Title:

Study of Operation and maintenance of 210 MW Ghorasal Power Station

A Thesis Submitted in the fulfillment of the requirements for the Degree of B.Sc. in EEE.

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APPROVAL

This thesis titled **"Study of Operation and maintenance of 210 MW Ghorasal Power Station"** submitted by **S.M.Rokibul Islam** and **Arifuzzaman** to the Department of Electrical and Electronics Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Electrical and Electronics Engineering and approved as to its style and contents. The presentation has been held on

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DECLARATION

We hereby declare that, this thesis has been done by us under the supervision of **Ms. Rifat Abdullah, Department of EEE** Daffodil International University. We also declare that neither this thesis nor any part of this thesis has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

This thesis is on **“Study of Operation and maintenance of 210 MW Ghorasal Power Station’’** Ghorasal power station is a subsidiary of Bangladesh Power Development Board and one of the largest power station in Bangladesh.Ghorasal power station follows international operations and maintenance standard and adopt modern technology,quality performance and satisfactory services to the consumers.To ensure successful commercial operation with meaning increase of income,this power stations fixed targats, determaine the actvites and mathods of achieving targats, resource requirements and responsivitities of the officers and staffs.total capacity of Ghorasal power station has 950 MW .

Study of Operation and maintenance of 210 MW Ghorasal Power Station

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Chapter 3

Chapter 4

Chapter 5

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Chapter 8

START UP OF 210 MW FROM COLD STATE

GENERAL

1. Make sure that all the Maintenance works have been done and clearances are received.

2. Ensure that,
(i) All Technological protection and Interlocking of Boiler and Turbine were checked by the Automation Division .
(ii) Electrical protection of ID Fan, FD Fan, FWP, CW Pump and Generator were tested by the Generator Division.
(iii) Ignition Torches of the Burners were tested by the Automation Division.

3. Check Oil system of Boiler and Turbine, Cooling water lines, safety valves .

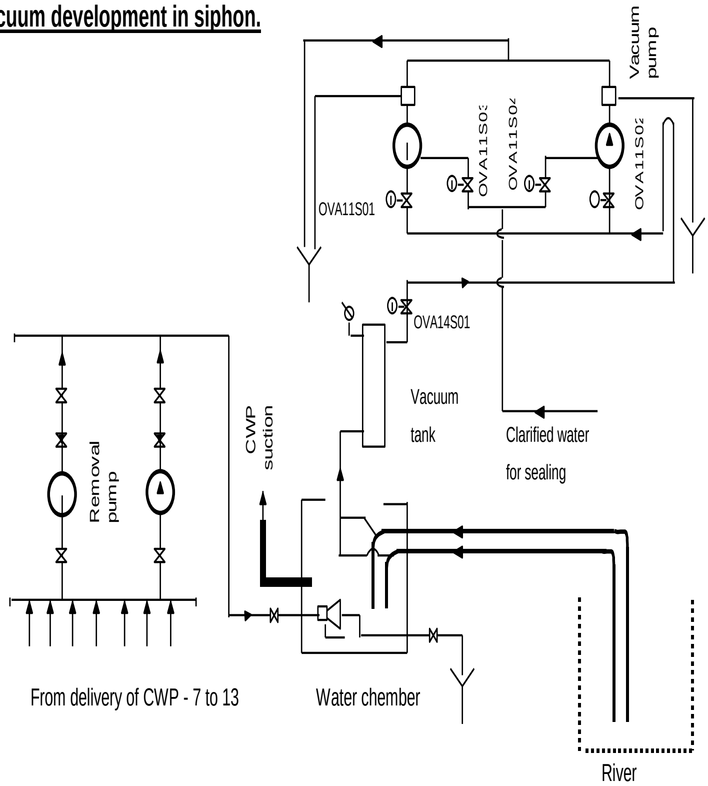
PREPARATION AND START UP OF CIRCULATING WATER SYSTEM.

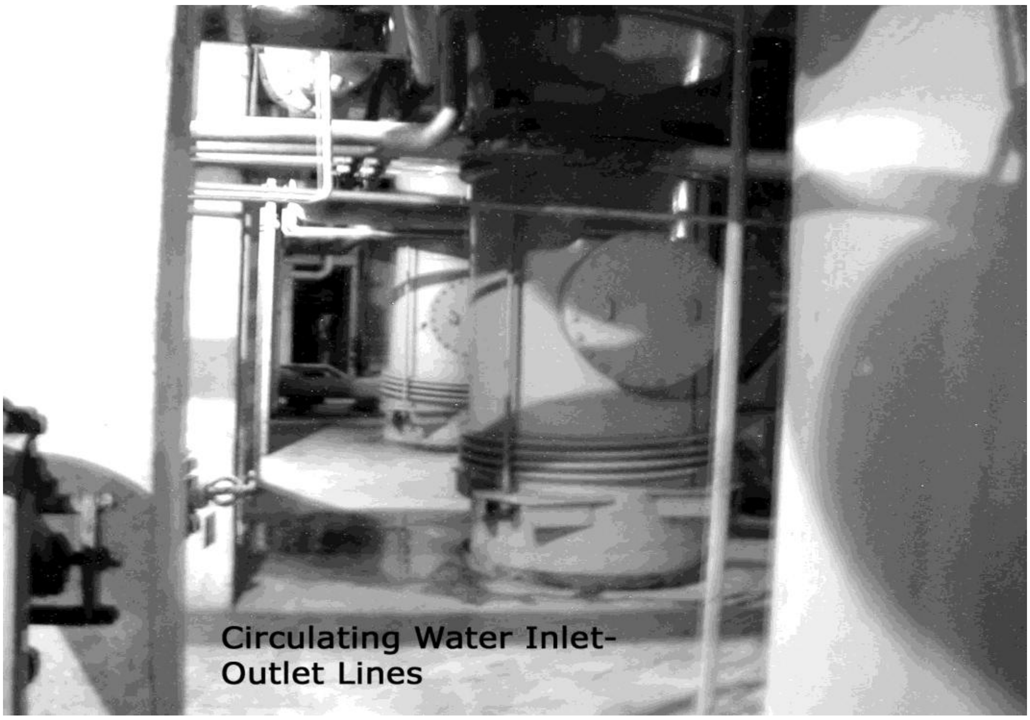
1. Check Oil tank in the Pump house, CW Pump, CW lines and Condenser.

2. Ensure that the flanges of the Condenser manholes are closed tightly.

3. Ensure that (for Pump) :
(i) the water chamber is filled up to the open end of the siphon pipe by the Air Removal Pump with the water from the delivery line of the running Pump.
(ii) The suction valve of Screen flushing Pump connected to the delivery line of the running C.W Pump valves No. OVC63S01 & OVC64S01 are required to be opened.
(iii) After starting up either of Pumps the delivery valves OVC63S02 or OVC64S02 to be opened for screen net flashing.

Filling / Empty of Water chember and vacuum development in siphon.





4. Electrical supply of the vacuum Pump is required to be made on. Open valves of vacuum Pump sealing line valves No. OVA11S03 or OVA11S04. Start vacuum Pump and ensure the vacuum of the siphon is about - 0.6 kg/cm^2.

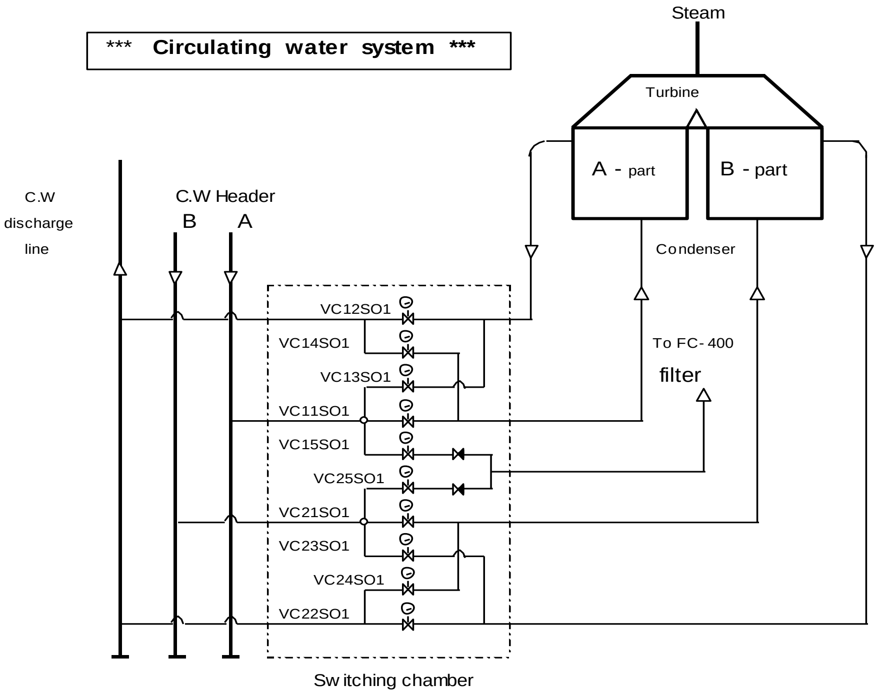
5.Check the clarified water pressure to the bearing of CW Pump.

6. Open the gate valve on the discharge line of circulating water from Condenser valves.

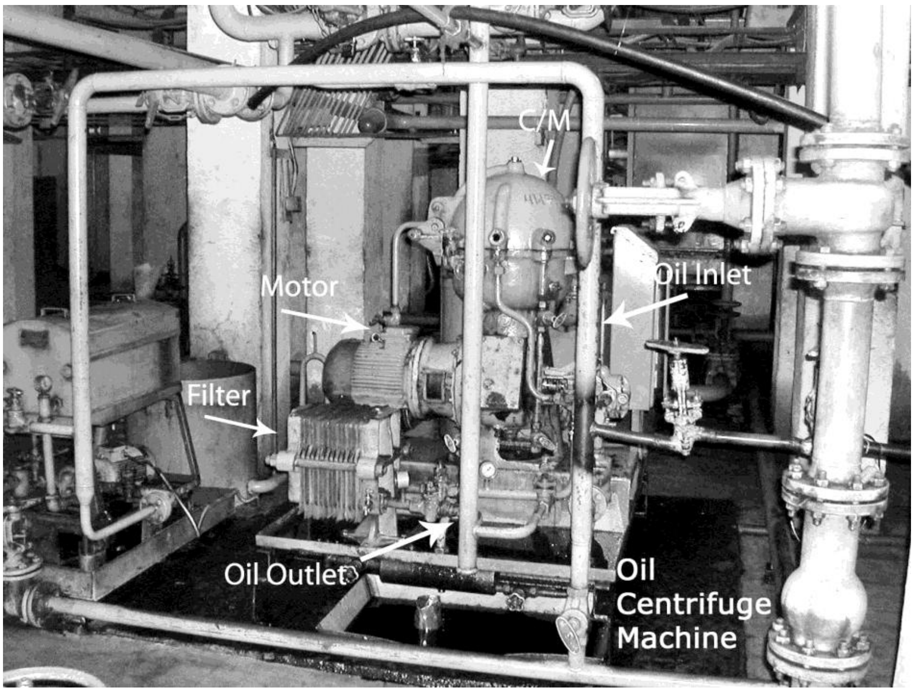
7. Close gate valves Nos. VC13S01, VC14S01, VC23S01 and VC24S01.

8. Start the CW Pumps and fill the both parts of the Condenser with circulating water.

9. Open the manual valve of the air suction from circulating water line of the Condensers upper side.



12. Open gate valves No. VC15S01 and VC25S01 to supply cooling water for other auxiliary equipment and open gate valves No.VC31S01, VC31S02 and VC31S03 and fill FC-400 filters. Remove air from the FC-400 filters by opening air vent.



CONDENSER FILLING WITH DEMI WATER

1. Close drainages of Condenser, check reserve Demi-water tank level. If the level of the tank is satisfactory start normal makeup Pump valves No. OUE21D01, OUE22D01 or by the emergency make up Pump (if required).

2. Open the regulating valve UE31S02 from UCB and gate valves after and before of this regulating valve.

3. Open Electrically operated gate valve No. UE32S03 and Regulating valve No. UE32S02 if required.

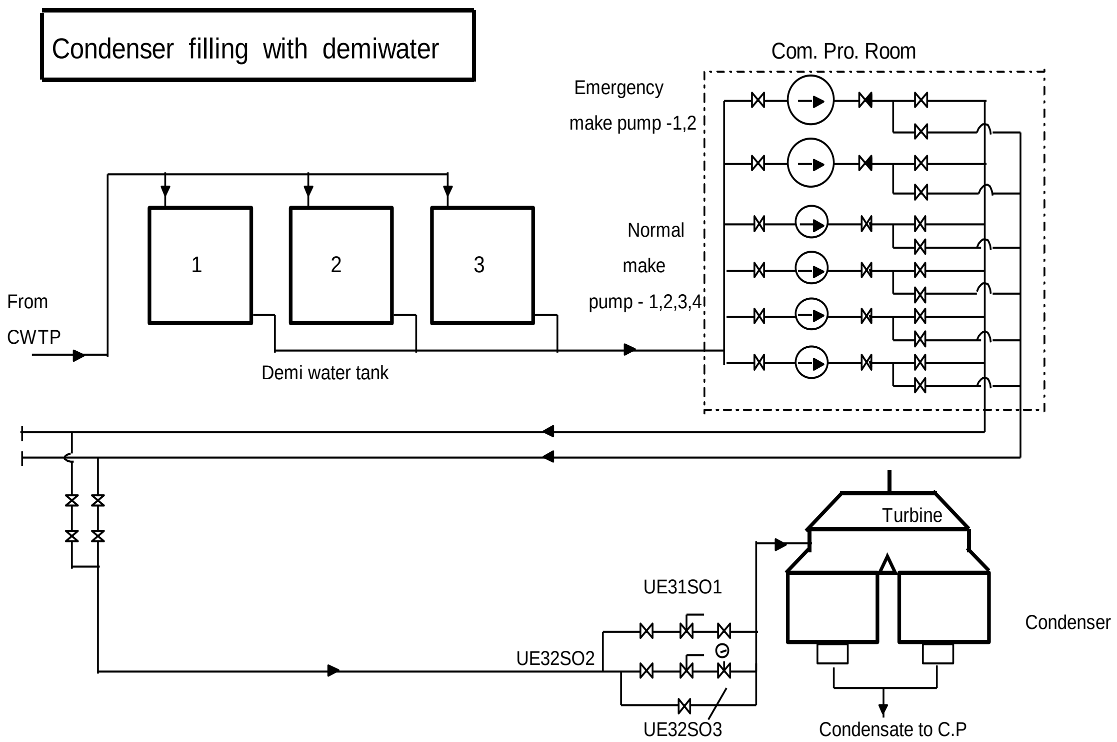
4. Filling of the Condenser is continued until its level becomes 2/3rd of the gauge glass of the Condenser.

6. Start the Condensate Pumps and open the delivery valve quickly.

7. Close valve RM70S01 and open valve RM53S01 for re-circulating and continue it for 30 minutes.

8. Demi -water of the Condenser should have the result of the chemical analysis as below:

SiO_2 <100 µg /liter
Fe <100 µg /liter
Hardness <3 µg /liter

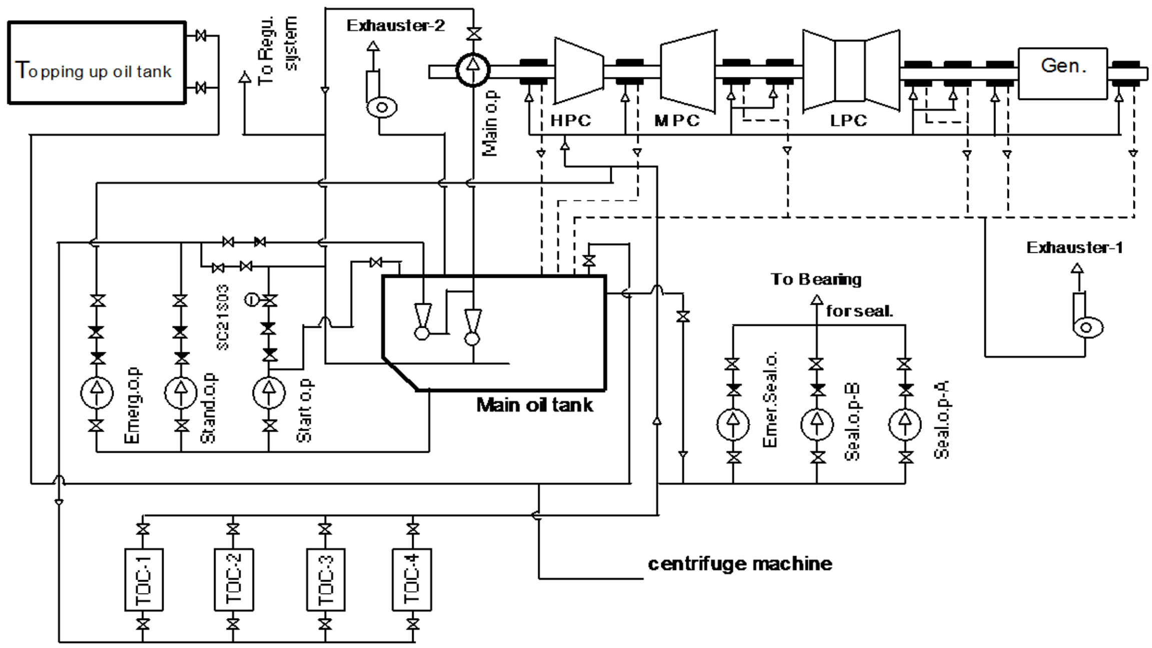


<u>**Preparation and start up of oil system of Turbo -Generator**</u>

1 i) Drain water sediment from Oil Tank.
ii) Test the oil quality.
iii) Check the level of Main Oil Tank, Topping up Oil Tank & Feed Pump Oil Tank.

2. Open the gate valve in the suction line of Starting Oil Pump, Stand by Oil Pump & Emergency Oil Pump and Pumps are filled up with oil by opening the vent valves.
3. After air release close vent valves.

OIL SYSTEM



4.Check the satisfactory functioning of Stand by Oil Pump, Starting Oil Pump & Emergency Oil Pump.
i) Start Stand by Oil Pump.
ii) Start starting Oil Pump & Stop Stand by Oil Pump. Ensure bearing lub oil pressure is 1 kg/cm ^{2} & in Governing system around 20 kg/cm^2.
iii) Open stop valves & regulating valves.
iv) Drop oil pressure to 10 kg /cm^2.
v) Drop further oil pressure to 6 kg/cm^2 and observe closing of stop valves of M.P cylinder
vi) Again open stop valves & regulating valves and test manual tripping from U.C.B & Machine house.
vii) Stop starting oil Pump.

5. Put into operation A.C. stand by oil Pump

DEAERATOR FILLING

1. Be sure that the Condenser is filled upto-required level with Demi water.

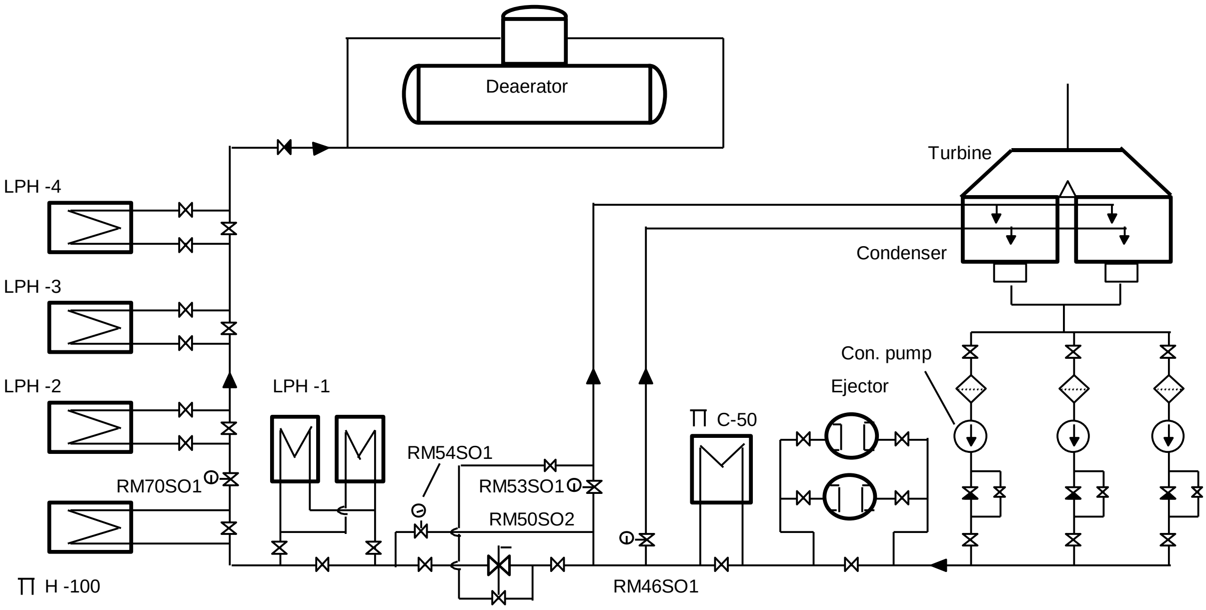
2. Ensure the closing of Extraction line from Turbine to LP heaters valves No.RH60S01, RH50S01 and RH42S01.

