.18	0.14
8	Sensible Heat Loss - Bottom Ash	%	0.138	0.124	0.15	0.12
9	Radiation Loss	%	0.36	0.36	0.36	0.36
	BOILER EFFICIENCY	%	87.922	88.17	85.61	88.84

Boiler Efficiency Test Report

Station: Rajghat
Unit: 2

Report date: 26.08.10
Test Date: 17.08.10

Test Conditions

1	Unit Load	MW	67	4	Coal Flow	T/hr	—
2	Steam Flow	T/hr	306	5	Mills in service	Nos.	COE
3	Air flow	T/hr	245	6	FW inlet temperature	C	243

Flue Gas analysis

Avg. Air Temperatures

1	AH Inlet O ₂ L/R (UCB)	%	1.8	7	Design air inlet temp	C	40
2	AH Inlet O ₂ L/R (Local)	%	1.95	8	Dry Bulb Temperature	C	35.3
3	AH outlet Avg O ₂	%	4.55	9	Wet Bulb Temperature	C	28.5
4	AH outlet Avg CO ₂	%	14.45	10	AH Air inlet Temp	C	40
5	AH outlet Avg CO	ppm	5000	11	AH Air outlet Temp	C	326
6	AH Gas OIL Temp (UCB)	C	181	12	AH Gas OIL Temp (Grid)	C	163.3

Coal - Proximate Analysis

Unburnt C in ashes

1	Moisture	%	16.84	6	Unburnt C in bottom ash	%	6.01
2	Ash	%	33.99	7	Unburnt C in fly ash	%	3.38
3	Volatile Matter	%	21.09				
4	Fixed Carbon	%	29.08				
5	GCV	kcal/kg	3391				

Boiler Efficiency

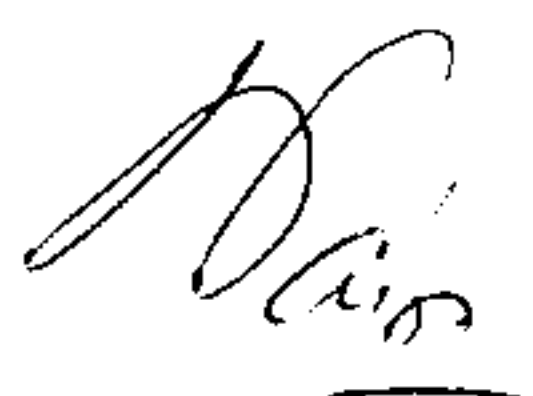
S.N	Heat Losses (%)		U2 PG Test Value (1991)		Current Test	
			Test Value	Test Corrected to Design conditions	Test Value	Test Corrected to Design conditions
1	Dry Gas Loss	%	5.204	4.94	5.47	5.33
2	Loss due to Unburnt Carbon	%	1.953	1.79	2.97	2.46
3	Loss due to moisture in fuel	%	0.899	1.47	3.13	1.45
4	Loss due to Hydrogen in Fuel	%	3.703	3.176	3.99	3.20
5	Loss due to Carbon monoxide	%	0	0	1.97	1.95
6	Loss due to moisture in air	%	0.899	0.256	0.21	0.12
7	Sensible Heat Loss - Fly Ash	%	0.192	0.167	0.22	0.18
8	Sensible Heat Loss - Bottom Ash	%	0.136	0.124	0.16	0.12
9	Radiation Loss	%	0.36	0.36	0.36	0.36
	BOILER EFFICIENCY	%	87.92	88.17	81.52	84.81



As fired coal had a lower GCV, lower ash & much higher moisture vis-à-vis design coal in both the tests as indicated in the following Table.

Prox analysis (as fired)	Design	U2 PG Test (1991)	Unit 1 (17.08.10)	Unit 2 (17.08.10)
FC %	34	37.07	27.73	28.08
Ash %	35	38.41	32.93	33.99
TM %	10	5.81	18.46	16.84
VM %	21	18.71	20.87	21.09
GCV Kcal/Kg	4230	4234	3363	3391

So, corrections have been applied to operating boiler losses / efficiency for variations in coal quality & difference in ambient temperature from design. Heat credits due to power consumption in PA fans & mills have not been considered in the efficiency computations. 'Test values' and 'Test values corrected to design conditions' for the two units have been tabulated in Section 4.1.3.



4.2 Turbine

Gross Turbine Heat Rate (GTCHR) Test was carried out at **Unit 1 & 2** of Rajghat Power House by CenPEEP and Station engineers on 17th Aug'10 as a consultancy assignment. Post Outage tests were conducted using on-line instruments in Unit 1 & 2 to determine current operating efficiency levels.

Feed water flow measurement was carried out using high temperature Ultrasonic Flow meter, model ADM 6725 (Accuracy +/- 1%) to validate the flow indicated in control room. Accurate FW flow measurement is very critical for accurate Heat Rate assessment. Average of the FW Flow measured by ultrasonic flow meter during the test period was used for the Heat Rate assessment.

