Bangladesh Power Development Board

INTEGRATED MANAGEMENT SYSTEM
(BASED ON ISO 9001:2015, ISO 14001:2015 & ISO 45001:2018 STANDARDS)

PROCEDURE FOR OPERATION & CONTROL OF AUXILIARY SYSTEMS – GAS STEAM POWER PLANT

1.0 Purpose

a) To determine and plan its processes and define the functions that are necessary for providing generation of electric power that can continue to meet the needs and expectations of customers
b) To plan and control in accordance with the organization's strategy
c) To run the processes under controlled conditions
d) To monitor, measure and review activities,
e) To ensure a method for safe and quality auxiliary operation.

2.0 Scope

Applies to all Gas Steam power plant of Integrated Management System of Bangladesh Power Development Board (BPDB).

3.0 Terms & Definition

Definition

None

Abbreviations

BPDB – Bangladesh Power Development Board
MR – Management Representative

4.0 Roles and Responsibility

None

5.0 Procedure

5.1 Plan of the operational procedures

Auxiliary processes consist of followings:

a) Water treatment Plant
b) Boiler pre-boiler water conditioning
c) Auxiliaries of boiler
d) Protection, Interlocking of Boiler
e) Auxiliaries of Generator
f) Auxiliaries of Turbine
g) Protections, interlockings and automatic device

Operation of Water treatment plant Plan

- The water treatment plant produce demineralized water by ion exchange method
- The quality of demineralized water is
    1. E Conductivity: .2-.3 µS/cm,
    2. pH: 6.5-6.8
    3. SiO_2: 20-30 µg/l
- The main source of water is nearby river or lake
- Clarification of raw water by clarifier
- Filtration of water by mechanical filter
- Removal of cation by cation exchanger (1^{st} stage)
- Removal of anion by anion exchanger (1^{st} stage)
- CO_2 gas removed by decarbonizer tower.
- Removal of rest of the cation by cation (2^{nd} stage)
- Removal of rest of the anion by anion exchanger (2^{nd} stage)
- Rest of the cation and anion are removed by mixbed exchanger
- After getting water from mixbed is known as demineralized water. The chemical used in chemical plant are H_2SO_4, NaOH, $Al_2(SO4)_3$, Polyacrylamide etc.
- After regeneration of cation and anion exchangers the wastes are discharge into the neutralization pond.
- The plant is running round the clock to produce quality demineralized water. To maintain quality of demi water, in every hour the chemist check the different parameters like Conductivity, pH, SiO_2, Chloride, Total Hardness etc.

5.2 Operation of Boiler & pre-boiler water conditioning

- Plan
    - Demineralized water used in boiler system is corrosive in nature in iron surface due to low pH value 6-6.8. The corrosive action of purified water is destroyed using some chemicals having strictly maintain their amount.
    - So that these destroy the corrosive action of the purified water but do not cause deposition in the system due to extra addition of minerals.
    - For quality control tri-sodium phosphate $Na_3P0_4.12H_20$), Ammonium hydroxide (NH_40H) & Hydrazine hydrate (N_2H_4. H_20) are generally used in boiler and pre-boiler system of the Thermal Power Station. The Chemical are dosing by the dosing pump.
- To Maintain quality of water, oil & gas in laboratory test are as follows-
    - Quality test of Raw water (River & Underground water).
    - Quality test of Demineralized water.
    - Test of boiler and pre-boiler Water & quality control by dosing Chemicals (Na_3P0_4. $12H_20$, NH_40H & N_2H_4. H_2Q).
- Quality test of Oil (Transformer oil, Turbine oil, Feed Oil, RAH oil etc.).
    - Test of Generator cooling gas (Hydrogen).
    - Test of Hydrogen gas of Electrolyzer Plant.

- Test of Fuel gas (Methane).
  - Quality test of all chemicals those are use in Chemical Plant and Laboratory.
  - Deposit & Scale analysis of different kinds of tube.
- The amount of chemical maintain according to the prescribe parameter suggested by the manufacturer every two hours interval test carried-out and take necessary action to maintain prescribed parameter.

5.3 Auxiliaries of Boiler

- Steam boiler is of drum type with two-stage evaporating system. To second belongs 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 super heater are in the furnace in the upper part of the furnace there is a platen super heater.
- In horizontal gas-duct there are inlet and outlet stages of convective super heater of high pressure (H.P.C.S.H.) outlet and inlet stages of L.P. convective super heater, all one-by-one along the gas-flow.
- The floor of the furnace chamber and o 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. Super heater 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 desired lay-out dimensions the walls are covered with gas-tight pipes, All the headers and wall tubes are fabricated of carbon steel. It has specific volume and Inter-pipe spacing.
  - In the lower part of the furnace the pipes of the front wall from a slope with desired horizontal slope angle, Panels are united with the headers. Inlet (lower) and outlet (upper] headers have desired diameter. Each pipe panel comprises of some pipes.
  - Each side wall has desired dimension, consisting of some pipes in each blocks. The pipes of panels of the side wall rear blocks from pipe arrangements for crawl-ways at elevations of desired dimension. Pipes of middle block panels from pipe arrangements for crawl-ways at elevation of desired dimension. The front and side walls are hanged to the metal structures of the boiler by means of suspensions.
  - Rear wall consists of some blocks-2 external and middle blocks each external panel has desired dimension and consist of 16 pipes, each middle panel has desired dimension and consists of some pipes. Each middle panel has two pipe-arrangements for the burners at desired dimension of

elevations. Arrangements are made in a conic form of smooth pipes. In a conic part of the embrasure the pipes are welded in between by rods. Inner surfaces of these pipes are tenoned and covered with carborund mass; these pipes from the embrasure of burner.