3. Open manual valves in inlet and outlet Condensate line of LP heaters valves No. 1, 2, 3 & 4 and close there by pass valves.

4. Open manual valves before and after RM50S02 and switch on RM50S02 for regulation of level in Condenser.

5. Open the valves on the Condensate line before and after the Main ejectors and close the bypass line.

6. Open the manual gate valves of Condensate lines before and after πc-50 and πH -100 and close their bypass valves



DEAERATOR FILLING

7. Open the RM70S01.

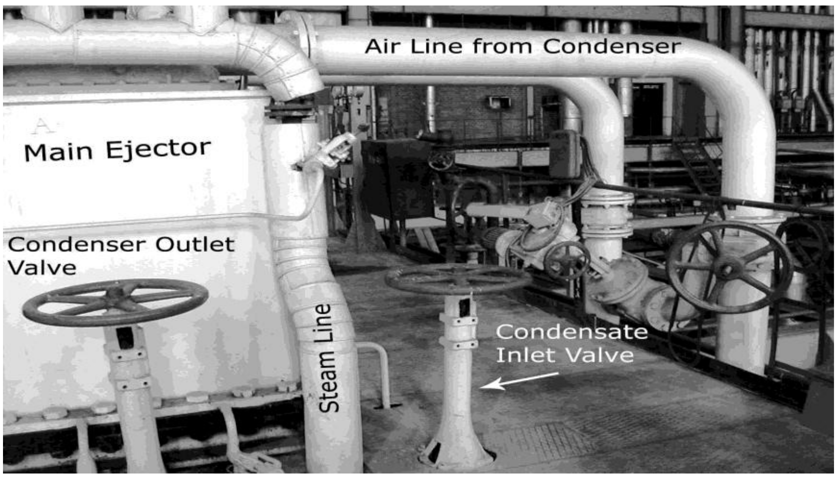
8. Close the valves of main Condensate lines.

FILLING UP OF BOILER DRUM.

1. Filling up the Boiler drum should be started with deaerated water through Economizer.

2. Temperature of water for filling up the empty drum should not be higher than 40^{o}C than the temperature of the Drum metal.

3. Check the proper functioning of the gate valves.

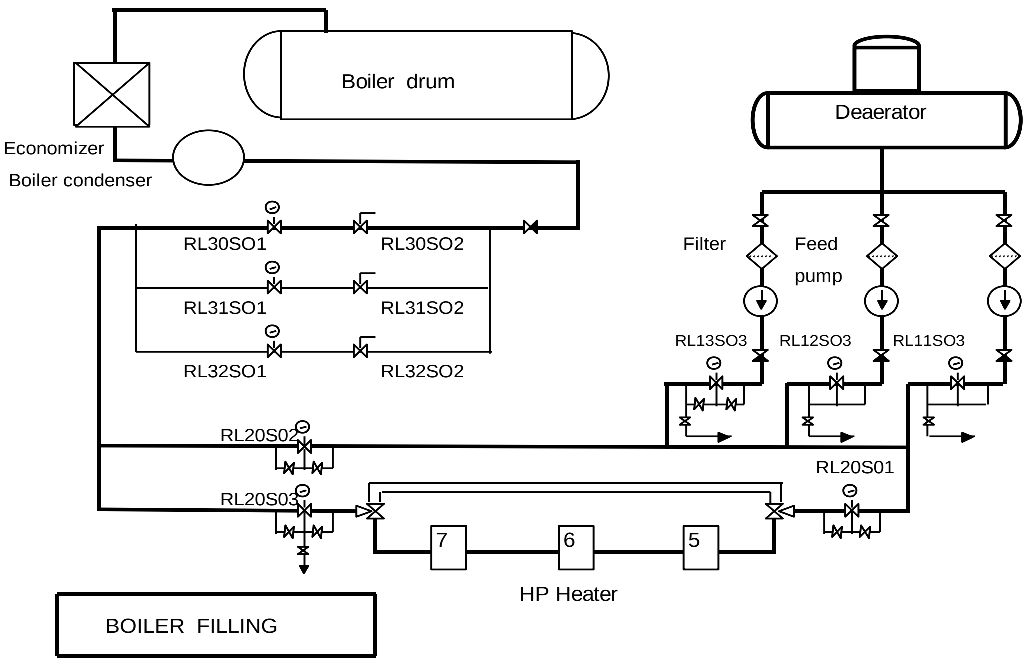


4. Ensure the condition of the Feed Pump is ok.

i) Supplying sealing water to FWP by opening two manual gate valves before and after the regulating valve.

ii) Switch of the oil Pumps should be changed to start position.

5. Close all drainages of feed lines, Economizer steam blow down of the lower collector; open air release vents prepare the feed line by passing all HP heaters.



6. Open the manual suction valve on feed line from Deaerator to feed Pump.

7. Close Drum re-circulation valve No. NA32S01.

8. Start FWP for filling Boiler Drum.

9. Monitoring of the water level in the Boiler drum is required to be done continuously during the filling of the Boiler Drum.

10. Open the gate valve RL32S01 of 65 mm dia feed line and open the regulating valve No. RL32S02 of the same line.

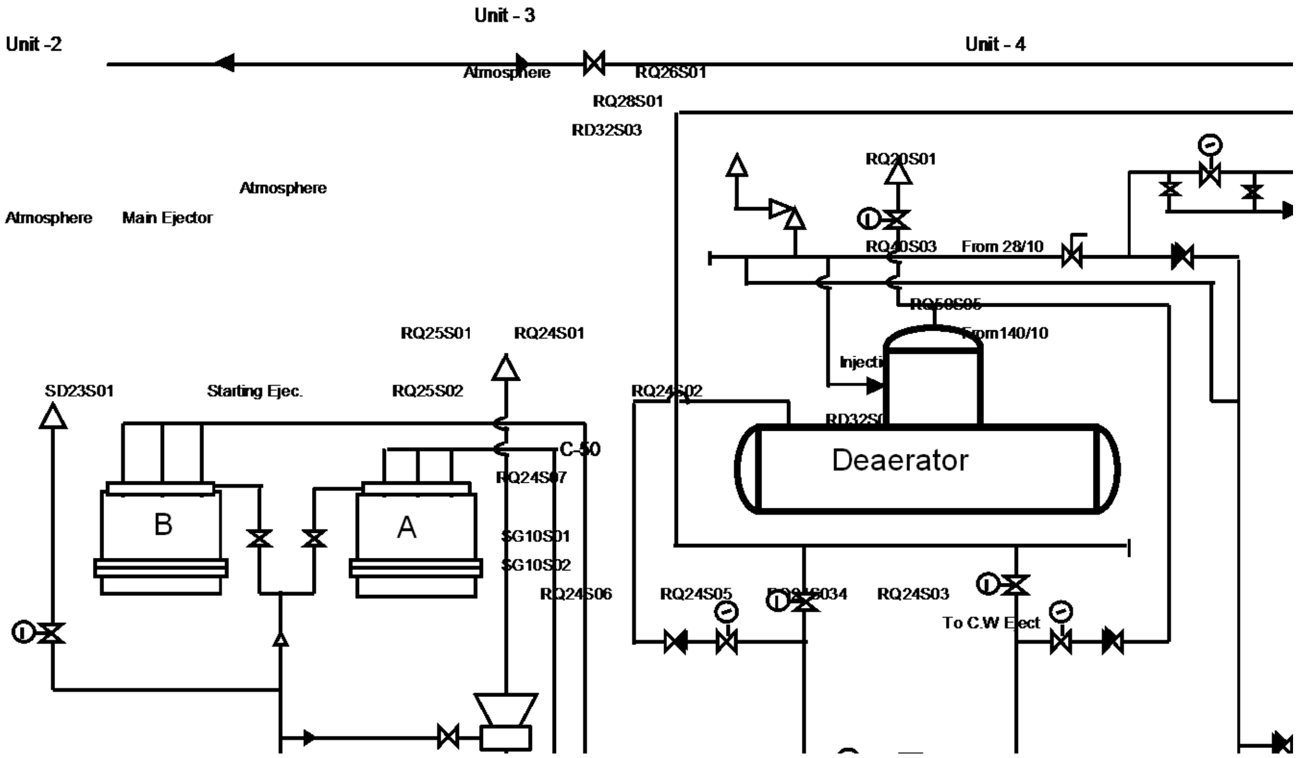
11. Open re-circulation gate valve from drum to Economizer

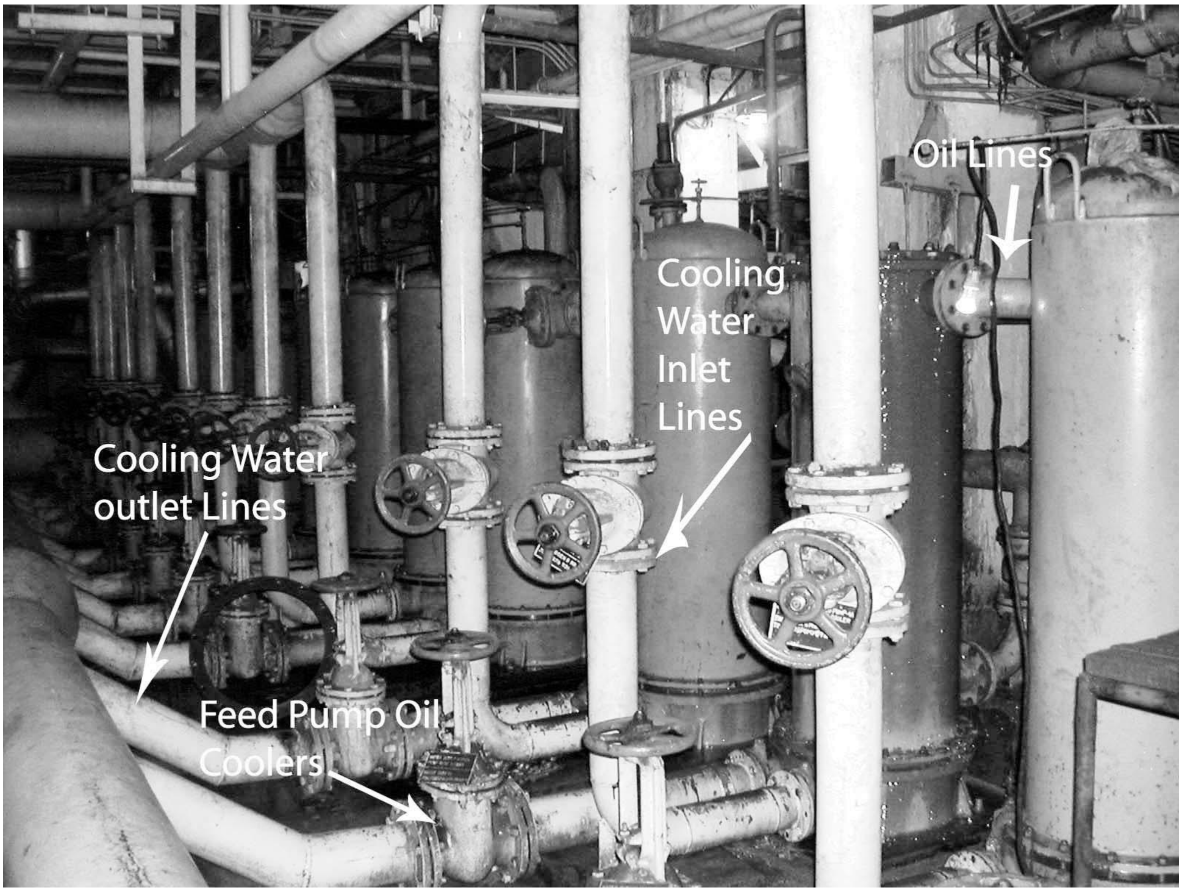
PREPARATION OF VACUUM SYSTEM FOR START UP.

1. Ensure proper operation of the Circulating water system, Condensate system, Generator shaft sealing system, Turbine lubricating system.

2. Start Shaft turning gear.

3. Close all air suction valves of LP and HP heaters to Condenser.


Unit -2
Unit - 3
Unit - 4
Atmosphere
RQ26S01
RQ28S01
RD32S03
RQ20S01
Atmosphere
Atmosphere
Main Ejector
RQ40S03
From 28/10
RQ25S01
RQ24S01
From140/10
SD23S01
Starting Ejec.
RQ25S02
RQ24S02
C-50
Deaerator
RQ24S07
B
A
SG10S01
SG10S02
RQ24S06
RQ24S05
RQ24S03
To C.W Eject


Oil Lines
Cooling Water Inlet Lines
Cooling Water outlet Lines
Feed Pump Oil Coolers

BOILER START UP

1. Make sure that maintenance works are finished and sites are clear.
2. Check all gas valve except NP10S01 and air guide vanes, their remote drives and position indicators.
3. Check readiness of ID Fan, FD Fan, RID Fan and RAH for start up.
4. Check impulse safety valves and their weight.
5. Prepare phosphate-dosing system.
6. Check oil level and purity of oil in the oil station of boiler side.
7. Open feed water re-circulation valve.

FIRING OF BURNERS AND HEATING UP OF TURBINE

1. Open manual valve on ignition line (150 mm dia) for burner No.2 &5.
2. Press start button for burner No. 2 & 5.
3. Check ignition flame.
4. Open electrically operated Gas valves.
5. Open manually operated Gas valves and adjust pressure of gas before burners 0.1 kg/cm^2.
6. Check the flame.
7. Switch off the ignition device. Make sure that the combustion is smokeless adjust gas pressure about 0.05kg/cm^2 and air pressure about 60kg/m^2
8. Open steam blow down valve.

TURBINE START UP.

1. Ensure.that
   - i) Shaft turning gear is in operation.
   - ii) Level of vacuum tank is satisfactory.
   - iii) Full closing of steam extraction line of HP & LP heater from Turbine.
   - iv) Technical water Pump, Gas cooling Pump and Stator cooling Pump are in operation.
2. Ensure before putting the Turbine into Rolling
   - A. Live steam temperature before stop valve = 300^o-320^{O}C
   - B. Live steam pressure = 20-25 kg/cm^2
   - C. Condenser vacuum not less than = - 0.748 kg/cm^2 (550 mm of Hg).
   - D. Span of rotor bending indicator at the UCB should not exceed 0.07mm
   - E. Rotor axial shift within- 0.5 mm to-0 mm.

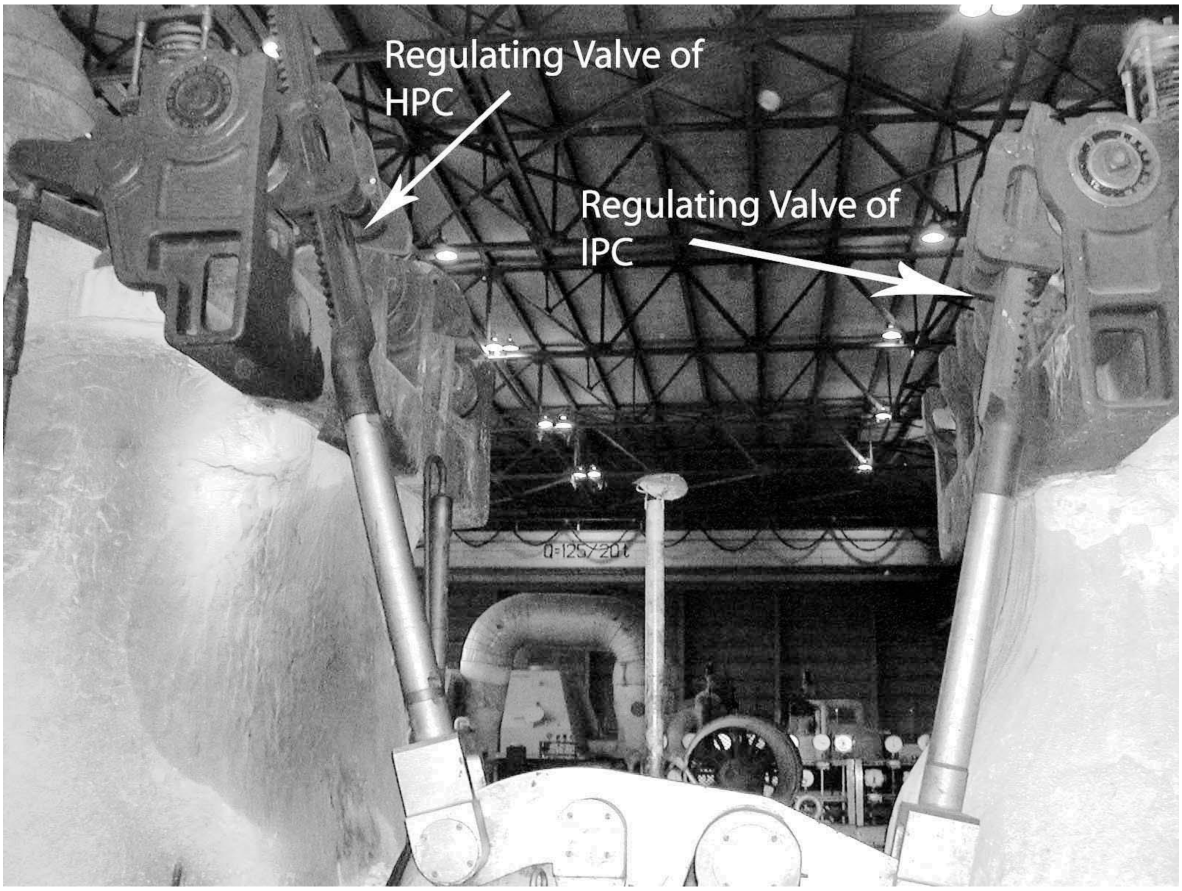
F. Differential expansion of HP rotor = (-1.2 mm to + 4 mm).
G. Differential expansion of IP rotor = -2.5 to + 3mm.
H. Differential Expansion of. LP rotor= -2.5 to + 4.5mm.
I. Difference of temperature of top and bottom HPC = 50 ^{O}C
J. Difference of temperature between top and bottom IPC =60 ^{O}C
K. Oil temperature after cooler = 40-45 ^{O}C.
L. Condenser level is satisfactory.
M. Pressure in Condenser is not higher than 0.3 kg/cm^2.
N. Live steam should have the following constituents within the limits.
SiO_2 < 100 µg / kg Fe< 100 µg / kg H= 1 µg eq/liter.

PUTTING THE TURBINE IN ROLLING.

1. If the parameters mentioned earlier are ok, the Turbine is to be pushed by opening the regulating valves by moving the control gear wheel in anti clockwise direction. Close the stop valves of IP cylinder manually for not to allow the discharge steam of HP cylinder to pass through IP and LP cylinder. Allow the discharge steam of HP cylinder through cold and hot reheat lines to Condenser through steam dumping valves 2. Increase the speed up to 500 RPM.

3. Check the decoupling of the Shaft turning gear.

4. Listen to the Turbine for detection of any abnormal noise and vibration wait for 10-15 minutes at 500 RPM.



5 If the HP rotors relative expansion increases to +4 mm start heating flanges and studs. Steam pressure in the header of flanges 2.0kg/cm^2 and for stud header it is 4 kg/cm^2 obtained by Manual gate valves. Open the drain valves No. SM21S01 and SM22S01.