4.2.1 Technical Design Data (at 67.5 MW load)

Sr. No	Description	Unit	Parameter
1	Rated output of Turbine	MW	67.5
2	Rated pressure of steam before ESV	kg/cm ² (abs)	90
3	Rated temp. of steam before ESV	deg C	535.0
4	Design Turbine cycle HR at 0% make up, 32°C CW inlet temp.	kcal/kWh	2232
5	Main Steam flow at 0% make up	t/hr	257.448
6	Rated back pressure at the exhaust of LP Turbine	mm Hga	69
7	Rated CW inlet temp.	deg C	32
8	Rated quantity of CW through condenser	t/hr	11200
9	Type of Turbine - Impulse type, Axial flow, Single cylinder, Condensing.	--	---
10	Type of Governing	--	Nozzle Governing

4.2.2 Test setup

Test – 1: Turbine Performance Test of unit – 1 at 100% load and design inlet parameters without HP Heaters – 1 & 2 in service; Auxiliary PRDS steam flow was isolated from the unit.

Test – 2: Turbine Performance Test of unit – 2 at 100% load and design inlet parameters with HP Heaters in service; Auxiliary PRDS steam flow was isolated from the unit.



4.2.3 Test Conditions

The tests were conducted under the following conditions.

1. GTCHR test was carried out by using the on line DCS parameters.
2. Unit – 1 GTCHR test was conducted on 17th August'2010 for one hour duration (12:00 hrs to 13:00 hrs) at stable load condition (Load: 67.5 MW) with both HPHs out of service (due to tube leakage).
3. Unit – 2 GTCHR test was conducted on 17th August'2010 for one hour duration (15:00 hrs to 16:00 hrs) at stable load condition (Load: 66 MW) with both HPHs in service.
4. FW flow was measured at HPH – 1 inlet FW line for both the units using high temperature ultrasonic flowmeter. FW flow value measured with ultrasonic flowmeter was used for calculation and assessment.
5. For power measurement, the values from on line Energy Meter (Accuracy 0.2 class) were taken.
6. For leg correction of on line pressure measurements, the elevation differences of tapping point of impulse line and the transmitters were measured and the same were used for calculation and assessment.
7. The transmitters and the thermocouples had been calibrated / checked by station during the unit shutdowns.

Test was carried out in Unit – 1 & 2 using on-line instruments at 67.5 MW & 66 MW respectively. DM makeup was not isolated and makeup value was recorded during the test. CBD was isolated during the test period. The test was done for one hour duration and average readings were recorded at an interval of five minutes. Prior to test, stable conditions were established and maintained during the test period.

4.2.4 Gross Turbine Cycle Heat Rate (GTCHR) of Unit – 1 (12:00 - 13:00 Hrs)

S.N.	PARAMETER	UNIT	DESIGN DATA	TEST DATA
1	Unit Load	MW	67.5	67.5
2	MS Pressure before ESV	kg/cm ² (a)	90	90.4
3	MS Temperature before ESV	Deg C	535.0	539.0
4	1st stage pressure	kg/cm ² (a)	-	58.5
5	FW Temp at Eco inlet	Deg C	236.85	157.0
6	FW Flow (Incl SH attemperation)	T/hr	258.0	262.0
7	SH Attemp. Flow	T/hr	0.0	16.0
8	Test CW Inlet Temperature	Deg C	32.0	36.0
9	Design CW Inlet Temperature	Deg C	32.0	32.0
Gross Turbine Cycle Heat Rate (Current Test)		kcal/kWh	2232	2611



Test & Corrected Gross Turbine Cycle Heat Rate (GTCHR)

Test Load	67.5 MW
Design GTCHR	2232 kcal/kWh
Test GTCHR	2611 kcal/kWh (at CW inlet temp of 36 Deg C)
Corrected GTCHR	2591 kcal/kWh (for design CW inlet temp of 32 Deg C)

The Corrected Gross turbine Cycle Heat Rate as per test data (corrected for design CW inlet temperature) is 2591 kcal/kWh at 67.5 MW load as against design GTCHR value of 2232 kcal/kWh.

4.2.5 Gross Turbine Cycle Heat Rate (GTCHR) of Unit – 2 (15:00 - 16:00 Hrs)

S.N.	PARAMETER	UNIT	DESIGN DATA	TEST DATA
1	Unit Load	MW	67.5	66.0
2	MS Pressure before ESV	kg/cm ² (a)	90	90.4
3	MS Temperature before ESV	Deg C	535.0	535.0
4	1st stage pressure	kg/cm ² (a)	-	76
5	FW Temp at Eco inlet	Deg C	236.85	237.0
6	FW Flow (Including SH attemperation)	T/hr	258.0	296.0
7	SH Attemp. Flow	T/hr	0.0	24.0
8	Test CW Inlet Temperature	Deg C	32.0	36.0
9	Design CW Inlet Temperature	Deg C	32.0	32.0
Gross Turbine Cycle Heat Rate (Current Test)		kcal/kWh	2232	2625

Test & Corrected Gross Turbine Cycle Heat Rate (GTCHR)

Test Load	66.0 MW
Design GTCHR	2232 kcal/kWh
Test GTCHR	2625 kcal/kWh (At CW inlet temp of 36 Deg C)
Corrected GTCHR	2605 kcal/kWh (For design CW inlet temp - 32 Deg C)

The Corrected Gross turbine Cycle Heat Rate as per test data (corrected for design CW inlet temperature) is 2605 kcal/kWh at 66.0 MW load as against design GTCHR value of 2232 kcal/kWh.