- Rear wall in the upper part form as aerodynamic 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, it has specific dimension. Pipes are connected by means of adaptors to pipes, which are taken into the lower headers of the walls.
- Out from upper headers of rear wall through a horizontal gas duct of some pipes of desired dimension. Pass -which form a single-row outlet wall screen with 610-650 ram spacing Draughts are fixed to these pipes, by means of which rear wall is hanged to the ceiling interflowing of the frame passing the ceiling the pipes of external-wall screen come into the, "boiler drum.
- Open pipe of each panel of the front, rear and side8 screens between elevations in desired dimension protrude in the furnace for fixing the panels of wall radiant super heater.

- Circulation circuit
  - All walls of the furnace chamber are sectionized. Each panel is a circulation circuit. All-in-all there are some circulation circuits.
  - Boiler has two-stage evaporation circuit. Second evaporation circuit includes 2 circuits (each consisting of some number of pipes) of front panels of each side wall. The rest circuits of circulation are included in the stage of evaporation. From the boiler drum water comes into specific dimension down comers by water-supply pipes. Water is supplied to each of the down comers by nine pipes.
  - Out from down-comers water flows into lower headers of the walls by pipes. Few pipes go from each of external down comers; few pipes-to front panels of the side walls and few pipes from each down comer go to middle and rear panels of side walls. Some pipes go from each of the, second: form, edge down comers; few pipes to the side panels of a side wall three- to the first and second from edge panels of the front wall, few pipe go from each of the middle down comers; few pipes go to two middle panels of rear wall and few pipes from each down comer go to the middle panels of the front wall.
  - Steam water mixture is separated to the drum from upper headers by pipes; few pipes from each panel of the front wall, few pipes- from middle panels of the rear wall, few pipes from side panels of the rear wall, few pipes-from front panels of side walls. The second evaporation state comprises 2 circuits each of them to be formed in the following way; for the drum boiler water goes by pipe to external steam -separating cyclone.

From cyclone water goes by two pipes into the header, after that to few pipes of the side wall front panel. Out from the upper header steam-water mixture is supplied by two pipes to the upper part of drum. Separated steam is supplied by two mm pipes to the drum. The total output of the second stage is measured.

- Interior of the Drum
  - 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 of desired dimension nearby the emergency drainage gate valve. The middle level of water is 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 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 Twiddle level
  - Separating devices inside the drum generally consist to the following parts; cyclones fixed in two rows by length of the drum; -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. Super heater
  - H.P. Super heater has two flows. Both flows are symmetrical. Coming out from the drum by few pipes, steam of each of the flows is then separated into two sub-flows.
  - By the first sub-flow steam is supplied by pipes to another pipe-line. At the inlet to this pipe-line one throttling wear for leveling steam rate by sub-flows.
  - Out from the pipes of horizontal gas duct steam by 4 pipes and one pipe comes to this header which is connected by a connector to another header.
  - Radiant super heater
    - Radiant super heater is placed in the furnace chamber and consists of some units: few units on the front and rear wall and one unit on side walls, front and rear panels have their specific dimension. Each unit consists of vertical headers and horizontal U-type bent pipes made of pipes of specific dimension.
    - The bent sections of pipes in desired numbers of furnace wall serve to fix radiant super heater. 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 super heater
    - Platen super heater is installed in the upper part of the furnace chamber and consists of one row of platens. There are some platens in the row with desired spacing.

Each platen consists of two headers and of U-type vertical bent pipe made of pipes of specific dimension.

- Ceiling wall super heater and Rear wall of down coming gas Duct
  - It is made of carbon steel and consists of some blocks. Its place is above the furnace and down coming gas duct, made of finned pipes of desired shape. The middle part of ceiling super heater is made of smooth pipes of desired dimension in order to make it possible to perform erection of the vertical heat transfer convective surface placed in over crossing gas duct and also for possible erection of steam extracting pipes of the rear wall and front wall pipes of the down-coming gas duct.
  - During erection between these pipes plates are welded to ensure gas tightness and to provide or possible installation of sealing ducts. Each block of ceiling super heater consists of inlet and outlet headers and some pipes (two second from edge blocks have 48 pipes). Ceiling super heater comes to pipes of rear wall of the down coming gas duct at elevation of desired dimension.
- Front wall of Down coming Gas Duct
  - It consists of some blocks. Each block has 2 headers and a panel made of pipes of specific dimension. Two side panels have few pipes each, few middle panels have some pipes each. Up to the level of the bottom part of horizontal gas duct these panels are made gas tight of finned pipes.
  - These pipes are cooled by steam but not all of them but every second one. Non-cooled pipes serve only to ensure gas tightness of the panel. That is why the super ends of these pipes at the bottom level have square blinds, specified thickness welded to them. The cooled pipes in the area of the horizontal duct made of smooth pipes and from a single-row furnace outlet screen with specified spacing.
- Horizontal gas duct-guard
  - It is fabricated from steel 20 end consists of some 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 and panels made of finned pipes. In two side panels there are some pipes, in middle panels there are few pipes.
- Side walls of Down coming gas Duct
  - Each side wall of down coming gas duct is formed by two blocks. A block consists of two headers and some finned pipes of desired dimension.
- Convective super heater of high pressure