6. As the steam flows through HPC Increases close the Broy (140/10 ata) station gradually. Increase the RPM up to 1200 slowly within 3-5 minutes. At that time rotor distortion should not exceed 0.1 mm. Wait 10-15 minutes for heating and listening if there is any abnormal noise.

7. During warm up the temperature increase should be as follows.

a. 100-200^{o}c, 4 ^{O}C/min.

b. 200-300^{o}c, 3 ^{O}C /min.

c. 300-400^{o}c, 2 ^{O}C /min.

d. 400-500^{o}c, 1 ^{O}C /min.

e. 500- above 0.6 ^{O}C /min.

8. Make ready the 230 KV outdoor switchgear.

9. When the required temperature of IP stop valve and main crossover pipes is obtained increase the speed of the Turbine from 1200 RPM 2850 RPM continuously without stop. Because the critical speeds of turbo-generator shaft is

1.1459 RPM

2. 1862 RPM

3. 1970 RPM

4. 2487 RPM

10. Close the drain of live steam and reheat steam pipelines. Increase speed up to 3000RPM.

GENERATOR SYNCHRONIZATION WITH GRID.

1. Ensure the satisfactory operation of

A. Gas cooling system.

B. Stator cooling system.

C. Thyristor cooling system.

D. Sealing oil system of generator.

E. Generator is filled with hydrogen with pressure 3kg/cm^2 and purity of Hydrogen is more than 98 %.

3. Open the generator circuit breaker of unit-3 of Bay No. 6 or unit No.4 of Bay No.8 close the isolator of breaker of Bay No.6 or No.8 in 230KV switchyard.

4. Check that the Cooling fans of the unit X-formers are in operation.

5. Ensure that the P.T of the LT side of generator is connected properly.

6. Check that the protection of generator is "ON" in the Protection and Excitation panel in generator terminal room. Panel no-   of unit relay room and panel no-9 of Thyristor relay room.

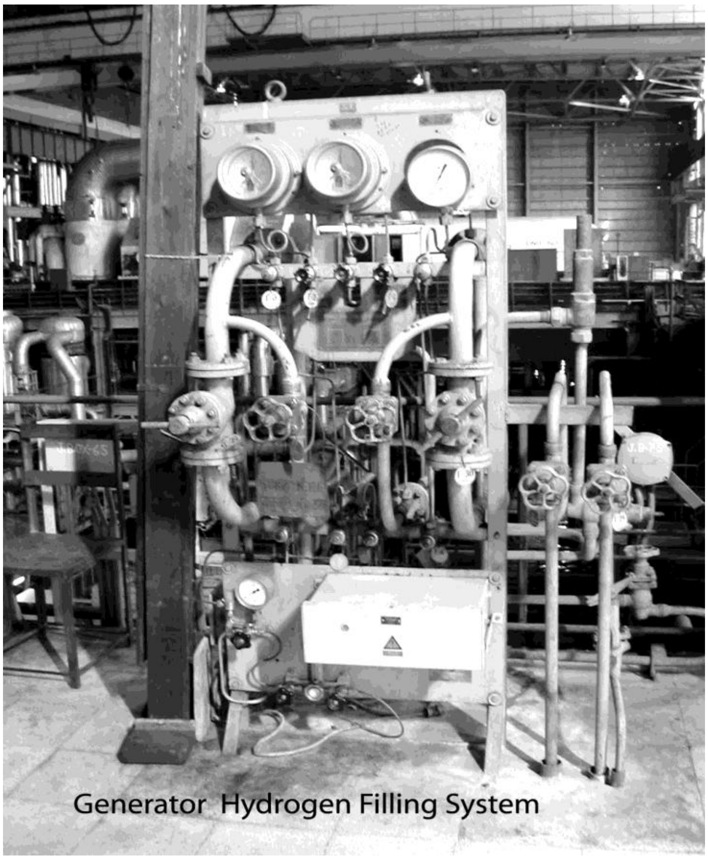
8. Switch on the supply of control circuit.

Generator Circuit breaker in Relay room.

Field Killer.

Input of working excitation.

9. At 3000 RPM place the Selector switch in Panel



LOADING.

1. Take 5-7 MW load by opening the regulating valve fully and closing the Broy (140/6) check up that the servo motor of regulating valves reach not more than 280 mm by scale. Reactive load should be 5-10 MVAR.

2. At boiler drum pressure about 20kg/cm^2 blow down the filters of injection line. At 30kg/cm^2 of drum pressure, water level gauge glass again.

3. At 5-7 MW load heat up Turbine about 30 minutes. The live steam temperature must be 350^o-370 ^{O}C -pressure is about 30kg/cm^2 reheat temperature is 320 ^{O}C HPC Expansion is about 10 mm

4. Close all the drains of Turbine cylinder, cross over pipelines and reheat lines.

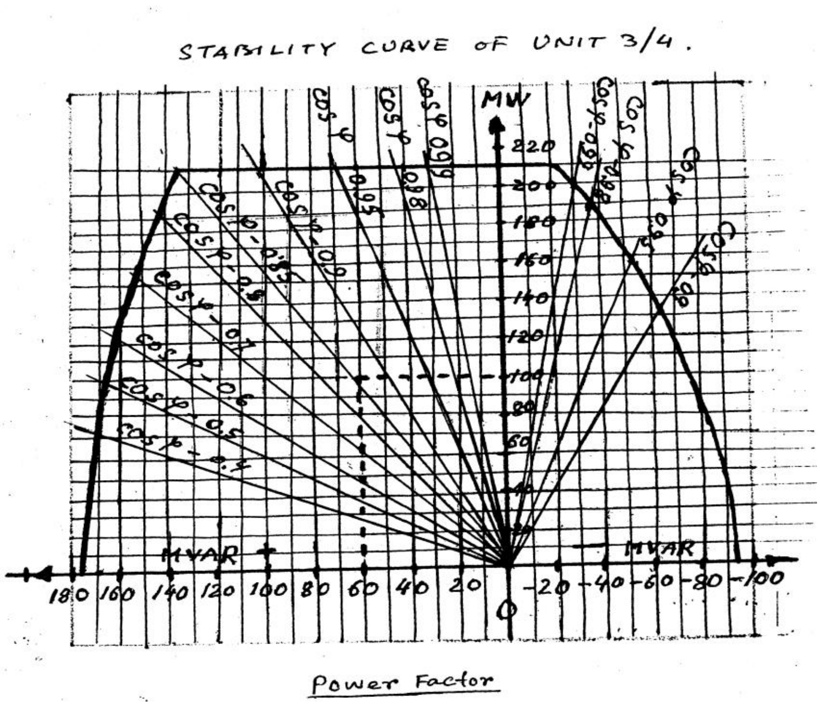
5. Open gate valve on steam suction line from stop and regulating valves. Steams to Deaerator (By opening of the drainages).

6. Check up to the function of all auxiliary equipment of Turbine plants.

7. Check up the oil temperature is about 40-45 ^{O}C , coming from the oil coolers. If necessary the temperature is to be maintain by controlling the water flow through the cooler.

8.Reheat steam temperature may be control by injection. Open gate valve No.RL54S01 and RL55S01 and regulating valves RL54S02 and RL55S02.

9.At about 200/250 ton/hrs. Boiler steam flow, start operation of boiler Condenser injection. Blow down the filters of boiler injection line.



10.Close the supply of steam for heating flanges and studs after reaching a steady live steam temperature around 470-500°C at nominal difference of expansion.

11.When load is 100MW the steam parameters are as follows

Steam pressure before HPC=80 kg/cm^2

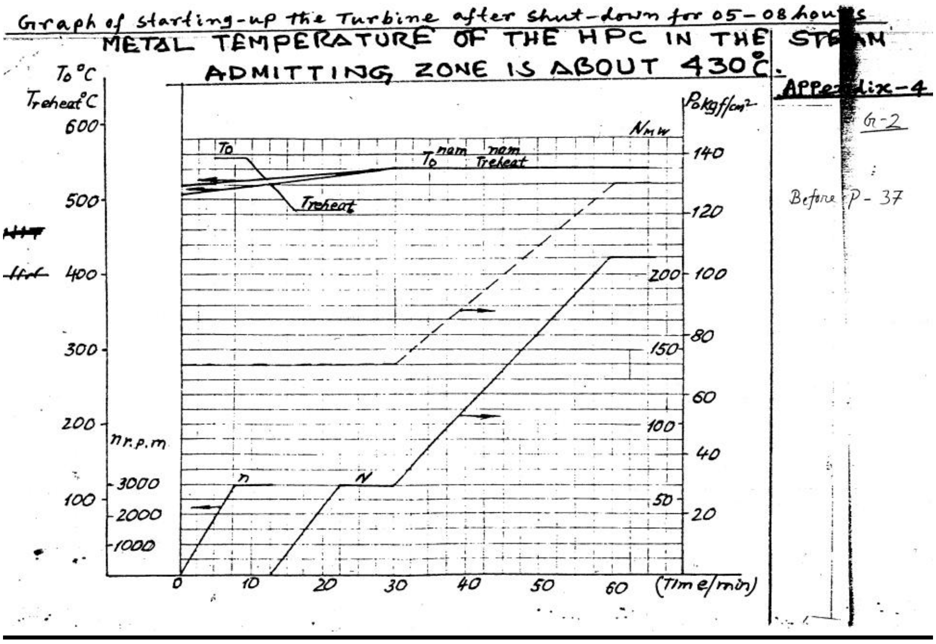
Steam temperature before HPC and IPC = 450 °C

Thermal expansion of HPC = 26 mm.

12.Increase the load up to 130 MW and start second Condensate Pump.

Live steam pressure = 130kg/cm^2

Live steam temperature =530°c


Graph of starting-up the Turbine after shut-down for 05-08 hours
METAL TEMPERATURE OF THE HPC IN THE STEAM ADMITTING ZONE IS ABOUT 430°C.
Appendix-4
G-2
Before P-37
To °C
Treheat °C
Po kgf/cm²
NMW
To nom
Treheat nom
Treheat
n r.p.m
n
N
(Time/min)

STARTING OF 210 MW

FROM HOT AND UNCOOLED CONDITION

Turbine

1.If the temperature of HP cylinder is higher than 400 ^{O}C is called hot and if temperature of lower part of HP cylinder is within 200-400 ^{O}C it is called un-cooled condition of the Turbine.

2.The Turbine of the above condition is not allowed to push to rotate if

a) Difference of temperature between top and bottom of HP cylinder is more than 50 ^{O}C.

b) That of IPC is more than 60 ^{O}C.

c) Rotor bending when running by shaft turning gear is 0.07 mm.

d) Axial shift of rotor and relative expansion of rotor with respect to HP, IP and

LP Cylinders are beyond following limits,

(I) Axial shift –1.7 mm to + 1.2 mm

(II) Relative expansion of HP = -1.2mm to + 4m

(III) Relative expansion of IP = -2.5mm to +3mm

(IV) Relative expansion of LP = -2.5mm to + 4.5mm

4.Start Starting oil Pump and stop Stand by oil Pump.

5.Check that main steam gate valves and their bypass valves are closed. Drains of cross over pipes are closed. Steam suction from valve steam, to de-aerator is closed.

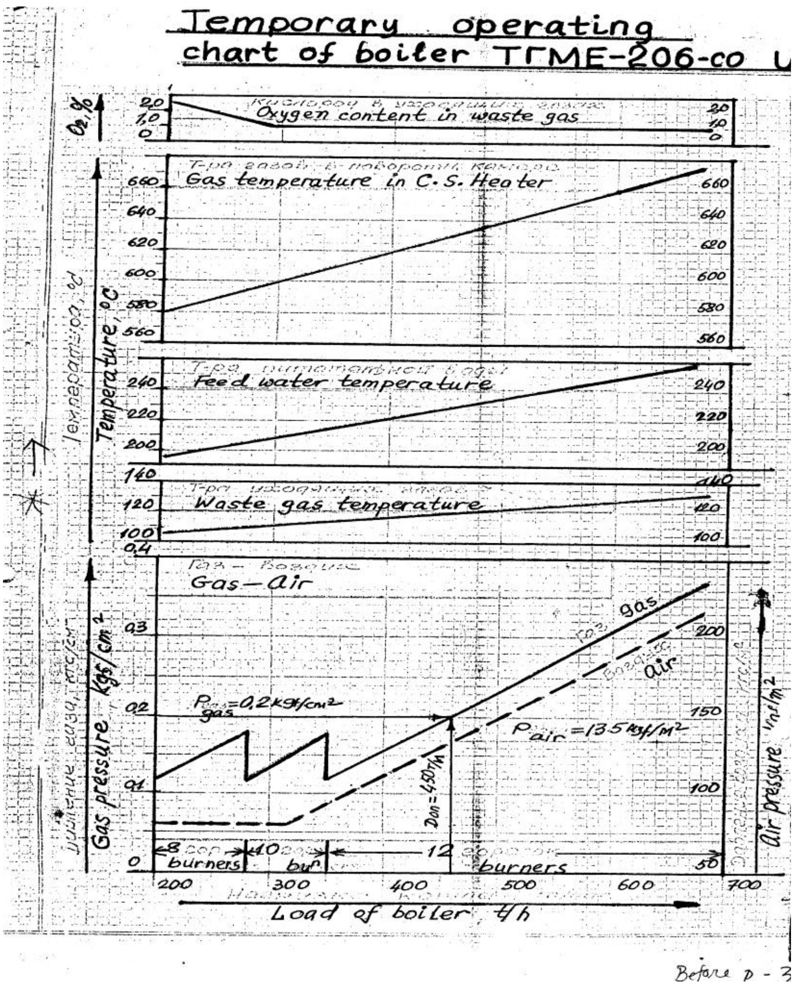
6.Supply steam to end seals and ejectors (starting and main). Watch the increase of vacuum in Condenser.

7.Open drain before Main steam gate valve and quick acting reducing coolant plant (140/6ata).

8.Light up the boiler when the vacuum is more than –0.7kg/cm^2.

9.Discharge steam through Broy (140/6 ata)

10.Close the delivery valve of Starting oil Pump. Check the pressure of Lubricating oil and regulating oil system are ok. Stop the starting oil Pump.



GENERATOR SYNCHRONIZED WITH GRID.

1. Increase the speed up to 3000 RPM.

2.Check that: - The Relative expansion curing of rotor bearing vibration, temperature of oil metal temperature, axial shift are within limits synchronize the generator with grid. Take the load 30-40MW for un-cooled state and 60 MW in hot condition.

3.Close all drains open steam suction line from stop valves steam de-aerator.

4.Wait with initial load for 30 minutes for stabilizing different parameters.

5.If the relative expansion of rotor increases up to 1.5 –2.0 mm. Supply the heating steam to the flanges and studs of HP and IP cylinder and stop the steam supply to front seals of HP and IP cylinder.

№4 Ghorasal TPP.

Chart Table of Boi

Постоянные параметры	Constant parameters.	
Давление первичного пара Live steam pressure	kgf/cm²	135±3
Температура первичного пара Live steam temperature	°C	545
Температура вторичного пара Secondary steam temperature	°C	545
Температура холодного воздуха Cold air temperature	°C	30÷35
Разрежение в топке Vacuum in furnace	кгс/м²	1÷2
Давление в теплом ящике Pressure in hot chamber	кгс/м²	10÷15
Ниже 350т/час отключать верхние горелки: попарно – 9,10 – 8,11 at load less than 350 t/h upper burners are to be put out in pairs – 9,10 – 8,11		
Шибера работающих горелок: – открыты полностью Slide valves of working burners – opened completely		
Шибера отключенных горелок: центр. в-х – открыт, перифер. – закрыт Slide valves of put out burners: central – open; peripheral – closed.		
Рециркуляция дымовых газов – через сопла на фронтов. экране топки Flue gases recirculation – through nozzles on furnace front water wall.		

Переменные параметры	Variable parameters.			100	120	140	160	180	200	210	
Паровая нагрузка Steam load	T/h	200	250	300	350	400	450	500	550	600	650
Давление газа Gas pressure	kgf/cm²	0.11	0.15	0.11	0.12	0.15	0.19	0.23	0.26	0.30	0.34
Давление воздуха air pressure	kg/m²	80	80	80	95	115	130	150	165	185	205
Кислород в дымовых газах Oxygen content in flue gases	%	2.5	1.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Т-ра газов перед ВКПП-I Gas t° before S.C. Superheater-I.	°C	580	585	595	600	610	620	630	640	660	670
Т-ра уходящих газов Waste gas t°	°C	105	107	110	114	116	118	122	124	128	130
Т-ра питательной воды Feed water t°	°C	195	204	209	216	220	228	234	240	246	255
Колич. горелок в работе Number of working burners.	num.	← 8 →		← 10 →		← 12 →					
Колич. ДРГ в работе Number of working G.R.I.D. Fan.	num	← 2 →			← 1 →			← 0 →			
Скорость дутьевых вентилят. F.D. Fan speed.	ck.	← 1 →								← 2 →	
Скорость дымососов I.D Fan Speed.	ck.	← 1 →								← 2 →	

И. О. Нач. КТЦ [signature] /Смородов Н.В./ Ст. инженер [signature] 19.03.85 /Костык В.Н./

Before p-39

When the pressure in the boiler drum is 70 kg/cm^2, put the drum cooling down equipment in operation.

1) The rate of drop of live steam pressure after the boiler is determined by decreasing the temperature of saturated steam in the drum 1 to 2^o c/minute.

2) The rate of drop of live steam and reheat steam temperature is determined by the rate of HPC and IPC metal temperature cooling down 1 ^{O}C /minute)

3) Open Broy (140/6 ata) and decrease the load further up to 10 MW until. The steam pressure becomes 30 kg/cm^2 and temperature 350 ^{O}C within 2.5 Hrs.

4) When the load is 30-40MW stop the LP heaters.

5) When the pressure of steam in cold reheated pipeline decreased to 10kg/cm^2. Put Broy (140/10 ata) station in operation and maintain the temperature in ROY (140/10 ata) station within 200-250 ^{O}C. Switch off BROY (28/10 ata) station.

EMERGENCY SHUTDOWN OF TURBINE

1) To shut down the turbo-generator it is necessary to:

   a. To test the Stand by/ Emergency oil pumps and their automatic reserve closing.
   b. To make sure that the stop valve sand regulating valves of HP and IP cylinder move Smoothly without sticking.
   c. To test all the measuring instruments are in good condition.
   d. To check the bypass valves of main steam gate valves are closed.
   e. To make sure that the quick acting pressure reducing and de-super heating station (Broy 140/6 ata) is ready to put in operation.

2) While decreasing the turbine load it is necessary to control the

   a) Relative expansion of turbine rotors.
   b) Difference of temperature between the top and bottom of HP and IP cylinder.
   c) Vibration of bearing.
   d) Temperature of flanges and studs.

3) If the contraction of the rotors observes it is required to supply live steam to the second Chamber of the front seals of HP and IP cylinder.

4) The temperature of the supplied steam shall not be higher than the temperature of the Metal in the area of regulating zone.

5) Switch off the LP heaters at a load of 30MW.

NORMAL SHUTDOWN OF 210 MW :

1) Before Starting Shut-down check:

i) Oil pumps for starting,
ii) HPC & IPC stop valves for closing 15 mm.
iii) Readiness of QAPRCP.

2) At the rate of 3 MW/MIN, decrease load up to 100MW,Keeping live steam temperature & pressure nominal.

i) At 150-160 MW shut-off HPH steam supply.
ii) At 140 MW stop one feed pump.
iii) At 130-140 MW stop one condensate pump.
iv) At 100 MW supply steam to 10 ata header from 140/10 ata close 28/10 ata. Supply steam to D-7, ejector & sealing from 10 ata header, maintain steam temp at 160^0C.
v) Reduce load up to 70 MW stop during drip pump and send heating steam condensate to condenser.

3) At boiler load 200 t/h close 250mm feed line & operate 100 mm line and maintain drum level.

i) Unload of boiler is done by decreasing gas pressure up to 0.1 kg/cm^2, simultaneously decreasing pressure & temperature & drum temperature difference 40^0C maximum.