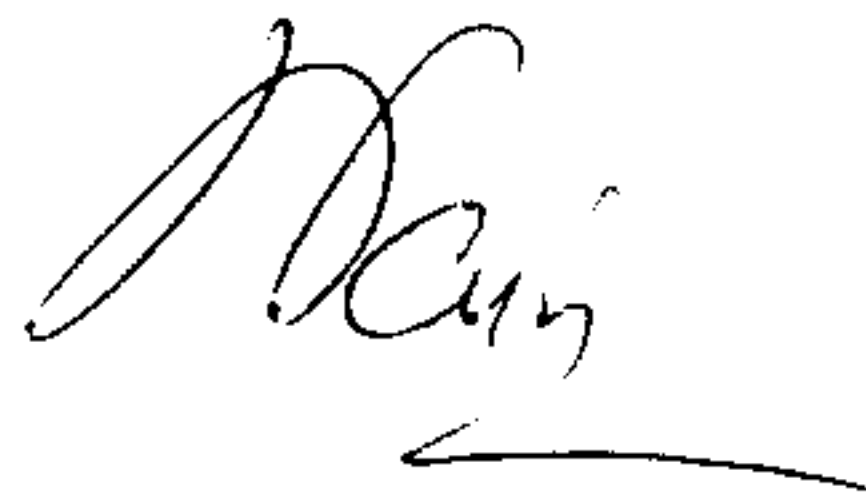
Annexure I

The following points were discussed during the visit of Mr. A.K.Arora and Mr. P Nag from CenPEEP/NTPC on 13th August'10 regarding Unit Heat Rate Assessment tests at Rajghat (2X67.5 MW)

- a) Heat Rate Test in Unit 1 & 2 would be conducted on 17th August from 1100 to 1300 hrs and 1500 to 1700 hrs respectively.
- b) Test instruments like Gas analysers, Conditioners, Ultrasonic Flow meter, Psychrometer, Thermocouples, Temp Readouts etc. would be shifted from CenPEEP, Noida to Rajghat on 16th August.
- c) HP heaters in both the units would be taken in service on 16th August. Operating condition to be maintained for the tests is enclosed as Annexure I.
- d) Station would provide five helpers to assist during the tests. (Two helpers for coal and ash sampling, one helper for flue gas sampling and two helpers to assist on Turbine side activities).
- e) Parameters that need to be cross-checked before the tests have been identified and list provided to station for checking the same.
- f) A listing of parameters has been made for recording parameters during the test; the same can be configured in Unit DCS and averaged at a 5 minute interval. List enclosed as Annexure II.
- g) The following requirements were identified during walk down with Mr. Harish (Boiler Maintenance).
 - Coal sampling points would be restored in feeder inlet chutes for raw coal sampling in both the units.
 - Test Port flanges / covers in air heater inlet and outlet gas ducts would be loosened / checked in both the units prior to the tests.
 - One test port in Unit 2 AH outlet gas duct is fouling with a temporary box structure, which needs to be removed for the traverse.
 - Four no. 3/8" tubes, each 3 m long would be arranged for traverse in gas ducts for gas composition and temperature measurement.
 - 220V supply point would be arranged at Air Heater location. CenPEEP would bring its own power boards for power supply.
- h) The following requirements were identified during walk down with Mr. K D Mishra (Chemistry).
 - Incremental coal samples would be collected from feeder inlet chutes of all running feeders during the tests.



- Incremental fly ash samples would be collected separately from left and right side from 1st ESP hopper.
 - Bottom ash sample would be collected just after the test.
- i) The following requirements were identified during Turbine side walk down with Mr. Narender (Turbine Maintenance).
- Locations for FW flow measurement were identified in BFP discharge header around 5 m elevation. 1.5 m insulation needs to be removed at identified location and a Table / platform to be arranged for the measurement in both the units.
 - 220 V power supply needs to be arranged near the test locations.

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Operating Conditions for the Heat Rate Tests

- k) Unit operation is kept steady for two hours prior to and during the tests.
- l) Tests to be conducted at rated load at nominal operating parameters to the extent possible.
- m) No furnace blowers or air heater blowers are operated during the test.
- n) Main Steam Pressure and Temperature are maintained as close as possible to the design values.
- o) Auxiliary PRDS steam flow is kept isolated for the unit being tested.
- p) Continuous blow down and Intermittent blow down is not operated during the test.
- q) All FW Heaters are kept in service with normal drip cascading.
- r) No mill changeover is done during the test and the test is conducted without any oil support.
- s) Economiser hopper de-ashing is not done during the test.
- t) Bottom hopper de-ashing is done prior to the test stabilisation period and immediately after the test.