        - It consists of two stages. Steam flow in each of them is parallel. Inlet stage of the H.P. convective super heater consists of some blocks. Each block consists of headers and nine packets of bent pipes of required dimension. Each packet has U-type bent pipes, made of pipes of desired dimension
    - Low pressure convective super heater
        - It consists of two stage-inlet and outlet. The inlet stage goes second as the gas flows and consists of some blocks. Each block consists of 2 headers: Inlet header and outlet header of specific dimension and few packets of bent pipes (two middle blocks have 17 packets of bent pipes). Each packet consists of some two-loop bent pipes made of pipes of required dimension.
- Condensing Plant
    - There are two condensing plants at the boiler for producing condensate, installed from the both side walls of the furnace chamber at el. 21800. Each plant consists of 2 condenser, two headers for steam supplying, one steam extracting header and two headers of feed water (delivery and discharge).
- 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 super heater in front of the plantens; second-after platens in front of H.P. convective super heater, 3rd -in between two stages of H.P. convective super heater. 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 super heater.
        - Injecting coolers
            - These are pipes of desired dimension, in which an injector is installed in protective cylindrical 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 desuper heater through a special nozzle along the exis of the tube.
- Water Economizer
    - It is placed in down-take gas duct and consists of two inlet headers and two outlet headers and some packets of bent pipes made from required dimension
    - All economizer chambers are inside the gas duct in parallel to boiler front, Each outlet header is suspended on some suspension pipes, these pipes being at the same time water tapping pipes.
- Burners

- There are some cyclone burners placed in two tiers on the rear wall. The burners of the lower tier are installed at elevation of desired dimension, upper at elevation of required dimension 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 peripheral channel is done by a swirl vane carrying 23 permanent blades. In the burner central gas supply is foreseen.
- 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 and pearlite-cement plates.
    - 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.
    - Heat wall" ("Hip-roof") of ceiling: Above ceiling of the boiler there is a "Heat wall" which is made gas-tight. Inside the hip-roof air is supplied for achieving pressure of specific amount in it in order to avoid the gases from the furnace coming in the space of the hip-roof in unstable operating modes or in case the ceiling becomes untight.

- Air Heater
    - There are some regenerative rotating air heaters of, 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.
- Draught installation:
    - For regulation of the output in suction of F.D. Fans there are axial guide vanes. In winter period in order to ensure required air heating, coming into R.A.H. it is possible to additionally start into operation a line of hot air recirculation to suction line of F.D. Fans
- Air Duct
    - After R.A.H the main air flow goes to the burners. Out from common airline 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 there is a hot air supply line with automatic regulator.
    - For making air pass enabling automation to work. There are two lines 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 I.D. Fans of desired dimension and designed capacity.
- 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 and desired head pressure under required gas temperature.
    - 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 war: specific output, pressure.
    - 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.

5.4 Protection, interlocking of Boiler

- On the boiler there is a protection system which is designed for prevention the appearance and progress of failures during 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 boilers 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 losing 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/cm2.
    - When the air pressure in front of burners is reduced up to 40 kgf/m2 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).
- When the steam consumption through the intermediate steam super heater is stopped reducing of the pressure drop up to the value equal to 20% of steam consumption through steam super heater from the nominal one and with the time delay up to 20 seconds. Pressure drops are measured on cold steam pipelines as per steam running after trapping on the safety valves and on hot steam pipelines (on one from the corresponding supplies to the stop valve of the M.P. cylinder). Each drop is being controlled by 2 devices, the contacts of which are connected sequentially. Protection operates with operation of the two devices, controlling the pressure drop in any flow. Protection setting-0.09 kg/cm2.
- The shut-done of the boiler is down by the key from the unit control Board.

- During the shut-down of the boiler protection carries out the following operations simultaneously;
  - Shut-off valve NPIOS02 is being closed; stop gate valves. NPIOS01, NPIOS09, NPIOS10 and regulating valve NPIOS04, NP10S03 on the gas supply to the boiler are closed
  - Stop gate valve NP11S01, NP11S03, NP12S01, NP12S03, NP12S05 NP13S01, NP13S03, NP13S05, NP14S01, NP14S03, NP14S05, on the gas supply line to each burner are being closed, in this case if they were opened and it is forbidden to open these gate valves. Valves NP10SO (11-14). NP10S02.
  - Gate valve NP20S01 on the supply of ignition gas to the boiler is being closed.
  - Gate valve NP30S01, NP30S02, NP40S01, NP40S02, NP50S01 and blow down of the gas pipe line to the burners are opened.
  - Gas recirculation I.D. Fans are switched off.
  - The action of automatic breakers on guide vance of I.D. Fans and F.D. Fans is switched off.
  - Stop valves RL40S01, RL40S02, RL41S01, RL42S01, RL43S01, RL44S01, RL45S01, RL46S01, RL20S01 on the water supply into injection into H.P. steam super heater are being closed.