4) Decrease load till idling mode (within 10-15 min). Close stop and regulative by key or protection. Close main steam line to D-7.

i) Make sure of closing stop & regulating valve. Close main steam gate valve. Open hot reheat discharge.
ii) Make sure MW is zero, no steam flow, trip generator from grid within 4 minute.

Condenset pump

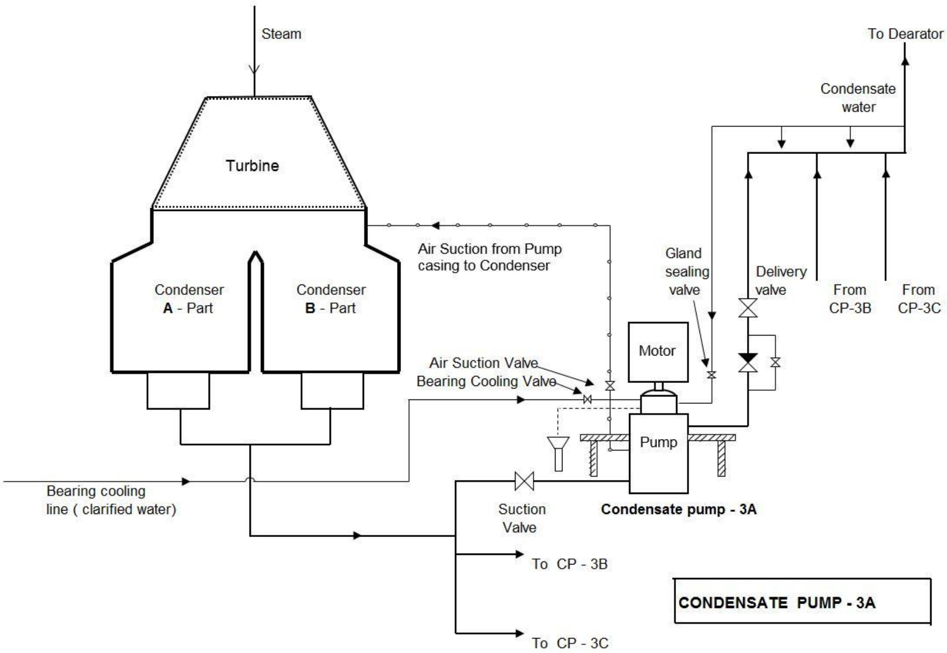
Capacity 174 kw, 6.6kv, 50Hz, 1480 rpm, 320 tn/h.

Normal delivery pressure 15 kg/cm^2, signal 9kg/cm^2 and reserve on 8kg/cm^2

Breaker 6.6kv

Closing procedure for maintanace

1. If one condensate pump is on then another condensate pump have. to on for closing the first one.
2. Then control supply off.
3. Delivery valve of the pump have to close.
4. Suction valve of the pump have to close.



Diesel Fire Fighting pump

Specification:

* Water supply → 290-500 m^3/h
* Head pressure → 120-92m
* Admissible cavitations reserve → 4-5 m.
* Rotations per minute

(a) Nominal → 1500 rpm.
(b) At no load → 500-600 rpm.

Start up procedure:

1. Check the Lub. Oil tank level (above the red Mark)
2. Check the Fuel tank level (above the red Mark)
3. Check the Demi water tank level (above the red Mark)
4. Check the opening of water suction valve of the Diesel fire-fighting pump.
5. Open Inlet & outlet valves on the Lub. Oil line.

Stopping procedure.

1. To stop the Engine decrease the rotation up to 600 rpm and let the Engine work for some time until water and Lub. oil temperature reach $60^{O}C$ or below.
2. Slowly pull the fuel supply handle (lever) to the stop position.
3. Close the valves in fuel and Lub oil lines.
4. Close suction & delivery valve of D.F.F.P and cooling water supply line to bearings and to water cooler.

TURBO GENERATOR

Description and Operating

PURPOSE

The three-phase synchronous hydrogen-and water cooled 210.00 kw, 300 r.p.m. turbo generator of the type TГB-200MT3 is intended for generating electric power when coupled directly is a 210.000 KW, 3000 r.p.m. steam turbine.

The turbo generator is manufactured according to the USSR state standards and IEC Publications. The turbo generator is designed for operation on under conditions of humid tropical climate during installation directly in a machine room.

SPECIFICATIONS

Ratings

The Turbo generator ratings are given in Table I.

Characteristics	Value
Power, KVA/KW	247,000/210,000
Power factor	0.85
Speed of rotation, r.p.m.	3000
Frequency, Hz	50
Number of phases	3
Phase connection	Star
Efficiency, %	98.45
Stator voltage, V	15750 ± 5%
Stator current, A	9060
x Rotor current (estimated), A	1950
Excitation voltage (estimated), V	430
Static overload	1.71
Short circuit ration	0.52

Therewith:

-Altitude above sea-level upto 1000 m;

-Lower value of ambinet air temperature limit up +5^{0}C.

The turbine generator may be installed in regions with increased seismicity upto magnitude 8 by the Mercally Cancanisiberg carthquake intensity scale.

Long-life operation of the turbogenerator at rated duties according to Table I is provided under the following conditions:

not less than -	97.0
Temperature at gas-cooler outlets ^0C about	41
b) characteristics of water entering the gas-coolers:	
flow rate, 1/s	III.I
temperature at inlet, ^0C	34
gauge pressure, MPa (kgf/cm^2)	0.35 (3.5)
pressure drop in gas coolers, MPa (kgf/cm^2)	0.08 (0.8)
c) characteristics of water entering the first heat exchanger circuit:	
flow rate, 1/s	about 56
temperature at inlet, ^0C	34
gauge pressure at inlet, MPa (kgf/cm^2)	not greater than 0.6 (6)
d) characteristics of distillate, entering stator winding:	
flow rate, 1/s	12.0
temperature at inlet, ^0C	41
gauge pressure at inlet, MPa (kgf/cm^2)	not greater than 0.28 (2.8)
gauge pressure at stator winding outlet, MPa/ (kgf/cm^2)	0.05-0.1 (0.5-1)
distillate resistivity at 41^{0}C, kΩ cm not less than	75
e) oil characteristics for bearings and x seals :	
flow rate through the two bearings, 1/s	10
flow rate through the two seals, 1/s continuous duty	3.3
short-time, but not longer than 30 min	5
gauge pressure at entering the bearing, MPa (kgf/cm^2)	0.1-0.17 (1-1.7)
"oil-to-hydrogen" pressure drop, MPa (kgf/cm^2)	0.075±0.005 (0.75±0.05)
temperature at entering the bearing and seal, ^0C	35-45

Permissible Temperatures

Temperature of individual: generator elements should not exceed the permissible limits indicated in Table 6

	Maximum temperature, ^{0}C		
Generator element description	Over the resistor	Over resistance thermometers	Over mercury thermometers
Stator winding	--	95	--
Rotor winding	100	--	--
Stator active steel (in nonend part)	--	105	--
Stator active steel (in end stacks)	--	130	--
Distillate at stator winding outlet	--	85	85

Difference between the readings of any resistance thermometers inserted between bars and the mean temperature of this group of sensors should not exceed +10^{0}C, and between maximum and minimum readings 20^{0}C.

Additional specifications

Critical r.p.m. value:	
first	1280
second	3200
Rotor flywheel moment GD^2, kg m^2 (t.m^2)	25000 (25)
Electrodynamics moment for sudden short circuit, kN m (tf m)	6200 (620)
Mass, kg:	
stator (for mounting purposes)	170000
rotor	48100
one outer shield	6940
brush holder gear without plate	961
one gas-cooler	2330
generator assembly	254000
Overall dimensions of stator, mm:	
length	7720
width	4020
height	4050

Rate critical RPM values for the shaft line of turbo generator for the K-200-130-3 turbine (turbo generator TTB-200MT3) according to the data of the turbine maker are as follows:

first	1530
second	1750
third	1970
fourth	2490
fifth	4640

spring-suspended stator core resonance at rotor,	R.P.M. 2180

Oil temperature, when drained from bearings, ^0C	70
Shaft bearing babbit and oil packing temperature, ^0C	80
Generator specifications for protection selection :	
Phase connection	star
Number of paralled paths	1
Number of terminals	6
Rated value for stator winding capacity per phase,	0.21
Effective value of impact current at sudden three-phase short circuit, A	about 8500

Factor of telephone interferences dose not rated.

Reactance and time constant (rated) values are given in Table 7.

Tab
le 7

8. Reactance, %							**9. Time constants, s**				
X″d	X′d	Xd	X_2	X_0	Td0	$T'd_3$	$T'd_2$	$T'd_1$	T″d	$Td_{2,3}$	Td_1
27	34	200	33	10.2	6.45	1.1	1.72	1.907	0.135	0.315	0.246

X′d is direct-axis sub transient reactance for forward phase sequence;

X′d is direct-axis transient reactance for forward phase sequence;

Xd is direct-axis synchronous reactance;

X_2 is reactance for backward: sequence;

X_0 is reactance for zero sequence;

Tdo is excitation winding time constant for operator winding;

$T'd_3$ is excitation winding time constant for stator winding three-phase short circuit;

$T'd_2$ is excitation winding time constant for two-phase short circuit of stator winding;
Td_1 is apperiodic component time constant for single-phase short circuit.

Shaft Oil Seals

The shaft oil seal is of the end type and includes a stationary housing secured to the outer shield and a moving bush inside the housing.

The bush is permanently pressed to the thrust ring with special springs. The end type design of the oil seal provides insignificant oil flow rate towards the hydrogen chamber, therefore, this type of seal dose not require a unit for vacuum purification of oil.

Cooling

The generator has combined cooling. The stator windings, connection bars and the leads are cooled with water (distillate), and the stator core and the rotor are hydrogen-cooled.

Ventilation of the generator is of a closed-cycle type, the gas being cooled by coolers built into the generator frame. The generator ventilation diagram is given in Fig. I. There is a division into high and low pressure zones.

One part is fed into the hollow conductors of one half of the rotor winding, at slip ring side. The other part, equal to the first, is passed through the two special ducts in the stator frame to the other half of the rotor winding at turbine side.

A special seal separates the high-pressure zone and the clearance.

The cooling water is distributed into the stator winding, connecting busbars and loadsby means of the manifold and fluuroplastic house.

Only one bar is connected in series for the water flow, and so is in the circuit with connecting basbars: bar-busbar-lead, with the feeding manifold at turbine side and the drain manifold at slip ring side.

The water cooling diagram is given in Fig. 2.

Water is supplied to the manifold through the stator frame and drained by means of through insulators. A centrifugal fan is mounted on the rotor shaft to cool the slip rings. The cooling is done by air.

The differential manometer is provided in water cooling system of stator winding for continuous control of hydrogen and distillate pressure difference.

The manometer provides singals when distillate pressure exceeds hydrogen pressure in the generator at rated operation duty.

SAFETY PRECAUTIONS

Access to open rotating parts of the turbogenerator as well as to those under voltage should be guarded off.

The design of operation grounds, guards the layout of supply busbars and power cables, location of safety precaution placards should meet the “Electric Installation Design Requirements” and “Safety Precautions for Operating Electric Installations, Power Stations and Substations” for the respective equipment the turbogenerator will be a part of.

The stator of the turbogenerator has two earthing bolts with contact anti-loosening fixtures.

The dissilate feed and drain manifolds for the stator winding should be earthed.

Responsibility for safety and fire prevention measures during mounting and operation rests with the user.

<u>Generator assembly procedure</u>

During generator assembly check the negative allowances and clearances. The values obtained should be written in the respective entires of the assembly clearance record (drawing OTX.468.652).

Assembly and adjustment of the auxiliary equipment (excitation, cooling, control instruments and automatic devices) should be done at the same time with the generator assembly.

Erect bed plates (see section 8.3).

Before putting in the rotor:

a) mount the lower part of the shield by drawing IT49I (item 7 if the drawing ITX.253.020.3), the mounting being final (see note of sheet 48);

b) check the condition of the resistance thermometers T045 and T046 (item 10, drawing 6TX.022.711);

a) install the lower half of the intermediate shield, drawing IT23 (item 6, drawing ITX.253.020.3), installation being final;

b) install the lower half of board of slip ring side, drawing5TX.013.503 (item 12, drawing ITX.253.020.3), installation being final (see not on sheet 90);

c) install the lower halves of the outer shields on the mounting supports and fasten (see drawing 6TX.000.580, position I, and view A).

Put the rotor into the boring of the stator (see section 8.9).

Secure the rotor suspension device on the stator drawing 2TI47 (position III, drawing 6TX.000.580).

Dismantle the trolleys and the pulley. Taka the mounting plate and spacer out of the stator boring (see 6TX.000.580).

Mount the lower halves of the outer shields without rubber packing (position IV), drawing 6TX.000.580). Therewith insert locking pins, item 31, drawing 5IX.021.595-596.

Gas-cooler Mounting

Before mounting the gas-coolers should be tested with water at a pressure 0.7 MPa (7 kgf/cm^2) for 30 min.

On detecting a leak stop the faulty pipes with metal plugs at both ends. Special pipes are provided for eliminating air locks in the coolers, which pipes are connected to the drainage system via funnels and drain cocks.

The pipe joined to the connection pipes of the coolers should be well secured to the foundation and not hang on connection pipes. The coolers are connected to the common water main in parallel.

The design of the gas-coolers provides for cleaning their pipes without evacuating hydrogen form the stator.

Testing the Rotor Gas Tightness

Test the rotor for gas tightness before introducing it into the stator as there may be gas leaks through the control hole in the rotor at turbine side or through the current supply bolts at the rotor body side. For this dry compressed air should be delivered through the hole in the flange stopping the rotor central hole at contact riggs side.

Check for leaks at a gauge pressure 0.5 MPa (5 kgf/cm^2).

Then reduce the gauge pressure to 0.3 MPa (3.0 kgf/cm^2) and take a pressure drop curve during not less then 8 hours.

Consider the rotor gas tight if, for an initial gauge pressure inside the rotor 0.3 MPa (3.0 kgf/cm^2), The pressure drop during 8 hours does not exceed 3 mm of mercury column.

Note: It is not permissible to check air leaks via the current supply bolts of the rotor with lather or water. To check leaks via the current supply bolts use only pure alcohol.

Rotor Mounting

Before rotor is put into the stator fit the parts of the air gap seal together according to the instructions in drawing 9TX372.546.

Before putting the rotor in throughly blow the vent ducts of the rotor through with compressed air. Blow through with compressed air the inner cavities of the stator (including the cavities access to which is a through the hatches with remoable plugs) and the rotor, look carefully for any foreign objects and test the resistance of the rotor windings insulation by the megger. Electrical strength of the stator winding should be tested before the rotor is put into the stator (see items II. I. I, II. I. 2, II. I. 3).

These tests must be carried out compulsory before closing the machine but after the inner shield have been mounted.

Clean the shaft necks and the half-clutch from corrosion resistant coating. Inspect the face of the half-clutch and eliminate accidental dents and burrs. Check the wobbling and flatness of the semi-coupling and face by method of two dial-indicators. Wobbling over the entire face should not excess 0.03 mm.

Permissible flatness deviation is not more than 0.02 mm. Scrape the end face, if required.

Mounting of Bearings and shaft oil Seals

All the conjugation in the planes of the detachable joints of the shields, bearings, seals, shells and oil traps should be checked, and a 0.05 mm clearance gauge should not go in at any point in the unbolted joint.

It is not permissible to use for sealing any gaskets or asbestos cords in the horizontal detachable joints during assembly. Before final mounting it is permitted to apply a thin coat of bakelite lacquer on the joints of the inside and outside oil traps, bearing caps (the horizontal and vertical joint in each cap).

PARAMETER MEASUREMENTS

Generator Gas tightness Check.

To detect and eliminate possible leaks test the stator separately from the gas system with dry compressed air at a gauge pressure e0.42 MPa (4.2 kgf/cm^2).

At this time oil pressure at seals should be by 0.075 ± 0.05 kgf/cm^2) greater than the air pressure in the generator housing. After detecting and eliminating the leaks lower the gauge pressure in the stator housing to 0.3 MPa (3 kgf/cm^2) and during 8 hours determine air lock value from the generator with stationary rotor. When temperature does not change air pressure drop should be not more than 15 mm of mercury column. The inner volume of the generator with the rotor inside is 70 m^3.

After checking individual elements of the generator gas system (the rotor, stator, assembled generator and gas equipment) for gas tightness check the gas tightness of the whole assembled generator.

Checking the stator winding water-cooling system for passability and water Tightness.

These tests should be performed with distilled water on an entirely assembled stator winding with terminals and water connections of the manifolds including the trough insulators (before the lower halves of the inner and outer shields are installed).

During preparing for operation and adjustment passability is tested by priming heated distillated through the stator winding and comparing simultaneity of temperature changes in the parts by the readings of the standard resistance thermometers inserted in the stators slots for which :

a) fill the stator winding with ambient temperature distillate
b) Record the intitial readings of the resistance thermometers (the resistance thermometers should be calibrated beforehand);

MAINTENANCE

Repairing for Operation

Work on preparing the generator for operation may be started on completion of the following job;

a) all construction works in the area of the set has been finished and the room cleared of refuse, dirt and dust;
b) checked have been made to make sure safety rules have been followed and –fire safety measures taken, the stator housing has been earthed; after having connected the outside line from the heat control terminal boxes, check proper assembly according to maker's drawings of the device in the these boxes meant for protecting the personnel in case of high voltage at the ends of the resistance thermometers inserted in the stator (capacitor paper between the bronze laminated springs and the earthing clip should be laid);
c) electric mains have been laid for general and local lighting;
d) the mounting of the generator and excitation system with main and control circuits has been completed and all the bolted joints and control instruments have been checked;

Control of the Generator during starting Operations.

Before starting the generator make arrangements with persons responsible for starting the turbine about the starting and operation of the turbine and generator unit.

The generator can be started to made checks for vibration and alignment only if the hydrogen gauge pressure in the stator housing is 0.02-0.03 MPa (0.2-0.3 kgf/cm^2).

In setting the rotor into motion and in increasing the number of revolutions upto the rated value watch for strange noises, catches and beating in the generator, for shaft play, impermissible vibration, etc. If some abnormality in the work of the generator is detected the unit should be immediately stopped till the fault is eliminated.

While increasing the revolutions of the rotor take account of the fact that at revolutions listed in 3.4 dangerous oscillations may appear.

By-pass valve operating procedure.

Check the by-pass valve for seizing.

Open the by-pass valve before starting the generator (see drawing IT 358).

To do that turn the by-pass valve handle smoothly till it stops in the position "Open" (OT KPHTO).

Close the by-pass valve when the generator achieves the rated 3000 r.p.m. For this purpose, turn the valve handle smoothly till it stops in the position "closed" (3AKPБTO). Operation of the by-pass valve is the same in working with both air-cooling and hydrogen-cooling of the generators.

Compressor Head Measurements.

Before starting compressor head measurements check the pipe connections, valves, hoses, and the differential gauge head for gas tightness by pressure test.

There should be a total absence of leaks.

Measure the head of the compressor each time you start the machine.

2. When hydrogen gauge pressure in generator is 0.3 Pa (3 kfg/cm^2), purity not below 97% and gas temperature 41^{0}C at output of gas coolers, compressor head should be not lower than 8500 Pa (850 mm of water column).

Fig. 4. Location of the valves on the generator frame and differential pressure gauge DT-50 connection.

Generator Drying

The drying of the stator and rotor winding insulation is usually done during mounting operations with the generator in a stationary position by means of a direct current source.

Direct current drying of the stator winding is done with all the phases connected in series at 1800 A and about 40 V (on the terminals) in the absence of water circulation through the stator winding.

After drying with the rotor put in check if it has been magnetized and, if necessary, demagnetize it by changing the direction of the current in the stator winding and decreasing the current by steps until a zero "hysteresis" loop is obtained.

ACCEPTANCE TESTS AT THE POWER PLANT

Acceptance tests of the turbogenerator during and after the mounting operations should be carried out by the user together with the representative of the manufacturer.

The acceptance test programme should include the following tests: for the generator during the mounting stage.