Walkdown Report Annexure II

List of Parameters required to be grouped in DCS

Sr. No.	Parameters	
1	Unit Load	
2	MS Pr. Before ESV	
3	MS temp. Before ESV	
4	MS Pr. (Boiler end)	
5	MS temp. (Boiler end)	
6	FW Flow	
7	SH Spray Flow	
8	MS Flow	
9	BFP discharge flow	
10	BFP discharge Pr.	
11	BFP discharge temp.	
12	HPH - 1 FW Inlet temp	
13	HPH - 1 Ext steam pr.	
14	HPH - 1 Ext steam temp.	
15	HPH - 1 drip temp.	
16	HPH - 2 FW inlet temp	
17	HPH - 2 Ext steam pr.	
18	HPH - 2 Ext steam temp.	
19	HPH - 2 drip temp.	
20	HPH - 2 FW outlet temp	
21	FW temp at Eco inlet	
22	FW pr. at Eco inlet	
23	FW temp at Eco outlet	
24	Turbine first stage pr.	
25	Condenser Vacuum	
26	CEP suction temp.	
27	CW inlet temp.	
28	CW outlet temp.	
29	D/A Ext pr.	
30	D/a Ext temp	
31	CEP discharge temp.	
32	Drum pr.	
33	O2 percentage	
34	Total coal flow	
35	Total air flow	
36	Secondary air flow	
37	Windbox pr. - Left	

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38	Windbox pr. - Right	
39	Hot PA header pr.	
40	Mills Currents A/B/C/D/E	
41	Mills airflows A/B/C/D/E	
42	Mills inlet temps A/B/C/D/E	
43	Mills outlet temps A/B/C/D/E	
44	FG temp at AH inlet	
45	FG temp at AH outlet	
46	Air temp at AH inlet	
47	Air temp at AH outlet	
48	AH DP Air	
49	AH DP Gas	
50	FD - A/B discharge pr.	
51	ID fan A/B Current	
52	FD fan A/B Current	
53	PA fan A/B/C/D/E Current	

Kam

The main activities carried out during Unit 1 Boiler & Turbine Overhaul

Boiler

1. Thickness survey of erosion prone area in the furnace and second pass including boiler to high heat zone.
2. Replacement of the plugged/blanked coils of economizer.
3. Platen superheater: Radiography of dissimilar joint (~600 joints) and defective joints welding. (~200 nos.)
4. Replacement of damaged worn out coal nozzles, air/oil nozzle tips and gaskets and replacement of 15 nos. coal pipe elbows.
5. Servicing of SADC dampers and repair of the wind box
6. Repair of flue gas duct (~200 sqm) in the second pass from eco outlet of 34.9 meter level to ESP inlet including replacement of worn out supports limited to 40 nos. In-situ repair of ESP guide vanes.
7. Air pre heater work: Repair / replacement of seals, baskets & other related duct work.
8. Repair of roof of penthouse and economizer roof by patch work including replacement of supports in economizer duct and refractory work/insulation work in the pent house.
9. Repair of furnace casing
10. Removal and reapplication of insulation and cladding in boiler (~1500 sqm)
11. CAVT diagnostic analysis & CFD in the Boiler
12. CFD analysis of flue gas duct and ESP to reduce ID fan energy requirements and reduce SPM emission
13. Replacement of ~ 600 nos. of bank tubes.
14. Conversion & retrofit of non metallic expansion joints in place of the existing metallic expansion joint in the second pass duct. (09 nos.)

Turbine

15. Refurbished spare turbine rotor was used during overhauling.
16. Mainly works was done on rotor refurbishment were sand blasting of rotor, NDT of rotor including MPI, Re-blading of LP stage – II, refining and machining of fins, dressing of damaged blades of other stages and slow speed balancing.
17. Sand blasting of all internals and rotor.
18. Removal of ovality, re-finishing and machining of GBC-I, GBC-II, GBC-III, GBC-IV, Balancing piston, Rear gland & Inner casing.
19. Matching of parting plane of casing, all GBC.
20. Replacement of front bearing (bearing No.1), complete set of thrust pad (active and non active) and front steam gland of turbine with new one after proper matching.



21. Modification of front pedestal by installation of Lubroid Plate, hardened plate in place of spherical washer arrangement.
22. Replacement of holding down bolts of front bearing with bigger size and disc spring.
23. Modification of rear pedestal by replacement of inner side bolts with M64 size in place of M56, replace existing four no. bolts of sole, exhaust and bearing housing plates with M56 bolts in place of M42 bolts and installation of two additional bolts of size M56 for more strengthen rear pedestal.
24. Replacement of all coupling bolts with new one after proper lapping/ honing as the spare rotor was used.
25. Replacement of oil flow control valves of jacking oil system with new one and modification also done by separating oil control of bearing no. 1 & 2 from common header.
26. Complete service of ejectors.
27. Complete service & cleaning of tubes of both turbine lube oil coolers.
28. Complete service & cleaning of tubes of all generator air cooler.
29. Replacement of Main Oil Pump with new one.
30. Replacement of complete Lube oil with fresh oil after proper cleaning of Main Oil Tank
31. Services of all control valves and both ESV.
32. Replacement of all condenser tubes (except air zone) with new one.
33. Replacement of L.P. Heater No.-2
34. Replacement of H.P. Heater No.-1.
35. Services of Deaerator, cleaning of Deaerator tank and replacement of vent condenser.