- Stop gate valves RL54S01, RL55S01 on the water supply on injection into L.P. super heater of the boiler are closed. If the boiler is being stopped due to overfeeding of the boiler's drum with water or due to losing the water level from the drum, or during shutdown of the Unit for emergency increase of the level in H.P. Heater it is extra carried out;
- Closing stop gate valve RL30S01, RL31S01, RL32S02, RL33S01 and valves RL32S02, RL33S02 on the feed water supply to the boiler.
- Switching off of the automatic regulators and closing the regulating valve RL30S02, RL33S02, RL32S02, RL31S02 on the feed water supply to the boiler.
- Main steam gate valves RA11S01, RA11S02, RA11S03, RA12S01, RA12S02, RA12S03 are being closed. During shut-down of the boiler due to switching off of both RAHS or both I.D. Fans, F.D. Fans are switched off. In all the other cases of the boiler shutdown, I.D. Fans & F.D. Fans are stopped by the personnel on duty after ventilation of the furnace and gas ducts of the boiler.

- Protection operating for decreasing the load of the boiler: Decreasing the Load of the boiler by protection of changing over of the Unit for 50-30% load is foreseen is the following cases;
  - With switching off of one from two operating, D. Fans (with 1 second time delay).
  - With switching off one out of two operating F.D. fans (with second time delay).
  - With switching off of one out of two operating RAHs (with 1 second time delay). ;
  - With rising the live steam temperature on the outlet from the boiler up to 5550C (with 5 minutes time delay)
  - At increasing steam reheat temperature on the outlet from the boiler up to 5600C (with 5 minutes time delay).
  - With switching off one out of two operating feed pumps and non-switching on of the stand-by one. At the same time in the protection scheme of the boiler regarding reducing the level in the drum 9 seconds time delay is introduced (in all other cases shut-down of the boiler as per level decrease is carried out w/o time delay).
- Protections, Performing local operations
  - When the boiler is overfeeded with water (1st limit)- increasing the level in the boiler on 150mm above the medium one is delivered by a signal for simultaneous opening of two subsequently installed gate valves on the pipe line of emergency drainage of water from the drum. When the level in the drum is reduced up to valve +

130mm a signal for simultaneous closing of gate valves is sent.

- When the pressure in the "hot box" of the ceiling is increased up to 50 Kgf/m2 a signal' for opening of all the valves on, air discharge from the "hot box" into the atmosphere is sent. If the pressure in the "hot box" is lower than 50 Kgf/m2 an order for opening the valve is cancelled. When the pressure is reduced up to 30 Kgf/m2, Valves on the line of the "hot box" blowing though are closed by protection.
- When the steam pressure from the outlet of the boiler in any of steam pipelines or in drum is increase up to 1.05 of nominal a signal for preventive opening of operating impulse safety valve NA11S03 (147 atm or NA12S04 (166 atm) accordingly is sent.
- When the steam pressure on the outlet from the boiler or in the boiler's drum up to 1.08 of nominal a signal for preventive opening of working impulse safety valves NA12S03 (151 atm.) or NA11S04 (170 atm) is sent accordingly. The operation of valve NA1 1S03 is blocked with NA12S03, and valve NA12S04-withNA11S04.
- When reheat steam temperature behind the boiler in any line rises up to 5500C a corresponding regulating valve RL54S02 (RL55S02) from the automatic regulator of emergency injection on the line of injection into the re heater is being opened. At the start of opening of the regulating valve RL54S02 (RL55S02) a gate valve corresponding to his channel RL54S01 (RL55S01) on the line of this injection is being opened.
- With burning of deposits in the RAH due to reducing gas temperatures difference before and air after the RAH till the adjusted limit 100C) the following operations on fire-fighting are taken place.
- 1.Gate valve VJ11S01, VJ12S01 on the water supply from the firefighting pipeline to the RAh are opened;
- 2. The el. motor of the corresponding F.D. fan with the following action of interlockings as per items 4.5. are being switched off. The rotor of the burned RAH should continue its rotation. This protection is adjusted for the signal

- Conditions of interlocking of auxiliary equipment mechanisms
  - With switching off of the el. motor of one out of two working F.D. fan the following is being carried out:
  - reducing of the boiler's load with switching of the action of the main unit regulator on the working fuel regulator with

pre-setting the task for the fuel regulator for keeping up 50-60% load;

- Switching off of the action of the common air regulator into guide vanes of the stopped. F.D. fan with preservation of the action of the regulator onto the guide vanes of the F.D. fan under operation;
- closing of guide vanes NG10S01 (NG20S01) of the stopped F.D. fan
- Dosing valves NG11S01, NG11S02, (NG210S1, NG21S02) on the air pipe lines and valves NR11S01, NR11S02, NR11S03 (NR12S01, NR12S02, NR12S03) on gas ducts before and after corresponding RAH.
- Closing of valve NG3S01 (NG23S01) on the line of recirculation of hot air onto the suction of the stopped F.D. fan NG10S01 (NG20S01);
- Change over of the el. motor of the operating F. D. fan onto higher speed. Switching off el. Motors of corresponding I.D. Fan as per item No. 4.5.4.