Measurement of the insulation resistance of each of the stator winding with respect to the frame and the other earthed phase with a 2500 V megohmmeter.
Measure the insulation resistance with no water in the stator winding but with the water manifolds connected with the megohmmeter screen though disconnected from the external cooling system and insulated from the frame, and with disconnected wires of the heat sensors on the drain manifold (plug connector on the drain manifold).

The resistance of each phase with respect to the earthed frame and other earthed phase with buses and wire disconnected, and also the insulation resistance with respect to the frame with all the 3 phases connected together should not be lower the values

Description	Value			
t^0C	75	55	35	35
R_{60} Moh	15	30	60	120

Contd...P/53

At the same time the insulation absorption coefficient is found, give by the ratio:

$$K = \frac{R_{60}''}{R_{15}''}$$

Where R_{15}'' and R_{60}'', respectively, are the 15 and 60-second values of the insulation resistance.
The value of the absorption coefficient K at temperatures from 10^0C to 30^0C should be not less then 13.

The leakage current values should not exceed thouse in Table

Description	Value				
Test voltage of step, Permissible maximum	KV 7	14	21	28	36
leakage current μA	250	500	750	1000	2000

The rotor winding insulation resistance with respect to the frame, measured with a 1000 V meg ohmmeter, should be not lower than the values given in Table 12.

Table 12

Description			Value		
t^0C	100	80	60	40	20
R M0h	0.5	1.0	2.0	4.0	8.0

<u>Insulation resistance is measured with a megohmmeter.</u>

Table 16

Description of objects tested	**Standard**	**Megohmmeter voltage, V**	**Description of test**
Stator winding	The insulation resistance of each phase with respect to the earthed frame and the other earthed phases as well as the insulation resistance with respect to the frame, with the three phases connected together and the busbar conductors disconnected, should be not lower then the values indicated depending on the winding temperature		
t^0C R_{60}'',	75 55 35 15 15 30 60 120		
M0h	The absorption coefficient value at a temperature 10-30^{0}C $K = \frac{R_{60}''}{R_{15}''} \geq 1.5$		
Rotor winding (stationary and rotating)	Insulation resistance should be not lower than indicated values depending on the winding temperature t^0C 100-80 60 40 60 R M0h 0.5 1.6 2.0 8.0	1000	G,R
Excitation circuits with all the equipment connected (without rotor winding)	Insulation resistance not lower than 50 k0h for a thyristor exciter with water cooling	1000	G,R
Generator bearing (at slip ring side)	Insulation resistance is measured with respect to the bed plate with oil pipes fully assembled. Insulation resistance should not be lower than 1.0 M0h.	1000	G

Direct current resistance of the winding is measured in a practically cool condition.

Permissible resistance deviation values are given in.

Description of objects tested	Standard	Description of test
Stator winding	Resistance of each phase is measured. The resistance values obtained should not differ from each other by more than 2% and the results of further measurements of the same phase resistances should not differ by more than 2% from preceding one	
Rotor winding	The value obtained should not differ from earlier measurement by more than 2%	G

Heating test (G).

The tests are performed at loads 60, 75, 90 and 100% of the rating once in 5 years previous to major repair or between repairs at one or two loads.

Temperatures are measured with the heat indicators mounted by the manufacturer and for the rotor winding using its resistance values.

The test results are used to check the correspondence between the values obtained and the certificate data as well as the results of earlier tests.

Table 18

Characteristic	Value	
Magnetic induction in the yoke, T	1.0	1.4
Voltage per I control-turn, V	334	468
Full ampere-turns	960	3200
Full power, kVA	354	1652
Power intake		
active power, kW	125	250
Specific magnetizing ampere-turns, A	1.5	5
Steel mark	3414 thickness	0.5 mm
Cross-section area of the stator active steel yoke, cm^2	15050	
Mean diameter of the stator active steel, cm	203.55	
Mass of the active steel of the stator yoke, kg	73150	

Note for item Before putting the machine into operation after repair, after closing the end boards test the stator winding insulation

OPERATION CONTROL

Timely direction and elemination of minor troubles, which might be found in periodical inspections and checks of the generator and auxiliary equipment, exclude serious trouble and breakdown.

Control of the turbogenerator operation duties should be carried out by the readings of the standard instruments and control devices at full scope envisaged by the control – and - automation scheme of the power unit. The readings of the instruments characterizing the condition of the turbogenerator in operation should be registered by recording instruments with automatic temperature control devices, which record automatically deviations from the prescribed standards temperature recording should be done only once in 24 hours.

The scope and periodicity of the turbogenerator operation duty records should corresponds.

Measured values	Recording periodicity
Stator current active power stator voltage Rotor current Temperature of copper and by the resistance thermometers	To be recorded by instruments, but in the absence of automatic continuous recording are written every two hours.
Difference in the readings of the resistance thermometers measuring the temperature of copper Temperature of distillate at discharge Cool and hot hydrogen temperatures according to the resistance thermometers Temperature of the seal bushes and support bearing shells Oil temperature as drained from the bearings Distillate flow rate Hydrogen pressure in the generator housing Oil-to-hydrogen pressure differential	
Rotor voltage Water temperature at gas-cooler and heat exchanger inlets and outlets Hot air temperature at brush holder apparatus outlet Temperatures of cool and hot gas by the mercury thermometers Pressure of sealing oil Distillate resistivity Water pressure before gas-coolers	Every 4 hours
Chemical analysis of hydrogen in generator housing	once in 24 hours

Operation Manual of Generator

Nominal data of generator

ТГВ-200 МТ3

Power-	-	-	247 MVA
Active Power	-	-	210 MW
Power factor	-	-	0.85
Stator voltage	-	-	15.75 KV
Stator current	-	-	9060 A
Rotor current	-	-	1950 A
Frequency	-	-	50 HZ
Speed of rotation	-	-	3000 r.p.m.
Cooling media	-	-	hydrogen.
Hydrogen pressure	-	-	3 Kgf/cm^2
Hydrogen purity	-	-	98%
Hydrogen temperature	-	-	40^{0}C

The turbo generator of Unit No.-3 utilizes the quick-actuating static self-excitation system with booster transformer in series controlled by silicon valves and strong automatic excitation regulation.
This stand-by excitation is an electric machine excitation.

Final data of the stand-by excitation

Type	**Generator BT 174-7 KT3**	**El. motor AC3-2-17-61-6T3**
Power, KW	990/3250	1250
Voltage, V	470/840	6600
Current, A	2100/3860	147
Speed of rotation, rpm.	990/970	990

MAIN CHARACTERISTICS OF COOLING MEDIA

Hydrogen :

-pressure	3 $kg/cm^2 \pm 0.2$
-volume purity, not less than	97%
-temperature at the gas cooler outlet	41^0C

Characteristics of water at the inlet of gas coolers

-flow rate	400 m^3/hr.
-temperature at inlet	34^0C
-pressure	3.5 Kg/cm^2
-water pressure loss in gas coolers	0.8 kg/cm^2

Water characteristics for cooling stator winding;

a) water for the first circuit (technical water)

-flow rate	200 m^3/hr.
-temperature at the inlet	34^0C
- pressure, no more than	6 kg/cm^2

b) Water (distillate) for stator winding:

-flow rate	43 m^3/hr.
-temperature at the inlet	41^0C
-inlet pressure no more than	2.8 kg/cm^2
-outlet pressure	(0.5-1) kg/cm^2
-electrical resistively of distillate at 41^0C	75 kΩ and more

Oil characteristics in bearings and scales:

flow rate through two bearings	36 m^3/hr.
flow rate through two seals	12 m^3/hr.
short-term flow rate through two seals	18 m^3/hr.
pressure at inlet of bearings	(1-1.7) kg/cm^2
"Oil-hydrogen" pressure drop	(0.75±0.05) kg/cm^2
Temperature at inlet of bearings and seals	$(35+45)^0C$
Oil temperature at the bearing discharge	70^0C
Temperature of bearings Babbitt and shaft oil seals	**80^0C**

Critical figure values of rpm of turbine K-200-130-3 and generator rotor ТГВ –200-МТ3;

II_1 = 1530 rpm.

II_2 = 1750 rpm

II_3 = 1970 rpm

II_4 = 2490 rpm

II_5 = 4640 rpm

Resonance of stator core on springs of hangers at speed of rotation of rotor.

11_5= 2180 rpm.

BRIEF DESCRIPTION OF GENERATOR DESIGN.

1. Turbo generators ТГВ-200, hydrogen-cooled, 3000 rpm are used for direct coupling with steam turbine, 200 MW capacity. The turbo generator rotates clockwise, if viewed from the turbine side. The turbo generator is hermetically closed. This ensures its normal operation with excess hydrogen pressure equal to 3 kgf/cm^2.
2. The generator stator consists of two concentrical parts: body (external part) and frame (internal part), which is secured to the body by means of plate springs located uniformly along the circle.

   Suspension of the springs of the frame of the core to the generator body is done to avoid vibration of the body with double frequency of 100 Hz during generator operation.

GAS-OIL FACILITIES OF GENERAOR

In order to make turbo- generator set tight in the places of rotor shaft outcome, oil-sealings of end type are provided for. Sealing bearings consist of a static race and dynamic shell, moving in the race. By its babbit the shell is always pressed by springs to rotor comb, it moves along Generator axis after the comb and is tightened in regard of the race by seal rings.

The sealing race is fixed from outside and through this race oil is being supplied in a sealing and is being drained from hydrogen zone into a crank-case of a board. To prevent oil from coming inside generator there are oil catchers attached to inside surfaces of the outside boards.

In order to avoid bearing currents a sealing race on the side of contact ring is separate from the outside boards. Oil under pressure exceeding gas pressure in Generator by 0, 7-0, 8 kg/cm^2 comes into pressure chamber of the shell and through the holes into a circular recess on a babbit seurface. While flowing from the circular recess the oil fills radial recess and wedge slopes, filling the gas between rotating comb of the rotor and a static surface of the shell. Resistance thermometers are built-in the Babbitt surface of the shell in order to control the temperature of the shell.

Bigger amount of oil is drained to air side, smaller to hydrogen side. This is ensured by design of the shell and the action of accleration forces. Due to small amount of oil (21/ min) through a sealing to hydrogen side the amount of air coming into generator is small (hydrogen pollution is insignificent) i.e. it is unnecessary to clean oil additionally.

SYSTEM OF OIL SUPPLY TO SEALINGS.

1. The system is designed to ensure a continuous oil supply of the generator sealings. It consists of the following components;
   a) pumps;
   b) automatic regulation system of ‘oil-hydrogen’ pressure difference;
   c) emergency oil supply device;
   d) device for draning oil from Generator bodies;
   e) oil cleaning and connection to turbine oil system unit.

Part a) is designed to increase the pressure of oil to sealing. Oil is taken from turbine & generator bearing lubrication system with the pressure of 1,0-1,5 kg/cm^2.

Pumps include 3 Nos. pumps: two with A.C. electric motor and one with D.C. motor.

D.C. Oil pump must provide for oil pressure of 5 kg/cm^2 under nominal rotation of Generator and Hydrogen pressure of 3 ata. The pump can be started into operation with a time delay. From the pumps oil is supplied through a filter to oil-pressure regulator.

System of automatic regulation of 'oil-hydrogen' pressure differential ensures maintaining the given pressure differential under any operation modes of T/Generator.

The value of P.D. is chosen so that under nominal rotation of Generator the damper tank be filled at full. While working on the barring gear the valve of the p.d. increases up to 20 by means of a soleniod velve installed on the feed-back line of pressure regulator 2 DPD-10T.

To automatically maintain p.d. on the sealings there is a differential pressure regulator in the circuit of 2 DPD-10/T with the rotating slide valve. The regulator makes it possible to keep pressure differential between oil and hydrogen within 0,14-1,0 ata and to maintain the chosen pressure differential with accuracy of 0,05 ata. Maximum permissible oil pressure before oil regulator is 12 ata, minimum, under which a slide valve can rotate, must exceed oil pressure after regulator not less than 1.0 ata.

Rotating slide valve has 3 pistons and it is being affected by two forces: from down upward pressure of oil coming from line to sealing; from up downwards-weight of a slide valve with weight washers (for regulating oil-hydrogen pressure differential) and hydrogen pressure, to the Generator body. Both forces are equal under stable mode with hydrogen pressure rise or oil pressure drop, the slide valve goes down and due to opening large cross-section windows the oil pressure will increase until a new balance is achived.

The oil flow-rate being decreased (pressure rise) or hydrogen pressure drop the slide valve goes up and closes the cross-section of the winding.

The rotation of a slide valve augments significantly sensitivity, accuracy and, most important, reliablity of regulation. If the slide valve stops its rotation it is necessary to reciprocate it but if it impossible to do it must be switched off for maintainance.

Emergency oil-supply device comprises damper tank with non-return valve on over flowing line and is designed to feed the sailings with oil for the time of emergency shut down of T/Generator (15 minutes) in case of the oil pumps malfunctioning and also prevents from a short time oil pressure drop when oil-pump are put on automatic stand-by.

2000-litres damper tank is fixed at elevation 18, 7 m and it is filled with oil at full due to regulation of oil-hydrogen pressure differential. A special non-return valve is used for avoiding any possibility of syphon when oil can overflow from damper tank. Normally the damper tank must be included in the circuit with oil-circulation.

Generator oil system must not work without damper tank. It is possible to switch off the damper tank for the time of generator stopping or its operation on berring gear. During the time that damper tank off two pumps of Generator shaft sealings must be in work.

There are two floaming h. gates in the scheme, one being reserve. If both h. gate malfunction the work of the Generator can be ensured by U-type h.gate with hydrogen pressure on pressure decrease upto 0,5 ata.

Hydrogen pressure of drainage line from turbine side and contact ring differs from each other in the head-pressure of the compressor. That's why in order to avoid back flows of hydrogen, the drainage lines of bearings are separated from each other by hydraulic loop.

From h. gate oil, saturated by hydrogen, goes into pipe-line of oil drain from the bearings in which hydrogen is extracted from oil and it is being drawn off by centrifugal fan, installed on the pipe-line before a hydraulic loop. Turbine oil tank is separated from oil drain pipe-line (regarding gate by a hydraulic loop. This loop prevents hydrogen from coming into turbine oil-system in case the hydrogen goes out through sealing bearings.

GAS FACILITIES SYSTEM:

Hydrogen utilization for cooling Generators made it possible to increase the unit capacities of the generators, to reduce their dimensions, to use more efficiently their active materials and to increase efficiency of the Generator.

Along with this, servicing of the Generator becomes more complicated with hydrogen cooling. This due to the fact that hydrogen/air mixture in concentrations from 3,3 to 81,5% is inflammable. Hydrogen/ oxigen mixture is inflammable when hydrogen content in it is from 2,6 to 95%.

Hydrogen can be easily inflamed by a part or flame and has a proporty to be inflamed when flowing through small holes and under high pressure.

The main reasons for using hydrogen as a cooling media are as follows;

a) reduced losses for ventilation due to smaller specific gravity of hydrogen;
b) large co-efficient of thermal transmission from the surface to gas at the rate of higher thermal conductivity of hydrogen;
c) extension service term of insulation in hydrogen media;
d) elimination of possible fire inside the Generator;
e) Generator noise reduction; as soon as the density of hydrogen is lower than air density.

Gas system provides for the generator shifting from air to hydrogen and from hydrogen to air monitoring all necessary parameters during those operations keeping a set up pressure and automatic control of hydrogen purity in the body of Generator. Direct pushing of air by hydrogen is not allowed for safety reasons against forming an explosive mixture in Generator body. That’s why all works regarding gas replacement inside generator are executed in presence of a neutral agent carbon dioxide gas. At first air is being pushed by carbon dioxide and after that hydrogen pushed carbon dioxide out.

WATER SUPPLY SYSTEM OF GAS COOLERS.

Water supply system of turbo generator gas coolers effects cooling water circulation both in generator gas coolers and in exciter air coolers.

Two centrifugal pumps are provided to pressurize the water supply system. One of them is in operation, the other is stand-by.

Water supply to generator gas coolers is to be controlled by means of emptying gate valves, while pressure gate valves to gas coolers are open so that temperature.

When hydrogen purity is decreasing, but oxygen and moisture content is increasing, blow the generator off with fresh hydrogen until normal parameters are restored and check if oil discharge from seals to the hydrogen end is not increased.

When humidity increases test drainage points for moisture content.

Hydrogen content in the air of oil drain lines of the generator journal bearing should not exceed 1%. No hydrogen should be present either in closed current leads or in the turbine oil tank.

If hydrogen is continuously present in the bearing casings at a concentration above 1%, blow the casings off with CO_2 and stop the generator at an earliest convenience to certify the leakage. If hydrogen concentration is high, supply CO_2 to the bearing casing continuously and stop the generator at an earliest convenience to rectify the defect.

If hydrogen is detected in current leads at a level 0,1 to 0,5%, check the meter (device) and test the generator gas tightness to establish the leakage; take steps to stop the leakage. The highest permissible hydrogen level in current leads is 0,6%.

If hydrogen level exceeds 0,6% supply CO_2 to the respective wall, stop the g turbo generator and displace hydrogen.

Oil temperature at the discharge from the seal to the air and should not exceed 65^0C. Temperature difference of input and output oil should not exceed 30^0C. Babbit temperature in the sealing shells should not exceed 80^0C.

If the temperature of sealing bearings increases beyond 80^0C, de-energize generator and break out vacuum, immediately being displacement of hydrogen with CO_2.

The allowed variation of cold gas temperature in the generator body is from 20 to 41^0C. Preferably, variation of gas temperature should not exceed 5^0C per hour.

If input gas temperature exceeds 41^0C permissible currents of stator and rotor decrease to the values specified in the Table. If cold gas temperature increase beyond $+55^0$C the generator is de-energized.

If the sealing oil pressure decreases check the rotation of the Γ 101 slide valve, as well as oil pressure before it. Great oil pressure drop after the regulator may be caused either by the closed hydrogen valve to the regulator, or by considerable hydrogen leakage in the regulator/ impulse line.

If packing oil pressure can not be raised and at the same time oil level in the damper tank drops, de-energize the generator, shut it down, and break down vacuum.

If signal “Water-oil in the generator body” appears, drain the liquid from the body by means of drainage valves of the liquid meters Nos. Γ40; Γ41 and estimate approximate amount of the drained liquid.

Water in the generator body may appear either from damaged gas coolers, or from stator winding, or it may be moisture condensed from the gas.

If after some time there is a repeated signal and water drain drainage is intensive (one litre in 10 min.) the generator show immediately unloaded and de-energized.

SAFETY REGULATIONS FOR OPERATION & SERVICING
OF HYDROGEN-COOLED TURBO-GENERATORS.

Strictly follow the instructions for operation of generator gas and oil system.

Special permission must be issued for works on gas and oil lines of the working generator.

Special permission must be issued for works with naked flame performed at a distance over 10m from hydrogen containing parts of gas and oil system. If works are executed within 10m distance special permission must be issued and safety ensuring measures must be taken (i.e. boards to be installed, tarpaulin to be put up, check that no hydrogen is present is to be made).

No work with flame can be done both at the generator body and pipelines of the system filled with hydrogen.

Placards “No smoking”. “Hydrogen” must be placed near generator and units of oil and gas system.

If hydrogen leakage at the generator are considerable no admission is allowed to strangers in the leakage zone, all works within 10 meter area stopped.

Bolts of flanges and glands in the valves under pressure must not be tightened up. Hoses on the nipples of all the apparatuses must be reliably secured.

If hydrogen stream coking through the leakage ignites it is necessary either to stop air access or to extinguish flame with a spurt of carbon dioxide.

Along with fire extinguishing immediately decrease hydrogen pressure. But take care not to decrease hydrogen pressure to the atmospheric pressure, this may cause vacuum in the generator body and air infiltration and consequently and explosive mixture may be formed in the generator body.

ALLOCATION OF DUTIES DURING GENERATOR OPERATION

During operation of generators their service and maintenance is assigned to the personnel of the electric, boiler-and-turbine shops, chemical plant and instrumentation and control personnel.