The main activities carried out during Unit 2 Boiler & Turbine Overhaul

Boiler

1. Thickness survey of boiler tubes, water walls, platen super heater, final super heater & economizer (~ 10306 spots)
2. Repair of tubes (~989 joints)
3. Replacement of tubes/bends (989 joints water wall, 177 joints platen superheaters (~2400 meters of fin welding)
4. Welding of scalloped bar at different level of boiler around w/w tubes
5. Flushing of bottom water wall header (Hand holes of ring headers - 04 nos.)
6. Repair of Economizer coil (~2995 joints)
7. Replacement of bank tubes (~254 tubes)
8. Replacement of Swage Tubes (40 nos.)
9. Repair / replacement of 20 nos. of damaged worn out coal burner nozzles
10. Repair/ replacement of air/ oil nozzle assembly (12 nos.)
11. Servicing of SADC dampers (20 nos.)
12. Replacement of defective PC elbows(20 nos.)
13. Replacement of defective coal discharge pipes & its sleeves
14. Replace/replacement of defective expansion joints
15. Repair of ducting (~20 tons)
16. Overhauling of both FD & ID fans (02 nos.)
17. Servicing of 22 nos. of wall blowers & 01 no. air preheater soot blower
18. Air tightness test of boiler on positive pressure of 50 mmWC
19. Removal of ash from pent house / dead chamber/ bottom ash hopper & cleaning of all areas of boiler including ground floor to pent house
20. Insulation work (~1798 sqm)
21. Air pre heater work: Repair / replacement of seals, baskets & other related duct work.


Turbine

22. Sand blasting of all internals and rotor.
23. Removal of ovality, refinishing and machining of Rotor, GBC-I, GBC-II, GBC-III, GBC-IV, Balancing piston & Inner casing.
24. Matching of parting plane of casing, all GBC.
25. Replacement of Rear steam gland of turbine with new one.
26. Modification of front pedestal by installation of Lubroid Plate, hardened plate in place of spherical washer arrangement.
27. Replacement of oil flow control valves of jacking oil system with new one.
28. Complete services of ejectors.




29. Complete services & cleaning of tubes of both turbines lube oil cooler.
30. Replacement of dampers with new one.
31. Services of all control valves replacement of cone and spindle of Control valve No. 1 and replacement of spindle of Control valve No. 2, 3, 4 & 5 and bushes of all control valves.
32. Services of both ESV and replacement of oil seals and O rings.
33. Replacement of all condenser tubes (except air zone) with new one.
34. Replacement of L.P. Heater No.-2
35. Services of Deaerator, cleaning of Deaerator tank

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		CONTRACT DATA SHEET				CONTRACT No 0419 & 0420	
PURCHASER		DELHI ELECTRICITY SUPPLY UNDERTAKING					
PLANT NAME		RAJGHAT T. P. S.				UTILITY	
PROPOSED FUEL		Bituminous Coal		Ash Fusion Temp.	HHV Kcal/Kg.	Grindability (HGI)	
FCx 34	Vol. x 21	Moist x 10	Ash x 35	Sx 05	—	4230	55
FUEL BURNING EQUIPMENT							
TYPE	Coal Burner - FT		Oil Burner - FT		Type : HP 703-P		
MAKE & NOS	BHEL-20		BHEL-12		Make & Nos BHEL - 5		
CONTROL	Air Damper		Air Damper		Capacity 24200		
CAPACITY	16.4 x 10 ⁶ Kcal/h		4.7 x 10 ⁶ Kcal/h		Motor KW 260		
DISPOSITION	Corner		Corner		System: Pressurised		
FURNACE		Type Fusion Welded, Dry Bottom					
Width 7899 mm		Depth 7899 mm		Volume m ³ 1268			
		Fuel Heat Input 187 x 10 ⁶ Kcal/h					
BOILER	Furnace EPRS 834m ²		Boiler Bank 980 m ²		Design 110 kg/cm ² (g)		
DESIGNATION	$\frac{26}{26}$ VU 40 $\frac{66}{36}$ $\frac{1}{2}$ $\frac{64}{20}$ x $\frac{20}{76}$		PRESSURE		Super Heater Outlet 95 Kg/cm ² (g)		
SUPERHEATER		Stage : I Type : Platen SH				440	
TOTAL H S m ²		Stage : II Type : Final SH				1580	
ATTENUATOR		Type : Spray		No of Stages Single		Medium of Spray Feed Water	