- With switching off el. motors of the both F.D. fans or one of them, if the second one was not working, the following operations are to be carried out: 1) Shut-down of the boiler as per item 4.2.; 2) Switching off the regulator of common air; 3) removal of the interlocking action as per item 4.5.1.
- With full opening of the guide vanes of one out of two F.D. fans and with operation of this fan on slow speed the following operations are to the carried out; 1. Change-over of the el. motor of this fan onto the higher speed by the operator from U.C.B. 2. Change-over of the el. motor of the second F.D. fan onto the higher speed by the operator from U.C.B.
- When the el. motor of one out of two working I.D. fans is switched off, the following operations are carried out;

  1. Reducing the load of the boiler according to item 4.5.1.
  2. switching-off of action of the vacuum regulator in the furnace on the guide vances o the stopped I.D. Fan with preservation of the action of the regulator onto the guide vanes o the I.D. fan under operation.
  3. change-over of the I.D. fan under operation on the higher speed.
  4. Closing of NR11S05 (NR12S05) guide vances of the stopped F.D. fan
  5. switching-off of the el. motor of the corresponding F.D. fan with the following operation of interlocking as per item 4.5.1.

- With switching-off of el. motor of both I.D. fans or one out of them, if the second one was not working, the following operations are carried out.

  1. shut-down of the Boiler as per item 4.2.

2. switching-off of the vacuum regulator;
3. Complete opening of guide vanes NR11S05, NR12S05 of I.D. fans.
4. switching-off of el. motors of both F.D. fans with the following operation of interlocking.

- With complete opening of guide vanes of one I.D. fans and when the above I.D. fan works with now speed, the following is being carried out;

  1-over of el. motor of the second I.D. fan of high speed with time lag up to 20 seconds.

- With switching-off of the el. motor of one out of two RAHs, the following operations are carried out.

  1. Reducing the load of the boiler as per item 4.5.1.
  2. switching-off of the corresponding F.D. fan with the posterior operation of interlockings as per item 4.5.1. and I.D. fan as per item 4.5.4.

- With switching-off of el. motors of both RAHS, the following operations are carried out;

  1. shut-down of the boilers as per item 4.2.
  2. switching-off of both I.D. fans with posterior action of inter locking as per item 4.5.5.

- With switching-off el. motors of one out of two operating flue gas recirculation I.D. fans the following operations are carried out:
  - Closing valves NS10S01, NS10S04, NS10S05; (NS20S01, NS20S04, NS20S05) before and after flue gas recirculation I.D. fan.
  - Switching-off of the action of the temperature regulator of the secondary steam at the outlet from boiler onto guide vanes NS10S02 (NS20S02) of the stopped flue gas recirculation I.D. fan with preserving the action of the regulator on guide vances NS20S02 (NS10S01) of the flue gas recirculation I.D. fan under operation.
  - closing of the guide vances of the stopped gas
  - Recirculation I.D- fan. Opening o' slide valves NG 10S.03 (NG20S03) into the atmosphere
- With switching-off of the el. Motors of both gas re-circulation I.D. fans or one of them, if the second one was not working, the following operation are carried out;

  1. switching-off of the action of the temperature regulator of the secondary steam onto grievances NS10S02, NS20S02 of gas recirculation I.D. fan.

2. Closing valves before and after gas recirculation I.D. fan NS10S04, NS20S04, NS10S01, NS20S01. Opening of slide valves NG10S03, NG20S03 into atmosphere.
3. closing of gas recirculation I.D. fan's guide vances

- Interlocking when a gas burner is put into operation and when it is switched off
  - Ignition protective devices
    - Control of ignition protective devices is performed from the U.C.B and locally, with sending the order the corresponding valve is being opened: NP21S02, NP21S04, NP21S06, NP22S02, NP22S06, NP23S02, NP23S04, NP23S06, NP24S02, NP24S04, NP24S06 on the gas supply to the ignition device and corresponding high voltage transformer for electrospark ignition (in case, if a permission confirming that the ventilation of the furnace during 10-15 minutes can done, is available).
    - If the ignition torch appeared (confirmation is given by ionization sensor), a signal to the U.C.B. is sent and the gate valve on the main fuel supply of this burner is opened automatically.
    - If during lighting-up of the burner in a present time (21 sec) the torch of the Lighting-up burner does net ignite (photo sensor's relay, controlling the torch of this burner will not operate), or the ignition torch died out, the movement of stop member of the gas supply for opening is being stopped and the corresponding stop member is being closed.
    - With sending the command from the UCB regarding switching off of the burner ignition torch, the following operations are carried out;
      1. closing valve, NP21S02 (NP21S04, NP21S06, NP22S02, NP22S06, NP23S02, NP23S04, NP23S06, NP24S02, NP24S04, NP24S06).
      2. switching-off of the corresponding high voltage transformer of the ignition torch.