The electric shop personnel is responsible for the following;

a) For inspect the generator once during the shift; electrician on duty is to inspect the generator 2 times during the shift; electric shop foreman is to inspect the generator once a day;
b) control of insulation in excitation circuits (once during the shift), measurement of insulation resistance both of the stator winding and excitation circuits after generator shut-down and before its start-up;
c) control of bearings insulation (once a month, by electrical laboratory personnel);
d) servicing the excitation system;
e) inspection of slip-rings (electrician on duty, 2 times during the shift), and in case of emergency inspection is made at the call of operator or UCB duty operator;
f) servicing hydrogen generating plants.

The personnel of the chemical plant are responsible for; Chemical analysis and control of gas parameters in the generator body, bearing casings and acreened bus bas (current lead), as well as check for hydrogen in the place of work.

PREPARATION OF GENERATOR FOR A START:

It is allowed to proceed with starting operations on generator after completion of all works on the Unit and presence of record in the register of start-up of equipment after erection or overhaul. Shift leader of electrical shop should be the following;

a) to check completion of works on orders;
b) to examine thoroughly and get convinced in absoluted cleanness and service-ability of generator-transformer unit unit. When examining special attention should be paid on fulfillment of safety regulations, antifire measures as well as on lighting of the equipment and premises;
c) to check open position of blow-off valve;
d) to remove all special and protective earthings;
e) all permanent fencing and placards should be on their places.

Resistance of insulation of generator winding, generator excitation circuit, transformer windings should be checked and the entry should be made in the register of measurement of generator insulation.

Checking of insulation of stator winding, low-voltage windings of unit transformer and high voltage windings of auxiliary transformer is carried out by megger.

The value of resistance of insulation of generator winding with disconnected busbar duct depends on windings temperature and varies with in the range of 4.7-56, 5MΏ (t=75-15^{0}C).

The value of absorption factor of insulation 60″/15″ measured at the temperature of windings+ 10+30^{0}C should not be less than 1.3:

$$\frac{R_{60}}{R_{15}} \geq 1.3$$

The value of resistance of the bused generator together with winding 15.75kv of unit transformer and tapped transformer and during circulation of distillate in stator winding is not standardized and putting of generator into a net work is allowed if total resistance of insulation is more than 100k Ώ.

The resistance of insulation of generator excitation circuit, measured by megger 1000v should not be less than 0.5mΏ. If the resistance of rotor insulation is less than 0.5mΏ it is necessary to take measures for its restoration.

Operation of generator with resistance of rotor winding insulation less than 0.5mΏ is possible with the permission of Chief engineer.

. Resistance of winding 6kv of tapped transformer measured by megger 2500V depends on conditions of measurement and as usual should not be less than 1mΏ for 1kv.

If the resistance of insulation on the equipment is less than the above values shift leader of electrical shop should inform shift leader of the station and Chief of Electrical shop and should act according to their instructions.

The circuit of the unit is assembled by switching on;

a) short-circulating switch of neutral terminal of unit transformer.
b) bus isolator for a corresponding busbar system and line isolator of the transformer;

START OF GENERATOR:

Start of generator on air cooling is allowed only for adjustment without excitation.

After start of turbine rotation it is considered that the generator and all unit equipment is under voltage.

After reaching 500 RPM it is necessary to check operation of the device of brush holders, to inspect and to listen to the generator.

During further increase of revolutions to control purity and pressure of hydrogen in the generator, pressure difference between sealing oil and hydrogen, pressure of sealing oil, temperature of oil and shells of sealing bearings, absence of hydrogen in bearings cases and busbar ducts.

After reaching 3000 RPM blow-off valve is closed and the generator is examined again in accordance with requirements of item 3. Pressure difference of hydrogen should be measured on the compressor and it should not exceed 63mm.w.c.

Hydrogen dryer is put into operation.

STEPPING UP OF VOLTAGE, SYNCHRONIZATION AND PUTTING OF GENERATOR INTO A NETWORK.

After receiving an order from station shift leader, shift leader of electrical shop starts synchronization and putting of generator into a network. If the state of thyristor excitation is normal generator should be excited and put into a network on a working exciter and if it is out of order on a stand-by exciter.

The speed of stepping up of voltage is not restricted. It is necessary to control that smooth increase of current in rotor winding corresponds to smooth increase of voltage on generator bush the current in stator phases should equal zero at his. At U_{nom}=15. kv rotor current should be equal to 720A.

Putting of generation in a network is carried out in accordance with “The instruction of synchronization of generator TГB200 ” by shift leader of electrical shop or station shift leader.

LOADING AND CONTROL OVER OPERATING GENERATOR.

After putting the generator into a network it is necessary to take 5-7 MW of active load, 5-10MW of reactive load and to start forcing.

To assemble the circuit of supply of sections of 6kv assembled switchgear. To shift power supply of bays of 6kv assembled switch-gear for working auxiliary transformer for what it is necessary to;

a) depending on voltage of generator bushings to set voltage regulator of working transformer into position which corresponds approximately to voltage on sections of 6kv assembled switch-gear;

a) to turn on oil circuit-breaker of working supply of bay 3BA and get convinced in presence of load on it;
b) to turn off oil circuit-breaker of reserve supply of bay 3BA and to check the value of voltage on the Section.
c) to turn on emergency start or interlocking switch of reserve of section 3BA;
d) to turn on oil circuit-reaker of working supply of section 3BB and get convinced in presence of load on it;

Further increase of active load should be made according to the schedule of worming-up of turbine with average rate of 0.8 MW/min. Total time from the moment of start of generator till complete load of 210 MW is 5.0-6,0h. Increase of active load on generator after its start and decrease till its shut-down is done by personnel of boiler-turbine shop.

The rate of picking up reactive load should not exceed the rate of increase of active load (0.8MV/min).

The rate of loading of generator at a hot state of turbine depends on temperature of separate components of turbine and loading is carried out in accordance with "The instruction on operation of steam turbine" K-200-130-3"

Loading of generator on active and reactive power is done not more than to nominal values.

Nominal data of generator at different pressures of hydrogen with its purity not less than 98% and temperature of cold gas at the excit from gas coolers not more than 41^0C;

Nominal data of Generator		**Pressure of hydrogen (kgf)/cm^2**		
	3.0	2.5	2.0	1.5
S,MV	235.3	200	177	141.2
P,MW	210	170	150	120
cos∅	0.85	0.85	0.85	0.85
I_{st}, ka	9.06	7.34	6.5	5.18
I_{rot}, ka	1.95		1.58	
U_{st}, kv	15.75	15.75	15.75	15.75

Operation of generator at a hydrogen pressure less than 1.5 atm gauge is not allowed.

With a change in temperature of cold gas after gas coolers the allowed conditions depending on stator voltage at a gas pressure of 3kgf/cm^2 are as following;

Name of windings	Stator voltage	**Temperature of entering gas ^{0}C**						
		55-51	50-46	45-41	40-36	35-31	30-26	26 less
	16.5	6650	7150	7700	8250	8650	8950	8950
Stator	15.75	6950	7500	8050	8630	9050	9350	9350
	15.0	7300	7900	8450	9070	9500	9850	9850
Rotor		1500	1500	1700	1830	1930	2020	2020

In order to prevent sweating of gas coolers the lower limit of temperature of cooling gas is set at 22^0C.

Operation of generator at hydrogen temperature exceeding 55^0C is not allowed.

Voltage of generator	%	110	109	108	107	106	105	100	95	90	85
Power and current in generator stator	kv	17.3	17.2	17.0	16.85	16.7	16.54	15.75	14.96	14.2	13.4
S	%	88	91	93.5	96	98	100	100	100	94.5	89
I_{st}	%	80	83.5	86.5	90	92.5	95	100	105	105	105
S	MV	207.1	214.1	220.0	225.9	230.6	235.3	235.3	235.3	222.4	209.4
I_{st}	Ka	6.90	7.21	7.46	7.77	7.98	8.20	8.63	9.06	9.06	9.06

Operation of generator at stator voltage exceeding 105% of nominal is not recommended.

Decrease of voltage leads to decrease of its static stability.

At long-term conditions stator current should not exceed 105% of nominal.

EMERGENCY OPERATION :

It is prohibited to interfere into operation of relay protection, emergency switch of reserve and forcing for 20 sec.

Operation of generator ТГВ-200 with load current above 105% of nominal is prohibited.

In Emergency cases short-time overloading on rotor and stator current is possible.

Possible overload on stator current at hydrogen pressure in generator body of 3.0 kgf/cm^2 is as follows:

current ratio to nominal	$\frac{I}{I_{nom}}$	1.5	1.3	1.25	1.2	1.15	1.1
Value of current of overload, ka	I_{st}	3.5	11.7	11.3	109	10.2	10.0
Duration of current of stator overload min.		1	2	3	4	6	10

The following short-time overload is allowed on rotor current:

current ratio to nominal	$\frac{I}{I_{n.r.}}$	2.0	1.7	1.5	1.2	1.06
Value of current of overload, a	I_r	3900	3300	2900	2150	2000
Duration of overload	min.	0.3	0.5	1.0	4.0	10

Duration of overload on rotor current of 1.06 can be less in accordance with stator overload.
Duration of excitation current during forcing which equals double nominal current should not exceed 20 sec.
It is prohibited to implement the above overload during normal operation. With appearance of one-phase earthing in the circuit of generator voltage of 15.75kv generator is put out of the system by operation of earth protection. In case of failure of protection generator should be immediately unloaded and switched off from the system.

-Generator is switched off automatically it is necessary;

- to find from what protection generator has been switched off;

- to examine the instruments whether the shut-down has been proceeded by short-circuit;

-if switch-off has happened because of wrong actions of personnel generator should be immediately put into the system and loaded.

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BRIEF CHARACTERISTIC OF Boliler

Steam Boiler, with natural circulation is designed for reheat steam generation by burning natural gas.

The nominal values of the main parameters are:

Boiler capacity (reheat steam)	- 670 t/h.
Steam flow-rate through Intermediate super heater	- 590 t/h.
Pressure in boiler drum	- 158kg/cm^2
Superheated steam pressure at outlet of boiler	- 140kg/cm^2
Superheated steam to temperature	-545^{0}C
Steam pressure at inlet to reheat	- 28.5kg/cm^2
Steam temperature at inlet to reheat	-334^{0}C
Steam pressure at outlet from intermediate S-H	- 26.3kg/cm^2
Steam temperature at outlet from intermediate superheater	-545^{0}C
Feed water temperature	- 250^{0}C
Boiler efficiency	-93%
Allowable minimal durable load	-30%
Heat release rate under nominal load (227.8kw/m^3)	- 195.1Kal/m^{3}h
Hot air temperature after R.A.H.	- 251^{0}C
Excess air co-efficient beyond boiler	-1.25
Fuel rate under nominal load	-53.6 thousand nm hour.
Temperature of flue gases after I.D. fans	-132^{0}C.
Water volume of boiler	-122m^3
Steam volume of H.P. Superheater	-89m^3
Steam volume of L.P. Superheater (within boiler)	-62 m^3

FUEL CHARACTERISTIC.

Natural gas from titas oil-field is burned is the boiler.

Gas composition:

Methane	CH_4	-97.2%
Ethane	C_2H_6	-1.8%
Propane	C_3H_8	-0.5%
Butane	C_4H_{10}	-0.2%
Nitrogen, oxigen	N_2, O_2	-0.3%
Sulphar and Hydrogen	S_2, H_2	- None
Carbon dioxide	CO_2	-None
Humidity	--	-0.11 g/m^3
Gas specific weight kg/nm^3	--	-0.77
Low heat value Kcal/kg		- 8894

Description of the boiler design.

Steam boiler of TGME-206C0b type, made at Taganrog Manufacturing plant is of drum type with two-stage evaporating system. To second belong external steam separating cyclone. Boiler as a II type design. It is equipped with burners using natural gas. It is gas tight with balanced draft and it has two separate flows passing along steam water ducts.

Boiler consists of a furnace and down-coming gas pipe-line which are connected in upper party by horizontal gas-ducts.

Evaporation screens and radiant superheater are in the furnace in the upper part of the furnace there is a platen superheater.

In horizontal gas-duct there are inlet and outlet stages of convective superheater of high pressure (H.P.C.S.H.) outlet and inlet stages of L.P. convective superheater, all one-by-one along the gas-flow.

The floor of the furnace chamber and of horizontal gas-duct, side walls and bottom of horizontal gas-duct and also, front and rear walls of down coming gas-duct are covered with H.P. Superheater tubes.

There is a water economizer in the down-coming gas duct. Two Regenerative air Heaters are installed behind down-coming gas duct.

Furnace Chamber:

The furnace chamber has a prosmatic configuration in lay-out dimensions as follows; 7680×18000 mm. The furnace chamber volume is equal to 2444.4m^3. The walls are covered with gas-tight pipes, fabricated from 60×6mm finned pipes. All the headers and wall tubes are fabricated of carbon steel. Inter-pipe spacing is 80 mm.

In the lower part of the furnace the pipes of the front wall from a slope with 15^0 horizontal slope angle, Panels are united with the headers. Inlet (lower) and outlet (upper) headers have 219×40 mm diameter. The front wall is 17840 mm wide and consists of 8 blocks. Each pipe panel comprises 28 pipes. At 6150 mm elevation there are 16 pipe-arrangements for gas re-circulation nozzles.

Each side wall is 7600 mm wide, consisting of 332-pipe each blocks. The pipes of panels of the side wall rear blocks from pipe arrangements for crawl-ways at elevations 3200, 19150, 2050 mm. Pipes of middle block panels from pipe arrangements for crawl-ways at elevation 20250 mm. The front and side walls are hanged to the metal structures of the boiler by means of suspensions.

Rear wall in the upper part form as aero-dynamic tooth (Protuberance) 2500 mm wide, formed by all panel pipes. In order to make this tooth stiff and to guard horizontal gas-ducts 28 non-heated pipes, 108×12 mm dia, are inserted in the upper headers of the rear wall. Rear wall panels before the tooth are welded to carrying pipes by means of special sheets these pipes serve as supports for the burners.

In the bottom part of the rear wall 180 ×12 mm dia. Pipes are connected by means of adaptors to 32×4 mm pipes, which are taken into the lower headers of the walls.

Open pipe of each panel of the front, rear and side screens between elevations 12650 and 15450 mm protrude in the furnace for fixing the panels of wall radiant superheater.

Circulation circuit:

All walls of the furnace chamber are sectionized. each panel is a circulation circuit. All-in-all there are 24 circulation circuits.

Boiler has two-stage evapouration circuit. Second evaporation circuit includes 2 circuits (each consisting of 12 pipes) of front panels of each side wall. The rest 22 circuits of circulation are included in the stage of evapouration. From the boiler drum water comes into 6465×40 mm downcomers by water-supply 133×13 mm pipes. Water is supplied to each of the downcomers by nine pipes.

The interior of the Drum:

The drum is manufacture from increased strength steel 16 THMA, The inner diameter is 1600 mm walls are 112 mm thick, the drum is 24310 mm long. The drum is installed on the two moving roller supports, providing for its free movement due to thermal expansion. The drum has three water indicating gauges glass one of them being used in case of full drum. There is also another water-indicating column at elevation 12mm nearby the emergency drainage gate valve. The middle level of water is 175 mm lower than geometrical axis of the Drum. This level is a zero level on scale of the water columns. The upper and the lower levels of water are respectively 50mm higher and lower than zero level. There is emergency drain pipe to prevent from overfeeding the drum. The pipe lets discharge excess water but lower than the middle level.

Separating devices inside the drum consist to the following parts; 84 cyclones 315 mm fixed in two rows by length of the drum 40+44;

-Separating duct of feed water planed by length of the drum in its steam space.

-flusher sheet w/hole;

-ceiling sheets w/holes

H.P. Superheater.

H.P. Superheater has two flows. Both flows are sysmmetrical. Coming out from the drum by eight 133×13 mm pipes, steam of each of the flows is then separated into two sub-flows.

By the first sub-flow steam is supplied by 4 133×13mm pipes to 219×20mm pipe-line. At the inlet to this pipe-line one throttline wear for levelling steam rate by sub-flows. From this pipe line steam simultaneously goes by:

Pipes 76×10 mm to 4 panels of the front wall of the down-coming gas duct.

Pipes 133×13 mm and 2 pipes 108×12 mm to 3 panels of horizontal gas duct pipes.

Pipes 76×10mm to 2 panels of side wall of the downcoming gas duct.

From the panels of the front side walls of the downcoming gas duct steam is accumulated into 219×26 mm header.

Out from the pipes of horizontal gas duct steam by 4 pipes 108×12mm and one 133×13mm pipe comes to this 219×26 mm header which is connected by a connector to 325×32 mm header.

Steam of the second sub-flow from the drum by 4 pipes 133×13 mm goes to 4 panels of the ceiling superheater. Passing to the rear wall of the downcoming gas duct. Then by 4,133×13 mm pipes steam is separated to 219×20 mm header, from this it goes into 325×32 mm header.

Radiant superheater.

Radiant superheater is placed in the furnace chamber and consists of 6 units: 2 units on the front and rear wall and one unit on side walls. Length of front and rear panels 9300mm, side walls-7425mm. Each unit consists of 2 vertical headers 159×16mm (12×IMQ) and 19 horizontal U-type bent pipes made of 42×5 mm pipes (12 ×IM).
The bent sections of pipes in 22 numbers of furnace wall serve to fix radiant superheater. Special panels are welded to support lower pipes of each block of panels. Between plane and pipe there is a strap welded to the lower pipe.

Platen superheater :

Platen superheater is installed in the upper part of the furnace chamber and consists of one row of platens. There are 24 platens in the row with 713, 736, 732 mm spacing. Each platen consists of two 159×16 mm headers and of 21 U-type vertical bent pipe made of 32×5 mm pipes (12×IM@).

Horizontal gas duct-guard.

It is fabricated from steel 20 end consists of 6 blocks, pipes of the panels are bent at a square angle forming side walls and bottom of horizontal gas duct. Each block consists of 2 headers 219×36mm and panels made of finned pipes 32×5mm. In two side panels there are 34 pipes, in middle panels there are 49 pipes.

Side walls of Downcoming gas Duct.

Each side wall of downcoming gas duct is formed by two blocks. A block consists of two 210×36mm headers (st 20) and 36 finned pipes 32×5 mm (st 20).

Convective superheater of high pressure :

It consists of two stages. Steam flow in each of them is parallel. Inlet stage of the H.P. convective superheater consists of 9 blocks. Each block consists of 325 × 25mm headers (st. 12×IM@) and nine packets of bent pipes. Each packet has 6 U-type bent pipes, made of 36×6mm pipes (st. 12×IM).

Low pressure convective superheater.

It consists of two stage-inlet and outlet. The inlet stage goes second as the gas flows and consists of 8 blocks. Each block consists of 2 headers: Inlet header 426×20mm (st. 20) and outlet header 426×20 mm. (at 12×IM@) and 19 packets of bent pipes (two middle blocks have 17 packets of bent pipes). Each packet consists of 6 two-loop bent pipes made of 42×4mm pipes (st. 12×IM@).

Steam and gas in the inlet stage circulate in back block the Ist gas flow stage (outlet) of L.P. convective superheater also consists of 8 blocks. Each block consists of 2 headers, fabricated from alloy steel; inlet header 426×25mm and outlet header 630×20mm and 19 packets of bent pipes (in two middle blocks there are 17 packets). Each packet consists of 5 two –loop bent pipes 42 ×4mm. The pipes are composed; approx. — outlet pipe is fabricated from 12×18 H12T the rest part made from steel 12×IM@. Steam and gases in the outlet stage have parallel flow circuit.

Steam temperature regulation :

Regulation of temperature of superheated steam is performed by injecting Boiler condensate and feed water in the steam coolers. Steam coolers are installed in each flow in three places as steam goes; 1 injector-after rediant superheater in front of the plantens; second-after platens in front of H.P. convective superheater, 3rd –in between two stages of H.P. convective superheater. Regulation of temperature of secondary steam is performed by recirculation of flue gases and also by steam coolers installed in one flow each in between two stage of L.P. convective superheater.
All-in-all there are 6 h.p. steam desuperheaters and two L.P. Steam desuperheaters at boiler.