		CONTRACT DATA SHEET				CONTRACT No 0419 & 0420				
ECONOMISER	Type : Plain Tube	Total : H. S Area m ² = 2078			No of Blocks : Two					
AIR HEATER	Type : 25 VI 1850 (2000)	Total : HS. m ² 11333			Motor kw 75					
		Nos. One			Make BHEL					
BOILER AUXILIARIES										
FANS	Type	Make	Nos	Flow m ³ /s	Pressure mmwc	Temp. °C	Drive	Speed rpm	Motor kw	Control
FD FAN	NDZV 19 TIEFSTACK	BHEL	02	57.0	505	50	Motor	980	400	Inlet Damper
PA FAN	NDV 17 Taranto	BHEL	05	18.0	680	290	Motor	1480	190	Inlet Damper
ID FAN	NDZV-25 Sidor	BHEL	02	81.0	345	155	Motor	740	400	Inlet Damper
SOOT BLOWERS	Type		Make		Nos		Medium			
FURNACE	Wall Blowers RW 5E		BHEL		22		SH Steam			
SH & BOILER BANK	LRSB T 30 Mark 1 E		BHEL		06		SH Steam			
AIR HEATER	Swivel Arm Type		BHEL		01		SH Steam			
DUST COLLECTOR	Make	Nos.	Dust Concent at Inlet Worst coal	Gas Weight Kg/h	Press Loss mm wc	Power Consum K W	Flue Gas Flow	Efficiency		
Elect. Precipitator	BHEL	02	gms/Nm ³ 65.4	385100	15	320	m ³ /s 130.8	99.78		
PIPE LINES	Main Steam		Feed Water							
Size	355.6 x 37		219.1 x 25							
No. of Lines	01		01							

Dein



CONTRACT DATA SHEET

CONTRACT No
0419 & 0420

BOILER MOUNTINGS

	Location	Type	Make	No.	Sat Pr Kg cm ²	Size
Safety Valves	Drum	1758 WA	BHEL	02	110, 111	75/150
	SH. Outlet	1738 WD	BHEL	01	100	63/150
	ESV	1538 VX	BHEL	01	99	63/100
Water Level Indicator	Drum	Multipoint Bi-Colour	Yarway	02	—	395
	Fire Man's Floor	Manometric	Yarway	01	—	395

MAIN PARAMETERS

FUEL			BITUMINOUS COAL			
			Unit	MCR	NCR	60% MCR
STEAM	FLOW	SH Outlet	t/h	275	259	162
	Total Heat. to Super Heater		M Kcal/h	161.9	152.2	93.6
	Pressure at Super Heater Outlet		Kg/cm ² (g)	95	94.2	91.2
	Temperature at SH Outlet		°C	540	540	540
Feed Water Temperature			°C	235	236	211
Ambient Air Temperature			°C	40	40	40
Combustion Air Temperature			°C	345	342	292
Fuel Quantity			t/h	44.2	41.5	25.3
Air Quantity (TOTAL)			t/h	321.6	302.3	183.8
FLUE GAS	Temp. Of Gas to Boiler Exit (Corrected)		°C	148	147	125
	Temp. Of Recirculation Gas		°C			
	Quantity Of Recirculation Gas		t/h			
Efficiency Based on HCV			%	85.5	86.6	87.4

Annexure IV

Boiler Performance Assessment Test
Rajghat Power Station
Unit # 1

Date:	17.08.2010
Time:	11:45-1315

Barometric Pressure		740	mmHg
Temperature	Start	End	
Dry Bulb Temperature	34	35.0	Deg C
Wet Bulb Temperature	28.5	28.5	Deg C

1st Round - AIR HEATER INLET

OXYGEN (%)						
2	4.3	3.9	3.2	3.6	3.7	4.7
1	4.6	3.8	3.8	3.8	4.4	5.0
Port	A	B	C	D	E	F
AVG. OXYGEN AT AH INLET				4.1	%	

TEMPERATURE (degC)						
2	325.0	327.0	329.0	321.0	317.0	316.0
1	322.0	321.0	324.0	317.0	310.0	306.0
Port	A	B	C	D	E	F
AVG. FLUE GAS TEMP AT AH INLET				319.6	Deg C	

1st Round - AIR HEATER OUTLET

OXYGEN (%)						
2	5.7	5.5	6.1	6.2	6.5	6.0
1	5.3	5.6	6.0	6.4	6.0	6.8
Port	A	B	C	D	E	F
AVG. OXYGEN AT AH -A OUTLET				6.0	%	

TEMPERATURE (degC)						
2	155	150.0	140.5	134.7	132.0	135.0
1	145.0	153.0	146.0	135.0	135.0	133.5
Port	A	B	C	D	E	F
AVG. FLUE GAS TEMP AT AH OUTLET				141.2	Deg C	

2nd Round - AIR HEATER INLET

OXYGEN (%)						
2	4.2	3.9	3.2	3.6	3.7	4.6
1	4.6	3.9	3.8	3.9	4.5	5.0
Port	A	B	C	D	E	F
AVG. OXYGEN AT AH INLET				4.1	%	

TEMPERATURE (degC)						
2	324.0	327.0	327.0	325.0	315.0	316.0
1	321.0	320.0	322.0	317.0	312.0	307.0
Port	A	B	C	D	E	F
AVG. FLUE GAS TEMP AT AH INLET				319.4	Deg C	

2nd Round - AIR HEATER OUTLET

OXYGEN (%)						
	5.7	5.5	6.4	6.2	6.5	6.1
	5.3	5.7	5.7	6.4	6.1	5.9
Port	A	B	C	D	E	F
AVG. OXYGEN AT AH OUTLET				5.9	%	

TEMPERATURE (degC)						
	155.0	151.0	143.0	135.0	132.0	135.0
	143.0	154.0	146.0	135.0	134.0	133.0
Port	A	B	C	D	E	F
AVG. FLUE GAS TEMP AT AH OUTLET				141.3	Deg C	