  - 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, JOG16S05, 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 ID. fans and two F.D. fans during 10-15 minutes. During this period it should be forbidden to open the following stop valves;
    1. on gas supply to the boiler; NP10S01, NP10S02, NP10S09, NP10S010, NP10SO (11-14), NP10S03
    2. on gas, supply each burner:- NP11S01, NP11S03, NP11S05, NP12S01, NP12S03, NP10S07, NP12S05, NP13S01, NP13S03, NP13S05, NP14S03, NP14S03, NP14S05.
- With switching off of the burner, working on the natural gas the gate valve on gas supply to the burner is closed;

5.5 Auxiliaries of Generator

- Design of Generator
    - Turbo generators, hydrogen-cooled, desired r.p.m. are used for imect coupling with steam turbine, specific capacity. The turbo generator rotates clockwise, if viewed from the turbine side. The turbo generator is hcremetically closed. This ensures its normal operation with excess hydrogen pressure.
    - The generator stator consists of two concertrical 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.
    - The stator body is welded and unsplit. It consists of transverse frames connected with pipes, longitudinal beams and ribs. The casing of the body is welded and gas-tight. Two vertical gas-coolers are mounted in the stator at the turbine side. The gas-coolers are manufactured of brass pipes ribbed with copper wire. The pressure and discharge pipe lines are secured to flanges located on the lower part of the gas coolers. Fill-in with water is controlled by drainage pipe. The terminal ducts are secured to the lower part of the stator body at the slip ring side. There are manholes on the lower part of the stator body, which make it possible to get inside the generator without its dismantling.

- The stator core is located inside the frame and assembled of high-alloyed electro-technical steel sheets, 0.5 mm thickness, 0-320 quality, insulated with varnish. The core is pressed of segments assembled in stacks/separated by spacers, forming ventilation ducts. After pressing, active form is tightened with flanges made of non-magnetic steel.
- The stator has a double layer chain-type bar winding with inner cooling by distillate circulating through the hollow conductors.
- The rotor is a massive solid high grade steel forging with a central hold bored along the entire axial length to control the material of forging; on one side the hole is used for mounting the current-carrying bars from the rotor winding to the slip rings.
- The brush holder gear is intended for transmitting current to the generator rotor winding. On current conducting busbars, there are secured brush holders electric graphitized brushes which holders are furnished with a regtor device providing required pressure of the brushes against the slip rings.
- The generator has combined cooling. The stator winding, connection bars, and the leads are cooled with water (distillate), and the stator core and the rotor are hydrogen-cooled.
- The centrifugal compressor fitted on the turbo generator rotor, while the generator increases its r.p.m, operates unsteadily. The character static of the centrifugal compressor H= f (0) at n=const. is a parabola. The operation ration of the compressor is determined by an intersection point- of net work for gas circulation and compressor.

- Thermocontrol of Generator
  - Temperature of rotor winding is determined by formula; t ,01 = 250*(R/ R16)-235 Where Rt-rotor winding resistance at given temperature; Ri5-rotor winding resistance at T =15°C
  - Temperature of individual sections of the generator under operation should not exceed the limiting values
  - Minimum temperature of cold water in gas coolers is maintained
  - Settings of temperature signaling operation are executed within the generator. Temperature of cold and hot gas before and behind gas coolers of the generator is controlled by mercury thermometers.
- Gas-Oil Facilities of Generator

- 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 habit 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.

- System Of Oil Supply to Sealings
  - 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 darning oil from Generator bodies; e) oil cleaning and connection to turbine oil system unit.
  - 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.O. 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 solenoid valve installed on the feedback line of pressure regulator 2 DPD-10T.
- 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.
  - 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.
  - Generator cannot work with air even at no-load running mode. During adjustment of G. it is allowed to operate for a short time with air cooling at no-load running without excitation with the coolers no. At this is necessary to a) make a preparation for start and start G. as per instruction