Injecting coolers:

These are pipes 325×25 mm (st. 12×IM@), in which an injector is installed in protective cylindical jecket. Injecting device consists of a ventury tube and nozzle. Condensate is inserted in a smaller cross section of the tube through holes in the end of the nozzle. Feed water is inserted inside steam desuperheater through a special nozzle along the exis of the tube.
Low pressure Desuperheater consists of header protective pipe and injector. The header is fabricated from 465×20 mm pipe (s.t. 12×IM@). The header has a cap 60×6mm and nipple 133×13 mm for fixing injector which is a pipe 42×6 mm (st. 12×IM@) with holes 4 mm in diameter. There are 12 holes at each of two generatrices perpendicularly to steam flow.

Water Economizer.

It is placed in down-take gas duct and consists of two inlet headers 219×26 mm and two outlet headers 219 × 36mm and 840 packets of bent pipes made from 28 × 4 mm (st. 20).

By height the Economizer can be divided into two parts; each parts consisting of 8 blocks. The side blocks have 54 packets each all the rest-52 packets. All economizer chambers are inside the gas duct in parallel to boiler front, Each outlet header is suspended on 16 suspension pipes 108×12 mm (st. 20) these pipes being at the same time water tapping pipes. From the suspension pipes water is collected in two headers 273×32 mm, (st. 20). By12 pipes 108×12mm (st. 20) feed water is supplied evenly into the drum by its whole length.

Burners.

There are 12 cyclone burners placed in two tiers on the rear wall. The burners of the lower tier are installed at elevation 6151 mm, upper at elevation 8750mm and are designed for burning natural gas. The air channel of the burner is divided into inner channel and peripheral one. In these channels air flows before entering the embrasure of the burner come through swirling vances. Air swirling in the inner channel is done by an axial device which carries 17 permanent blades. Air swirling in peripheral channel is done by a swirl vane carrying 23 permanent blades. In the burner central gas supply is foreseen. Gas is supplied in the circular space between central pipe 245 ×8 mm and 325 ×9 mm pipe. From the furnace side gas header is ended with truncated cone in which there are two rows of holes. The first row has 8 holes 12 mm dia, second row has 8 holes 30 dia. Gas outlets from these holes under angle to the air flow. In the central pipe of the burner electric-gas igniter is fixed. The burners are regidly fixed to the metal structures of sealing circuits of embrasures of the rear wall of the furnace, and they move together with a wall due to heat expansion.

Technical specification of the burner;

Output (regarding gas)	- 4500nm^3/h.
Limits of load regulation	-30-100%
Thermal capacity under pressure of	-
gas before burner 0.5 kg/cm	-45MW.

Boiler insulation.

As all the walls of the gas ducts are made of gas-tight all welded screens, there is no refractory protection of the boiler (except several places). All gas-tight panels, except embrasures of burners, man-hole crawl-ways and places where pipes go through a ceiling are insulated by silica-lime plates, 100 mm thickness and pearlite-cement plates, 50mm thickness. The overall thickness of insulation is 160mm. A part of convective shaft is insulated by mineral wool mats. From outside insulation plates an mineral wool mats are covered by relief not on which magnesia coating is applied.

In places of man-holes, crawl-ways, where pipes go through a ceiling superheater special sealing are provided for which are filled with heat-insulating concrete and heat resistant castable refractory. In order to prevent burning of the man-holes and crawl-ways the holes for the crawl-way is chamotte bricked. Carborund mass covers embrasure surfaces with buses.

The surface of the bottom towards the furnace is also covered by chamot to brick, 125mm thickness, bricks are covered by high-temperature resistant coating, 125 mm.

Air Heater:

There are two regenerative rotating air heaters of PB11-68, which are designed for air heating at const of heat of flue gases from the furnace.

The air heater consists of the following components; rotor, body with covers, support structures with the shaft, drive with a drive sprocket sets of packing boxes of sealings, air-blowing and flushing devices.

The rotor is divided by radial separations into 24 equal parts. Parts is divided by distance separation into 4 sections, in which boxes of heating steel sheets are placed in two tiers by rotor height. The upper tier of boxes, which comes first along the gas-flow is a "hot part" of rotor, the lower tier-"cold part". In the middle part of rotor there is a cogged wheel. The rotor shaft is made of thick wall pipe. The rotor weight is accepted by support spherical roller-bearing of the lower support. A radial roller bearing is installed in upper support. The bodies of the upper and lower supports are made welded and have, water jackets for cooling. The drive which consists of electro-motor with vertical planetary reducer, rotates the rotor under 2 r.p.m velocity. In order to decrease suctions of air in gases the peripheral, radial and central sealings are fixed on the upper and lower covers of R.A.H.

Temperature of gases:

Before air heater	-	325^0C.
After air heater	-	138^0C.

Air Duct.

After R.A.H the main air flow goes to the burners. Out from common air line two air lines go to each of the boiler side, which then are divided into the ducts of central and peripheral air supply to burners. In air lines to the burner channels there are tight valves installed. For ventilation of the Heat wall and for maintaining pressure differential between the "heat wall" and furnace (5-10kg/m^2) there is a Dy. 800 hot air supply line with automatic regulator. For making air pass enabling automation to work. There are two lines Dy. 400 for air extraction to the fan suction. Besides, hot air supply is provided for into recirculation duct for cooling recirculation nozzles when Recirculation I.D. fan in not in operation.

I.D. Fans.

In order to remove gases from the furnace the boiler is equipped with two I.D. Fans of DH-26×2-0. 62 IM type of designed capacity Q=480/380 thousand m^3/h. head pressure H=460/300 kg/m^3 under gas temperature t=100^0C. The I.D. Fan is driven by el. motor DA30-2-17-69-8/10TI, capacity N=800/500 KW and N=744/595 r.p.m.

Recirculation of chimney gases:

It is provided for maintaining nominal overheating secondary steam under reduced boiler loads. In order to make recirculation possible there are two gas recirculation I.D. Fans of ID-20-500Y type with Q=200000M^3/h and head pressure H-490 kg/m^2 under 400^0 gas temperature. The ID. Fan is driven by el. motor DA30 13-67MT2 with N=300 KW, N=1000 r.p.m. Regulation of the output of R.I.D. Fan is done by the guide vanes of axial type, installed at suction line. Chimney gases are tapped after water economizer and are supplied through 16 recirculation nozzles at the front wall and through burners into the furnace.

Cooling of transducers of the burners.

For cooling the ionization transducers of the gas burners of boiler there are two rotating gas blowers with 102 m^3/h output, pressure 1.6kg/cm^2 of IA24-60-2A type. The gas-blower is a two rotor compressor of volume section and consists of a gas blower proper and el.motro, installed on a common foundation.

Protection, interlocking:

On the boiler there is a protection system which is designed for prevention the appearance and progress of failures durings violations in the boiler operation mode. Protection effect is accompanied by light and sound signal. The equipment tripped by protection is put into operation by the personnel after the removal of the fault caused the protection effect.

Depending on the character of the fault in the work of the boiler the protection performs the following: shut-down, reducing the boiler's load, local operations.

Protection for the shut-down of the Boiler.

During over feeding up of the boiler by water (2nd limit)-increasing the water level in the drum on 200mm above the medium level.

While loosing water level in the drum-decreasing the water level in the drum on 100mm below the average.

When the gas pressure behind the regulating valve is reduced till 0.01 kgf/cm^2.

When the air pressure in front of burners is reduced up to 40 kgf/m^2 with the time delay up to 9 seconds.

With switching off the two I.D. fans or one of them, if one was not operating.

With switching off the two F.D. Fans or one of them, if the other one was not working

With switching off of the two RAHs or one of them, if the other one was not working (protection operates with 9 seconds time delay).

Gas burner.

Gate valve on the natural gas supply to the burner NP11S01, (NP11S03, NP11S05, NP12S03, NP12S05, NP13S01, NP13S03, NP13S05, NP14S03, NP14S05) may be opened, if the valves on the air supply to this burner NG25S01, NG24S03, NG25S02, NG24S04, NG25S03, NG24S05, NG15S01, NG14S03, NG15S02, NG14S04, NG15S03, NG14S05, NG26S01, NG26S03, NG27S02, NG26S04, NG27S03, NG25S05, NG17S01, NG16S03, NG17S02, NG16S04, NG17S03, NG16S05, are opened.

Without preliminary ventilation of the furnace, the opening of stop valve on fuel supply to the boiler is not carried out. The furnace should be ventilated by switching on of two I.D. fans and two F.D. fans during 10-15 minutes. During this period it should be forbidden to open the following stop valves;

on gas supply to the boiler; NP10S01, NP10S02, NP10S09, NP10S010, NP10S0 (11-14), NP10S03

Preparation of the boiler for its operation.

Inspection and operation of the boiler for its start-up:

Before start-up, after the erection or overhaul it is necessary to carry out the internal inspection of the drum to make sure of the absence of strange objects in it, as well as of dirt, fin, sliming, etc. to check up the reliability of fixing to the inner devices of the drum. After the above inspection the man-holes should be closed.

To make sure that all the repairing works are completed, working places are cleaned and the people are removed. To check up the condition of the furnace, heating surfaces, frame, casing, insulation, service ability, tightness, easiness of gas-air valves motion, serviceability of their remote drives, correspondence of their positions to the indicators and marks.

To check-up the readiness of I.D. fans, F.D. fans and flue gas recirculation fans for their start-up in accordance with the instruction on their operation.

To check up the readiness of the RAH for the start-up as per their instruction on operation.

Erection of the gas duct schemes

During the erection of the above scheme follow the scheme of the boiler gas duct.

The position of gates and barriers should correspond to the position shown in Table No. 1.

To supply water for cooling the bearings of I.D. Fans, F.D. fans, gas recirculation I.D. fans, RAHs.

To heck up the rediness for the start-up of the oil station of the RAH;

1. To run the pumps of the oil station;
2. To put the working pumps into operation;
3. To test the operation of Automatic Reserve closing the stand-by pump should be automatically put into operation with reducing the pressure of oil in the pressure line upto 0.5 Kgf/cm^2. To adjust the oil supply to the lower supports of the RAH.

To test the remote control of gates and guide vanes. The serviceability of the gates with manually operated drive is tested during the erection of the scheme at the site.

Filling up of the Boiler with water.

Before filling-in of the boiler with water at the start-up of the boiler after maintenance or erection, it is necessary to make sure that all the man-holes of the drum are completely closed, to mark and write down zero positions of the bench marks, showing movement of its elements.

Filling-up of the boiler before its lighting-up should be carried out by deaerated water only through the economizer.

During filling-in of the empty drum the temperature of the water coming into the drum should not differ on more than 40^0C from the temperature of the drum metal as per its perimeter.

To check up the condition of valves on the feed sub-unit.

To fill in and keep under pressure the area upto the lowered feed sub-unit. It is necessary to be careful enough during filling-in of the line, avoiding kicks and impacts. If the water jets appear from the air vents of the feed line, it is necessary to close the air vents.

To open valve Ø 65 (RL32S02) on the by-pass line of the feed sub-unit and start up filling-in of the boiler by the water. Gate valve Ø 100 (NA32S01) on the water recirculation line from the boiler. After filling-in of the boiler before lighting-up of the burners it is necessary to open gate valve Ø 100 on the recirculation line. Filling-in of the non-cooled drum should be carried out with the opened recirculaiton line. With the appearance of the level in the drum it is necessary to close the recirculation and additionally to feed-up the boiler in order to be sure that the economizer has been filling in.

During filling in of the boiler with water it is necessary;

1) to conduct continuous control for the water level in the drum as per water measuring columns. Filling-in should be stopped with the approaching of the lighting-up level i.e. 100mm below the average.

BOILER LIGHTING-UP.

Ventilate the furnace and the air-gas duct thoroughly 15 min. I.D. and F.D. fans should operate on the Ist speed. After the gas line is filled in with gas and blow down, close slide valves No. NP10S011 and NP10S013; close valves No. NP10S03 and NPI0S04 of the pressure regulator.

Close valves (Dia 20 mm and dia 50 mm) on the drainage lines of guarding surface and radiation on wall superheater leave Dia 10 valve open.

Servicing the boiler and auxiliary equipment during operation (under load).

When boiler is working at nominal parameters all automatic controllers must be switched on.

When performing control the frequent and considerable deviations of the values under regulation are undesirable. In case of such deviations from allowable quantities when any mal operation problems arise in the work of automatic controllers shift to remote controlling.

The most important tasks regarding regulation of the Boiler in operation are;

1) provision for reliable operation of all main and auxiliary equipment;
2) Provision for nominal steam generation of the Boiler keeping required operating and steam parameters;
3) Efficient Boiler operation with minimum power consumption for auxiliaries.

The operation personnel during work of the Boiler unit must maintain;

1) normal steam pressure before the turbine-130 kg/cm^2, steam pressure in boiler drum under nominal load-not more than 158 kg/cm^2.
2) even feeding the boiler with water, deviations from the medium level must not exceed ±50 mm;
3) normal calculated temperature of live steam –545^0C, deviations must not exceed ±5^0C, reheated steam temperature is maintained at 545^0C within 70-100% of nominal load. Allowed deviation of reheated steam temperature is ±5-10^0C;
4) normal vacuum in the top part of the furnace-2-3 kg/cm^2;
5) Normal steam quality;

Shut-down of the Boiler.

With the planned shut-down (for reserve) in case if the maintenance of the boiler is not bring foreseen, the shut down of the boiler is carried out without its cooling at almost invariable live steam temperature and reheat steam temperature.

Unloading is carried out at first by decreasing of gas pressure upto 0.05 kgf/cm^2 and then by uniform switching-off of the burners of lower and upper tiers.

During 1-1.5 hours it is necessary to decrease the Unit load upto 70 MW with reducing the load the temperature of the fresh steam should be left invariable, equal to 530+540^0C.

Shut-down of the Boiler for Maintenance.

With the shut-down of the boiler for the maintenance, when some prepairing works are planned to be carried out on the steam water duct, furnace, gas ducts etc. It is necessary before the shut-down of the boiler to cool it by reducing is not more than 2.5^0C/ min. and the difference "up-down" of the drum should not be more than 40^0C.

During 1-1.5 hours to reduce the load upto 70MW. With smooth loading of the quick acting reducting cooling unit it is necessary to unload the turbogenerator upto Zero and disconnect from the grid in accordance with the instruction.

At the same time protection separation is to be put on Turbine, position by use of switch SAB-2.

II. Groups protection are to be removed.

With the loading of the boiler below 200 t/h it is necessary to pass to lighting-up by-pass Dy-100 on the feed sub-unit and for that purpose;

1. to close the valve on the main feed line Dy. 250 (RL30S02) and line Dy-100, to adjust the required water flow rate;

   with the reducing the steam temperature it is necessary to full close the temperature regulators and gate valves and make sure due to temperatures behind the steam coolers that there is no water leakage to the injection.

Unloading of the boiler is being performed by reducing the pressure in the drum with the provision for the uniform speed of change of the saturated steam temperature in accordance with item 10.2.1.

Before putting out the boiler, it is necessary to leave 2 burners under operation.

Emergency shut-down of the boiler.

The boiler set should be immediately stopped and tripped out by the operation of protections or by the personnel in case of:

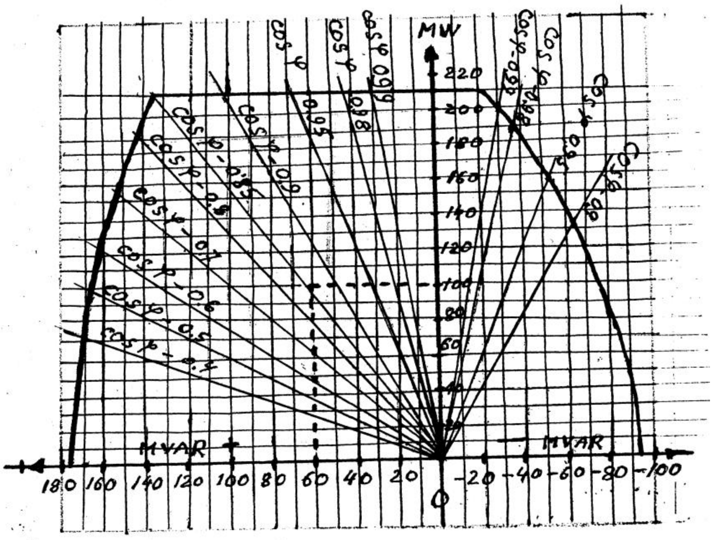
1. inadmissible increase (+200mm) or decrease (-100mm) of the level from the average;
2. all the water-indicating instruments are out of order;
3. breakage of the pipes of the steam-water duct or finding-out creaks and holes in steam pipelines or feed line;
4. decreasing of air pressure in front of the burners upto $40Kgf/m^2$.
5. in admissibly high increase of the steam pressure (1.08 P.non), failure in operation of the safety valves.
6. Putting out of the torch in the furnace or inadmissible decrease of gas pressure upto $0.35\ kgf/cm^2$.

BOILER PROTECTION

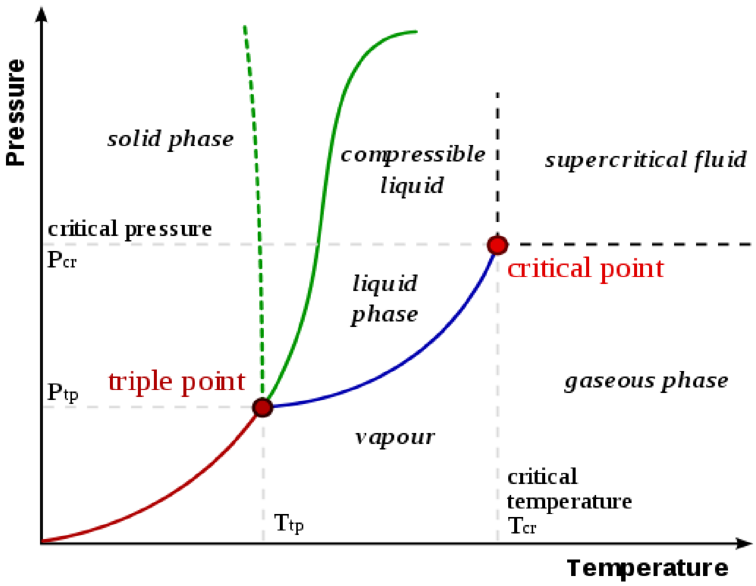
Description of protection, interlocking, auto. reserve closing,signalling	Type	Position	Location	Parameter setting	Time setting	Conditions for activating the protections, interlocking, auto. reserve closing, signalling.
1	**2**	**3**	**4**	**5**	**6**	**7**
1. Decrease of Gas Pressure before burners	KPU-1	$N338P_1$ $N339P_1$	Panel 24 UCB	$0.01kgf/cm^2$ Two out of two protections operate.		Unit trips off. Protection will be actuatec by switch-key SAB-1 and the plate before firing-up the first burner and disengaged after shut-down of the boiler. The protection will also operate with out the SAB-1 key (pulse command to close gas valves). Signal “Gas pressure is at emergency low level”

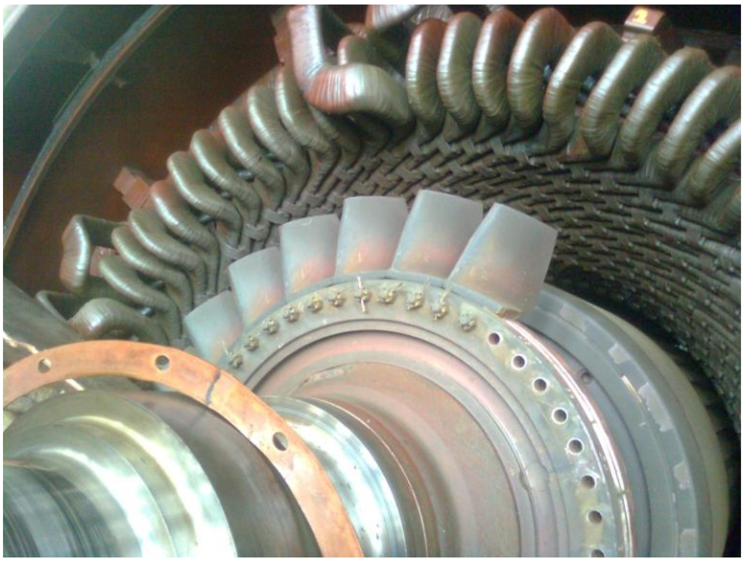
2. Drum level Decrease 3. Drum level increase	KSU-2	$N447P_1$ $N447P_2$	Panel 24 UCB	-160mm +200 mm Two out of two protections operate		Unit trips off. protection will be actuate and disengaged by switch-key SAB-2 and the plate at 30% load. "Level decrease" signal. "Boiler overfeed, 2nd limit" Signal
4. Decrease of steam flow	KPU-1	$N804P_1$ $N804P_2$	Panel 9 Panel 24	0,1 kgf/cm^2 Two out of two	20Sec.	The protection will be

STABILITY CURVE OF UNIT 3/4.