San

Boiler Performance Assessment Test
Rajghat Power Station
Unit # 2

Date:	17.08.2010
Time:	15:00-1630

Barometric Pressure		740	mmHg
Temperature	Start	End	
Dry Bulb Temperature	35.5	35.0	Deg C
Wet Bulb Temperature	28.5	28.5	Deg C

1st Round - AIR HEATER INLET

OXYGEN (%)						
2	2.1	1.9	2.4	0.9	1.0	1.9
1	3.0	2.5	2.7	1.2	1.4	1.9
Port	A	B	C	D	E	F
AVG. OXYGEN AT AH INLET					1.9	%

1st Round - AIR HEATER OUTLET

OXYGEN (%)						
2	4.5	4.6	5.1	4.9	3.9	3.8
1	4.0	4.8	5.5	5.3	3.3	3.0
Port	A	B	C	D	E	F
AVG. OXYGEN AT AH -A OUTLET					4.4	%

TEMPERATURE (degC)						
2	361.0	364.0	367.0	361.0	356.0	362.0
1	351.0	356.0	362.0	356.0	352.0	354.0
Port	A	B	C	D	E	F
AVG. FLUE GAS TEMP AT AH INLET					358.5	Deg C

TEMPERATURE (degC)						
2	171	172.0	166.0	160.0	164.0	160.0
1	171.0	162.0	159.0	156.0	163.0	156.0
Port	A	B	C	D	E	F
AVG. FLUE GAS TEMP AT AH OUTLE					163.3	Deg C

2nd Round - AIR HEATER INLET

OXYGEN (%)						
2	2.2	1.8	2.3	0.9	0.9	1.8
1	3.5	2.4	2.7	1.2	1.5	2.3
Port	A	B	C	D	E	F
AVG. OXYGEN AT AH INLET					2.0	%

2nd Round - AIR HEATER OUTLET

OXYGEN (%)						
	4.4	4.8	5.2	5.5	3.9	4.4
	4.3	5.7	5.6	5.3	3.0	4.0
Port	A	B	C	D	E	F
AVG. OXYGEN AT AH OUTLET					4.7	%

TEMPERATURE (degC)						
2	362.0	365.0	368.0	361.0	357.0	362.0
1	351.0	357.0	362.0	357.0	353.0	355.0
Port	A	B	C	D	E	F
AVG. FLUE GAS TEMP AT AH INLE					359.2	Deg C

TEMPERATURE (degC)						
	170.0	172.0	166.0	160.0	164.0	160.0
	168.0	163.0	160.0	156.0	163.0	156.0
Port	A	B	C	D	E	F
AVG. FLUE GAS TEMP AT AH OUTLE					163.2	Deg C

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**Boiler Performance Assessment Test
Rajghat Power Station Unit 2
Control Room Data**

Date: 17.08.10

		PG Test	15:00 Hrs	1520 Hrs	15:40 Hrs	16:00 Hrs
		Oct-91				
Unit Load	MW	67.5	66.7	65.6	67	67.8
MS Flow	t/hr	277.7	304	305	306	307
FW flow	t/hr	268.3	315	312	316	315
SH Spray flow	t/hr	12.6	24	25	24	25
Drum pressure	ksc		102	99	100	100
MS Pressure	ksc	93.6	92	91	93	92
MS Temperature	C	537.3	530	529	539	535
FW Temp at Econ. Inlet	C	240	243	242	243	243
FW Temp at Econ. Outlet	C	289	-	-	-	-
O2%	%		1.7	1.9	1.9	1.9
Total Air Flow	t/hr	299.3	245	246	244	244
Secondary Air Flow	t/hr	—	132	132	130	130
Windbox Pressure Left	mmWC	—	55	55	54	60
Windbox Pressure Right	mmWC	—	89	89	89	90
Hot PA header pressure	mmwcl		-	-	-	-
Mills in service	—	BCD	CDE	CDE	CDE	CDE
Mills Currents A/B/C/D/E	A		22/22/22	22/22/22	22/23/22	22/23/22
Mill Airflows A/B/C/D/E	t/hr	39/32/32	37/34/36	37/34/36	37/34/36	34/35/36
Mill Inlet temperatures	C	-154/220	296/276/279	296/276/280	295/276/279	294/275/280
Mill Outlet Temperatures	C	70/63/75	80/76/80	80/75/78	80/77/79	80/76/79
FG Temp at AH Inlet	C	350.3	347	347	346	347
FG Temp at AH Outlet	C	147.7	181	181	181	181
Air Temp at AH Inlet	C	30.0	43	43	43	42
Air Temp at AH Outlet	C	330.1	326	326	326	325
AH DP Air	mmWC	41.1	59	56	61	66
AH DP Gas	mmWC	99.2	76	77	75	78
FD A/B Discharge Prsr	mmWC	190/204	133/125	133/125	139/137	135/137
ID fan A Suction/Discharge Prsr	mmWC	144.6/9.6	-	-	-	-
ID fan B Suction/Discharge Prsr	mmWC	-10.9	-	-	-	-
ID fan A/B Current	A		42/40	42/40	42/40	42/40
FD fan A/B Current	A		36/36	36/36	36/36	36/36
PA fan current A/B/C/D/E	A		18/18/19	18/18/19	18/18/19	18/18/19
CBD posn		Closed		A PRDS	CLOSED	
AH Sootblowers in service		No				