- Air Pushing By Carbon Dioxide
  - Air pressure if it was high in G. body, is reduced to 0,1-0,2 atm, but before that reducing the settings of signaling of hydrogen pressure in G. After that assemble the line by valves for pushing out air by carbon dioxide on gas panel. T-24 valve is closed and T-25, 29 and 34 are opened. By opening P-23 carbon dioxide is being supplied in G. body. Open f-21 valve so that gas pressure in G. body during blow down be not more than 0,2-0,3 kg/cm2, while doing this control oil drain to hydrogen side; it must be kept constant. Blow-down is done through fully opened T-29.
  - First sampling of gas mixture for analysis should be done after approximately 1,1 stator volume of carbon dioxide has been supplied in Generator, ie.e.800m3 which corresponds to carbon dioxide pressure reduction in the header, that is in two receivers by 2 kg/cm2.
  - After that take off removable rubber hose-pipe on airline and blow-down air supply line by carbon dioxide, open f-18 valve for a short time.
  - The flow rate of carbon dioxide for full blow down of G. with a still rotor equals to 1,3-1,5 volumes of G. i.e. appr. 100m3 C02 and this is equal to approx. 2,2-2,3 kg/cm2 pressure drop in two receivers. Due to the fact that gas pressure in receivers exceeds significantly the nominal gas pressure in G. body it is necessary to constantly control pressure in its body while changing the media.
- Carbon Dioxide Pushing By Hydrogen
  - Before fixing a removal connection on hydrogen line, blow down this section of pipeline by carbon dioxide by opening for a short time F-18 valve. After that fix a removable connection on hydrogen line.
  - When supplying not less than 1 volume of hydrogen into G., i.e. which is equal to hydrogen pressure reduction in one pair of receivers, connected to G. at approx. 2 atm. pressure, it is possible to take analysis of gas mixture for hydrogen content from F-2A valve.
  - Pushing carbon dioxide by hydrogen can be considered as finished after purity of hydrogen, taken from f-9 valve reaches 97%, After that 29, 38, 39, 40, 41 drainage valves are blown down, f-3,4 impulse lines M-16, 17 gas-oil linese are blown are blown down, f-30, 34 valves are closed.
- Hydrogen Pushing By Carbon Dioxide.
  - This process differs small from air pushing process by carbon dioxide. Before pushing it is necessary to reduce setting of gas pressure change signalling in Generator

body, to switch off gas analyzer by closing f-6,3 valves (C & I personnel on duty).

- Carbon Dioxide Pushing By Air
  - Sequence of operation is the same when carbon dioxide is pushed out by hydrogen. After supply line to the panel is blown down to prevent from moisture, dust, rust up to removable connection from the side of air supply and by T-26, 27, 28, valves from Generator side.
- 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.
- Safety Regulations For Operation & Servicing Of Hydrogen-Cooled Turbo-Generators
  - 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 containg 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).
  - Placards "No smoking". "Hydrogen" must be placed near generator and units of oil and gas system.
  - If hydrogen leakage at the generator is 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.

- 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.

5.6 Auxiliaries of Turbine

5.6.1 Design of the Turbine

- Steam condensate turbine is a one-shaft three-cylinder set with intermediate overheat of steam and two exhausters, it is designed for direct rotation of A.C. generator and it operates within a Unit jointly with one-body drum boiler.
- Maximum capacity of the turbine is provided at the nominal parameters of steam, completely switched on regeneration, clean flow part and when the cooling water temperature does not exceed100C-215MW.
- Turbine Sub-units
    - a device for measuring the expansion of the turbine, which allowed to carry out a remote control for the thermal displacements of the bodies and consisting of hinge less variable reluctance pickups, installed at the foundation frame of the first and second bearings and indicating instruments at the U.C.B.;
    - a device of frequency control of the turbine rotation and issuance of the signaling at the U.C.B at the excess of the rotation frequency
    - Indicators of the relative expansion of L.P., M.P. rotors, which are controlling the difference of expansion of rotors and cylinders with the -signaling of admissible values of expansions.
    - by means of the control device of the rotor axial shift, consisting of two side action relay installed at the special arm in the body of the second bearing and indicating device at the U.C.B. which provides for: the possibility of remote observation for the axial shift of the rotors to the generator's side as well as to the front bearing side
    - By the protective pressure regulator of the live steam "up to yourself", designed for prevention of big changes of the live steam pressure in front of the turbine.
    - A device for measuring of the rotor curving in the course of startup and shut-down of the turbine. Variable curving pickup is installed opposite the H.P. rotor semi-coupling at this the adjusted clearance in between the cores of the pickups and semi-coupling is equal to 2± 0.03 mm.
    - Beating gear prevents the rotor curving in the heated condition at the start-up and shut-down of the turbine.

The bearing gear has an automatic device which provides for the turn of the rotor on 5400C each ten minutes.

- by the device for heating of flanges and studs of H.P. & M.P. cylinders, the saving the time for heating H.P. & M.P cylinders is provided as well as reducing of temperature difference as on the width of flanges and in between the flanges and studs
- The turbine is equipped with the metal temperature control of the cylinders and steam-admitting members as well as with supporting inserts and stop shoes of the bearings with the output of the readings into the U.C.B.