Power Factor



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UNIT NO-6
বিপদ জনক! হাইড্রোজেন গ্যাস
DANGER ! HYDROGEN GAS

Daily Generation Report Of Ghorasal Power Station

February'2013

Date Unit Comissioning Date Capacity Generation(Peak)
MW Total Generation MW Remarks

1st February'2013	Unit 1	16th June 1974	55	37
	Unit 2	13th February 1976	55	0
	Unit 3	14th September 1986	210	170
	Unit 4	14th March 1989	210	0
	Unit 5	14th September 1994	210	0
	Unit 6	30th January 1999	210	0
2nd February'2013	Unit 1	16th June 1974	55	0
	Unit 2	13th February 1976	55	0
	Unit 3	14th September 1986	210	0
	Unit 4	14th March 1989	210	0
	Unit 5	14th September 1994	210	0
	Unit 6	30th January 1999	210	0
3rd February'2013	Unit 1	16th June 1974	55	0
	Unit 2	13th February 1976	55	0
	Unit 3	14th September 1986	210	0
	Unit 4	14th March 1989	210	0
	Unit 5	14th September 1994	210	0
	Unit 6	30th January 1999	210	0
4th February'2013	Unit 1	16th June 1974	55	0
	Unit 2	13th February 1976	55	0
	Unit 3	14th September 1986	210	0
	Unit 4	14th March 1989	210	0
	Unit 5	14th September 1994	210	0
	Unit 6	30th January 1999	210	0
5th February'2013	Unit 1	16th June 1974	55	38
	Unit 2	13th February 1976	55	0
	Unit 3	14th September 1986	210	170
	Unit 4	14th March 1989	210	0
	Unit 5	14th September 1994	210	0
	Unit 6	30th January 1999	210	0
6th February'2013	Unit 1	16th June 1974	55	38
	Unit 2	13th February 1976	55	0
	Unit 3	14th September 1986	210	170
	Unit 4	14th March 1989	210	0
	Unit 5	14th September 1994	210	0
	Unit 6	30th January 1999	210	0

7th February'2013	Unit 1 16th June 1974	55	38	
	Unit 2 13th February 1976	55	0	
	Unit 3 14th September 1986	210	170	
Unit 4	14th March 1989 210	0		
	Unit 5 14th September 1994	210	0	
	Unit 6 30th January 1999	210	0	
8th February'2013	Unit 1 16th June 1974	55	42	382
	Unit 2 13th February 1976	55	0	
	Unit 3 14th September 1986	210	170	
	Unit 4 14th March 1989	210	0	
	Unit 5 14th September 1994	210	170	
	Unit 6 30th January 1999	210	0	
9th February'2013	Unit 1 16th June 1974	55	38	378
	Unit 2 13th February 1976	55	0	
	Unit 3 14th September 1986	210	170	
	Unit 4 14th March 1989	210	0	
	Unit 5 14th September 1994	210	170	
	Unit 6 30th January 1999	210	0	
10th February'2013	Unit 1 16th June 1974	55		0
	Unit 2 13th February 1976	55		
	Unit 3 14th September 1986	210		
	Unit 4 14th March 1989	210		
	Unit 5 14th September 1994	210		
	Unit 6 30th January 1999	210		
11th February'2013	Unit 1 16th June 1974	55		0
	Unit 2 13th February 1976	55		
	Unit 3 14th September 1986	210		
	Unit 4 14th March 1989	210		
	Unit 5 14th September 1994	210		
	Unit 6 30th January 1999	210		
12th February'2013	Unit 1 16th June 1974	55		0
	Unit 2 13th February 1976	55		
	Unit 3 14th September 1986	210		
	Unit 4 14th March 1989	210		
	Unit 5 14th September 1994	210		
	Unit 6 30th January 1999	210		
13th February'2013	Unit 1 16th June 1974	55		0
	Unit 2 13th February 1976	55		
	Unit 3 14th September 1986	210		
	Unit 4 14th March 1989	210		
	Unit 5 14th September 1994	210		
	Unit 6 30th January 1999	210		
14th February'2013	Unit 1 16th June 1974	55		0
	Unit 2 13th February 1976	55		
	Unit 3 14th September 1986	210		
	Unit 4 14th March 1989	210		
	Unit 5 14th September 1994	210		
	Unit 6 30th January 1999	210		

15th February'2013	Unit 1 16th June 1974	55	0
	Unit 2 13th February 1976	55	
	Unit 3 14th September 1986	210	
	Unit 4 14th March 1989	210	
	Unit 5 14th September 1994	210	
	Unit 6 30th January 1999	210	
16th February'2013	Unit 1 16th June 1974	55	0
	Unit 2 13th February 1976	55	
	Unit 3 14th September 1986	210	
	Unit 4 14th March 1989	210	
	Unit 5 14th September 1994	210	
	Unit 6 30th January 1999	210	
17th February'2013	Unit 1 16th June 1974	55	0
	Unit 2 13th February 1976	55	
	Unit 3 14th September 1986	210	
	Unit 4 14th March 1989	210	
	Unit 5 14th September 1994	210	
	Unit 6 30th January 1999	210	
18th February'2013	Unit 1 16th June 1974	55	0
	Unit 2 13th February 1976	55	
	Unit 3 14th September 1986	210	
	Unit 4 14th March 1989	210	
	Unit 5 14th September 1994	210	
	Unit 6 30th January 1999	210	
19th February'2013	Unit 1 16th June 1974	55	0
	Unit 2 13th February 1976	55	
	Unit 3 14th September 1986	210	
	Unit 4 14th March 1989	210	
	Unit 5 14th September 1994	210	
	Unit 6 30th January 1999	210	
20th February'2013	Unit 1 16th June 1974	55	0
	Unit 2 13th February 1976	55	
	Unit 3 14th September 1986	210	
	Unit 4 14th March 1989	210	
	Unit 5 14th September 1994	210	
	Unit 6 30th January 1999	210	
21st February'2013	Unit 1 16th June 1974	55	
	Unit 2 13th February 1976	55	
	Unit 3 14th September 1986	210	
	Unit 4 14th March 1989	210	
	Unit 5 14th September 1994	210	
	Unit 6 30th January 1999	210	
22nd February'2013	Unit 1 16th June 1974	55	
	Unit 2 13th February 1976	55	
	Unit 3 14th September 1986	210	
	Unit 4 14th March 1989	210	
	Unit 5 14th September 1994	210	
	Unit 6 30th January 1999	210	

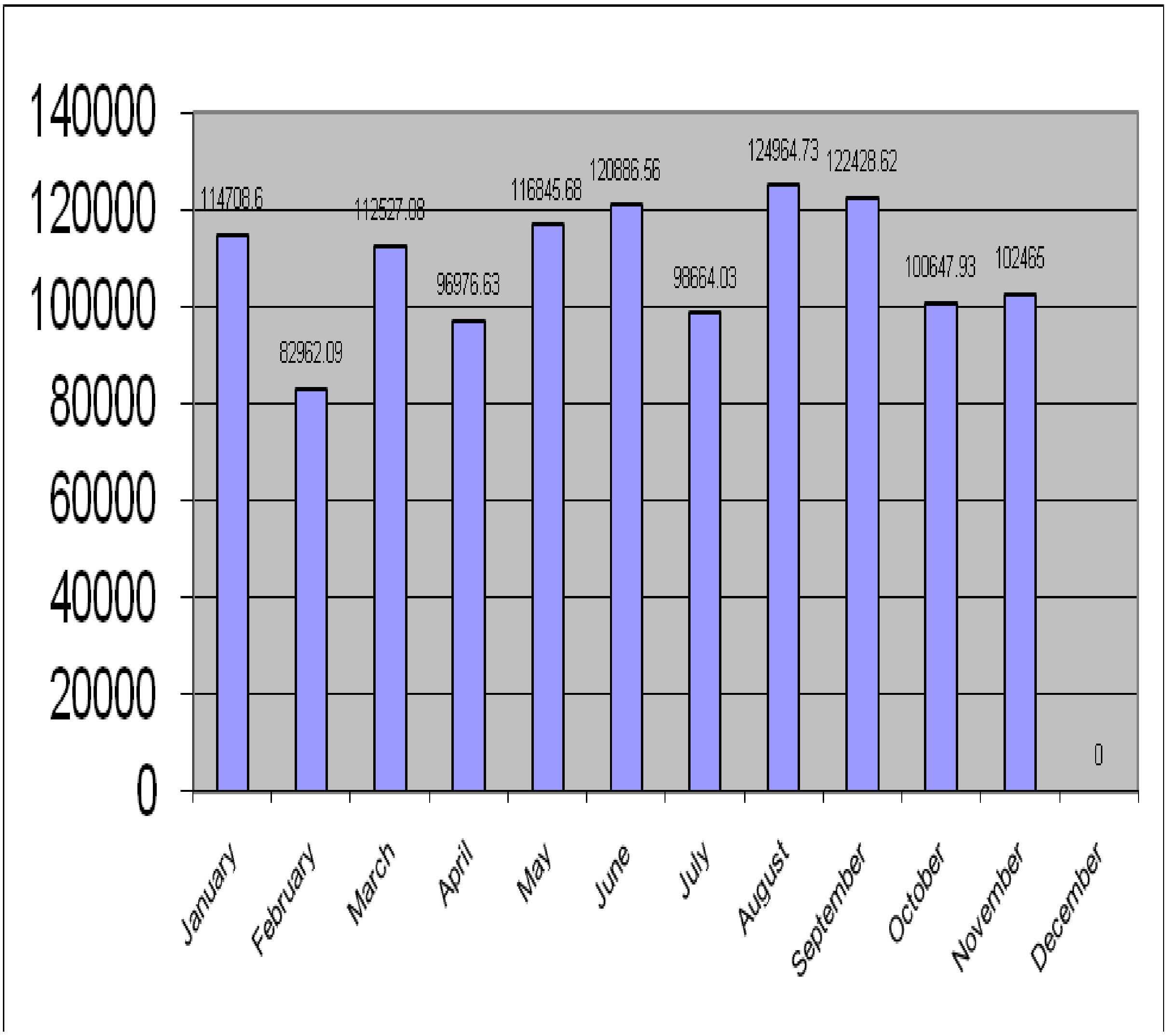
23rd February'2013	Unit 1 16th June 1974	55	
	Unit 2 13th February 1976	55	
	Unit 3 14th September 1986	210	
	Unit 4 14th March 1989	210	
	Unit 5 14th September 1994	210	
	Unit 6 30th January 1999	210	
24th February'2013	Unit 1 16th June 1974	55	
	Unit 2 13th February 1976	55	
	Unit 3 14th September 1986	210	
	Unit 4 14th March 1989	210	
	Unit 5 14th September 1994	210	
	Unit 6 30th January 1999	210	
25th February'2013	Unit 1 16th June 1974	55	0
	Unit 2 13th February 1976	55	
	Unit 3 14th September 1986	210	
	Unit 4 14th March 1989	210	
	Unit 5 14th September 1994	210	
	Unit 6 30th January 1999	210	
26th February'2013	Unit 1 16th June 1974	55	0
	Unit 2 13th February 1976	55	
	Unit 3 14th September 1986	210	
	Unit 4 14th March 1989	210	
	Unit 5 14th September 1994	210	
	Unit 6 30th January 1999	210	
27th February'2013	Unit 1 16th June 1974	55	0
	Unit 2 13th February 1976	55	
	Unit 3 14th September 1986	210	
	Unit 4 14th March 1989	210	
	Unit 5 14th September 1994	210	
	Unit 6 30th January 1999	210	
28th February'2013	Unit 1 16th June 1974	55	0
	Unit 2 13th February 1976	55	
	Unit 3 14th September 1986	210	
	Unit 4 14th March 1989	210	
	Unit 5 14th September 1994	210	
	Unit 6 30th January 1999	210	
29th January'2013	Unit 1 16th June 1974	55	0

Date	23-Apr-14				
Unit No.	Yesterday Peak	Today			
		09:00AM	Estimated Peak		
Unit 1	40	40	40		
Unit 2	48	48	50		
Unit 3	100	100	170		
Unit 4	110	110	180		
Unit 5	190	190	190		
Unit 6	0	0	0		
Total	488	488	630		

Yearly Report (5th Unit) - 2012

Month	Total Running Hours (Boiler)	Total Running Hours (Generator)	Total Energy Generation KWH	Average Load Factor	Average Plant Factor	Total Gas Consumption MCF	Total Gas Consumption NCM	Average Fuel Consumption NCM/KWH	Total Auxiliary Consumption MWH	Total Energy Export MWH
January	738.04	733.25	121936500	86.26	78.04	1248817	35362226	0.292	7227.90	114708.60
February	552.83	552.83	88515000	81.61	73.18	915339	25919269	0.298	5552.91	82962.09
March	730.38	725.80	120078000	87.24	76.85	1209798	34257341	0.292	7550.92	112527.08
April	612.53	612.53	103509000	88.31	78.99	1046779	29641201	0.287	6532.37	96976.63
May	727.30	723.80	124803000	88.45	79.88	1275440	36116098	0.296	7957.14	116845.86
June	720.00	720.00	129244500	94.48	85.48	1303176	36901487	0.286	8357.94	120886.56
July	616.92	613.58	105493500	90.59	80.69	1083427	30678947	0.296	6829.47	98664.03
August	744.00	744.00	133969500	94.77	85.75	1374794	38929463	0.291	9009.77	124959.73
September	720.00	720.00	131260500	95.95	86.81	1346072	38116155	0.291	8831.88	122428.62
October	612.32	612.32	108045000	87.89	79.40	1103006	31233357	0.315	7397.07	100647.93
November	671.53	671.53	110076750	86.21	78.00	1114635	31562650	0.287	7611.75	102465.00
December	0.00	0.00	0	0.00	0.00	0	0	0.000	0.00	0.00
Year-2012	7445.85	7429.64	1276931250	89.25	80.28	13021283	368718193	0.294	82859.12	1194072.13

One Year Load Curve-2012



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Time in Month

Yearly Report (5th Unit) - 2013

Month	Total Running Hours (Boiler)	Total Running Hours (Generator)	Total Energy Generation KWH	Average Load Factor	Average Plant Factor	Total Gas Consumption MCF	Total Gas Consumption NCM	Average Fuel Consumption NCM/KWH	Total Auxiliary Consumption MWH	Total Energy Export MWH
January	21.58	18.42	1653750	34.71	16.41	19048	539374	0.542	0.25	1653.50
February	578.75	574.98	100674000	91.37	79.90	1024686	29015602	0.300	6308.46	94365.54
March	660.41	657.58	115731000	91.15	82.01	1208944	34233159	0.298	7143.50	108587.50
April	611.33	606.30	95917500	90.61	73.20	1022995	28967719	0.304	6917.89	88999.61
May	744.00	744.00	121023000	95.69	77.46	1269706	35953731	0.297	8622.27	112400.73
June	648.67	648.67	104454000	91.46	74.02	1100242	31155090	0.296	7633.08	96820.92
July	683.77	683.77	121700250	89.92	80.49	1255503	35551550	0.298	8314.19	113386.06
August	744.00	744.00	131558750	93.07	84.20	1344761	38079032	0.290	9042.67	122516.09
September	720.00	720.00	127764000	93.39	84.50	1284843	36382359	0.285	8760.03	119003.97
October	744.00	744.00	126945000	92.94	84.09	1329652	37651196	0.288	9005.58	122380.93
November	532.33	532.33	96626250	92.13	83.36	984528	27878465	0.293	6597.20	90029.06
December	726.75	724.60	125007250	88.62	80.01	1284444	36371060	0.297	8695.24	116312.02
Year-2013	7415.59	7398.65	1269054750	87.09	74.97	13129352	371778338	0.295	87040.34	1186455.91

BOILER					GENERATOR							SHUTDOWN TIME		FUEL						
Date	Firing Time	Shutdown/ Tripping Time	Running Hours	Total Running Hours Since Installation	Time Of Synchronisation	Tripping/ Shutdown Time	Running Hours	Total Running Hours Since Installation	Peak Load With Time	Energy Generated KWH	Total Energy Generated MKWH	Load Factor	Plant Factor	Flow Meter Reading MCF	Gas Consumption NCM	Total Consumption Since Installation	Fuel Consumption Per Unit Generation NCM/KWH	Auxiliary Consumption MWH	Energy Export MWH	Remarks
1st September 2014			24	162982.33			24	154482.17	190	4331250	24000.563	94.98	85.94	45761	1295794.99		0.299	297.720	4033.530	
2nd September 2014			24	163006.33			24	154506.17	190	4410000	24004.973	96.71	87.50	44507	1260286.00		0.286	295.740	4114.260	
3rd September 2014			24	163030.33			24	154530.17	190	4347000	24009.320	95.33	86.25	44885	1270989.66		0.292	298.350	4048.650	
4th September 2014			24	163054.33			24	154554.17	190	4221000	24013.541	92.57	83.75	42845	1213223.84		0.287	300.330	3920.670	
5th September 2014			24	163078.33			24	154578.17	190	4347000	24017.888	95.33	86.25	43965	1244938.41		0.286	299.700	4047.300	
6th September 2014			24	163102.33			24	154602.17	190	4315500	24022.203	94.64	85.63	43969	1245051.68		0.289	301.680	4013.820	
7th September 2014			24	163126.33			24	154626.17	190	4315500	24026.519	94.64	85.63	43801	1240294.49		0.287	283.860	4031.640	
8th September 2014			24	163150.33			24	154650.17	190	4347000	24030.866	95.33	86.25	45040	1275378.73		0.293	312.840	4034.160	
9th September 2014			24	163174.33			24	154674.17	190	4347000	24035.213	95.33	86.25	44673	1264986.55		0.291	294.410	4052.590	
10th September 2014			24	163198.33			24	154698.17	190	4347000	24039.560	95.33	86.25	45426	1286308.93		0.296	302.940	4044.060	
11th September 2014			24	163222.33			24	154722.17	190	4378500	24043.938	96.02	86.88	44400	1257256.12		0.287	285.840	4092.660	
12th September 2014			24	163246.33			24	154746.17	190	4378500	24048.317	96.02	86.88	43471	1230950.02		0.281	303.030	4075.470	
13th September 2014			24	163270.33			24	154770.17	190	4252500	24052.569	93.26	84.38	44471	1259266.60		0.296	304.290	3948.210	
14th September 2014																				
15th September 2014																				
16th September 2014																				
17th September 2014																				
18th September 2014																				
19th September 2014																				
20th September 2014																				
21st September 2014																				
22nd September 2014																				
23rd September 2014																				
24th September 2014																				
25th September 2014																				
26th September 2014																				
27th September 2014																				
28th September 2014																				
29th September 2014																				
30th September 2014																				
Sep-14			312				312			56337750		95.04	85.99	577214	16344726.04		0.290	3880.73	52457.02	

CONCLUSION

Electricity is the most essential commercial energy source in the world. Electrical power-station play vital role in generation electrical power. So selection of site, Operation & maintenance of a power-station is very important from commercial point of view. In this dissertation efforts have been made to present essential elements of a Operation and maintenance of 210 MW Ghorasal Power Station in a systematic way. Here Operation & maintenance of essential systems are well illustrated. The major stations include a control room from which operations are coordinated. The central component of the power-station is the Boiler,Turbine &Generator. Other crucial components are Feed pump, circulating water pump,Drip pump,Raw water pump,etc

Reference

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[4].http;www.wikipedia.com