Boiler Performance Assessment Test
Rajghat Power Station Unit 2
Control Room Data

Date: 17.08.10

		PG Test	15.00 Hrs	1520 Hrs	15.40 Hrs	16.00 Hrs
		Oct-91				
Unit Load	MW	67.5	66.7	65.6	67	67.8
MS Flow	t/hr	277.7	304	305	306	307
FW flow	t/hr	266.3	315	312	316	315
SH Spray flow	t/hr	12.6	24	25	24	25
Drum pressure	ksc		102	99	100	100
MS Pressure	ksc	93.6	92	91	93	92
MS Temperature	C	537.3	530	529	539	535
FW Temp at Econ. Inlet	C	240	243	242	243	243
FW Temp at Econ. Outlet	C	289	-	-	-	-
O2%	%		1.7	1.9	1.9	1.9
Total Air Flow	t/hr	299.3	245	246	244	244
Secondary Air Flow	t/hr	---	132	132	130	130
Windbox Pressure Left	mmWC	---	55	55	54	60
Windbox Pressure Right	mmWC	---	89	89	89	90
Hot PA header pressure	mmwcl		-	-	-	-
Mills in service	---	BCD	CDE	CDE	CDE	CDE
Mills Currents A/B/C/D/E	A		22/22/22	22/22/22	22/23/22	22/23/22
Mill Airflows A/B/C/D/E	t/hr	39/32/32	37/34/36	37/34/36	37/34/36	34/35/36
Mill Inlet temperatures	C	-/154/220	296/276/279	296/276/280	295/276/279	294/275/280
Mill Outlet Temperatures	C	70/63/75	80/76/80	80/75/78	80/77/79	80/76/79
FG Temp at AH Inlet	C	350.3	347	347	346	347
FG Temp at AH Outlet	C	147.7	181	181	181	181
Air Temp at AH Inlet	C	30.0	43	43	43	42
Air Temp at AH Outlet	C	330.1	326	326	326	325
AH DP Air	mmWC	41.1	59	56	61	66
AH DP Gas	mmWC	99.2	76	77	75	78
FD A/B Discharge Prsr	mmWC	190/204	133/125	133/125	139/137	135/137
ID fan A Suction/Discharge Prsr	mmWC	144.6/9.6	-	-	-	-
ID fan B Suction/Discharge Prsr	mmWC	-/10.9	-	-	-	-
ID fan A/B Current	A		42/40	42/40	42/40	42/40
FD fan A/B Current	A		36/36	36/36	36/36	36/36
PA fan current A/B/C/D/E	A		18/18/19	18/18/19	18/18/19	18/18/19
CBD posn		Closed		A PRDS	CLOSED	
AH Sootblowers in service		No				

[Signature]

Turbine Test Average data (17.08.2010)

Sr. No.	Parameters	Design	Units	Average Unit 1 12:03PM to 13:03PM	Average Unit 2 15:03PM to 16:03PM
1	Unit Load	67.5	MW	69	67
2	MS Pr. Before ESV	90	Ata	90	90
3	MS temp. Before ESV	535	Degree C	539	537
4	MS Pr. (Boiler end)		Ata	91	92
5	MS temp. (Boiler end)		Degree C	533	541
6	FW Flow	258.037	TPH	234	316
7	SH Spray Flow	0	TPH	17	25
8	MS Flow	257.44	TPH	256	308
9	BFP discharge flow	258.16	TPH	248	284
10	BFP discharge Pr.	142.68	Ata	144	134
11	BFP discharge temp.	157.93	Degree C	160	164
12	HPH - 1 FW inlet temp	157.93	Degree C	160	164
13	HPH - 1 Ext steam pr.	15.236	Ata	HPH not i/s	13
14	HPH - 1 Ext steam temp.	292.89	Degree C	HPH not i/s	260
15	HPH - 1 drip temp.	165.71	Degree C	HPH not i/s	186
16	HPH - 2 FW inlet temp	192.52	Degree C	HPH not i/s	193
17	HPH - 2 Ext steam pr.	21.621	Ata	HPH not i/s	37
18	HPH - 2 Ext steam temp.	406.59	Degree C	HPH not i/s	421
19	HPH - 2 drip temp.	200.43	Degree C	HPH not i/s	244
20	HPH - 2 FW outlet temp	236.85	Degree C	HPH not i/s	240
21	FW temp at Eco inlet	236.85	Degree C	150	240
22	FW pr. at Eco inlet	140.1084	Degree C	101	104
23	FW temp at Eco outlet		Degree C	171	#DIV/0!
24	Turbine first stage pr.		Ata	58	76
25	Condenser Vacuum	0.094	Ata	662	679
26	CEP suction temp.	44.26	Degree C	64	54
27	CW inlet temp.	32	Degree C	36	36
28	CW outlet temp.		Degree C	47	46
29	D/A Ext pr.	5.756	Ata	7	6
30	D/A Ext temp	195.15	Degree C	254	252
31	CEP discharge temp.	44.72	Degree C	56	56

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