- H.P. Cylinder casted from chromiummolybdeniumvanadium steel has 12 stages the first one out of those twelve is a regulating one. Steam inlet into the H.P. Cylinder is located form the 2nd bearing side that is why the blade apparatus of the H.P. Cylinder is made for the left rotation H.P. rotor is solid-forged.
- The turbo/generator has seven plain bearing, one of them (No.2) is support-thrust; all the others-supporting.
- H.P. & M.P. rotors are connected in between themselves by rigid coupling and have one common bearing. M.P. & L.P. rotors as well as L.P. rotors and generators are connected in between themselves by semi-flexible couplings. Rotors are rotating clockwise if to look at the generator from the front bearing side (Turbine side).
- At the medium frame of the front part of the L.P. Cylinder there is a fixture post of the turbine.
- Steam, distribution is of a nozzle type. Regulating valves of H.P. & L.P. Cylinders, four per each cylinder, are installed directly at H.P. & M.P. Cylinders in the steam boxes. H.P. & M.P, Cylinders are located by steam inlets to each other that provides for the possibility of control for the regulating valves of H.P. & M.P. cylinder by one serve motor and reduces the
- Regulating valves of H.P. & M.P. cylinders supply steam to the nozzle boxes. First simultaneously two upper valves are opened they supplying steam to the upper nozzle boxes and then with some displacement the regulating valves are being opened, supplying steam to the nozzle boxes located in the lower half of the cylinder.
- Non-returned valves, installed at the pipelines of the 1st, 3rd, 5th and 6th Steam extraction from the turbine is designed for prevention speed-up of the turbine by the reverse steam flow at the closed valves of the turbine and switching-off of the generator from the grid
- End sealings of the turbine rotors of the labirinth type are made with the intermediate chambers for supply and extraction of the steam and consist of ring necks on the rotor and immovable sealing ring which are installed at the stator.
- To reduce the relative shortening of H.P. & M.P. Cylinder rotors during decreasing the load and start-up from the not cooled state the supply of

live steam to the second chamber of the front sealing of H.P. & M.P. Cylinder is foreseen.

- Steam suction from the first chambers of the shaft sealings of the stop and regulating valves of H.P, & M.P. Cylinders is performed into the deaerator, from the second chambers-into the steam cooler

5.6.2 Steam supply to the Turbine

- Live steam: from the boiler is supplied to the turbine by two steam pipelines through the main steam gate valves which have by-pass by pipeline on which throttle valves as well as stop gate valves are installed. After the main steam gate valves, live steam, having passed through two stop valves of specific dia comes into four cross-over pipes and further through four regulating valves to the nozzle boxes of the H.P. Cylinders.
- Waste steam from H.P. Cylinder goes as on two steam pipelines to the intermediate steam super heater of the boiler, from there on the four stem pipelines, it comes to the two stop valves of M.P. Cylinders. From the stop valves of M.P. Cylinder the steam goes through the cross-over pipes through four regulating valves into the M.P. Cylinder. From M.P. Cylinder steam on two pipes is directed into double-flow L.P. Cylinder.
- For the discharge of the steam from the boiler during its lighting up, as well as in case of increasing the pressure in the live steam pipelines at the sudden load decrease the quick-acting reducing cooling plant is foreseen, which discharges the steam from the connection of live steam pipelines through the discharge pipeline into the turbine condensers.
- From the pipelines of hot reheat the scheme of steam discharge from each line in front of the stop valves of M.P. Cylinder into the condenser through the steam receiving devices is performed.
- For the preliminary heating of the reheat steam pipelines before the start-up of the turbine 140/10 reducing cooling plant is foreseen with a desired capacity (at the nominal parameters of the steam), ii supplied the steam from the connection of steam pipelines of the live steam into the cold reheat pipelines.
- To regulate the temperature of the steam in front of the stop valves of M.P. Cylinder within the start-up duties the connection with electrified gate valve and gate valve are performed which can cross over the steam from "cold" reheat pipe lines apart the intermediate steam superheated of the boiler into the "hot" reheat steam pipelines.
- All the steam pipelines working at specific steam temperature are made of steel, crossover pipes of H.P. & M.P. Cylinders steel. Valve bodies are made of steel, studs of the flange connections are made of steel, nuts-ll-10 steel.

5.6.3 Condensate Plant

- Condensate plant of the turbine consists of condenser group, condensate pumps, main and start-up ejectors
- Condenser group consists of two surface-two-pass condensers
- The body of the condenser is all welded with welded-in from the both side pipe boards into which the pipes with intermediate pipe partitions are expanded. The water chambers make solid with the body and are closed with the removable covers. Steam spaces of the condensers are united with the leveling branch pipes, with 935 m2 section.
- To avoid the deviation of expanding the pipes in the pipe boards due the thermal shifts of condensers. Lens compensators at their bodies are foreseen, which are providing for mechanical compliance of the pipe boards against the body.
- Pipe system of the unit condensers is made of smooth pipes of MH 5-I alloy. Cooling water is delivered by circulating pumps from the river and. having passed through the pipes is discharged into the outfall channel.
- Each condenser has built-in section of L.P. heater No.1. At the exhausting branch pipes of the L.P. Cylinder atmospheric diaphragm valves are installed which are being opened with increase of pressure in the condensers up to 1 .2 atm.

- High and low pressure regeneration system
  - Regenerative plant of the turbine is used for warming up feed water and turbine condensate with steam, which is taken form intermediate stages, to 1600C after the L.P heater No. 4 and 2450C after the H.P heater No. 7 (at full load).
  - Heat exchangers are placed down the flow of turbine condensate and feed water in the specific sequence
  - High pressure heaters are provided with group protection, which includes some important parts, such as-automatic inlet valve, valves with "electric drive and manual by pass etc.
  - To protect tube bundle of H.P. heater from high pressure at the valve, at the feed water output line from H.P. heater there is a bypass line with two non-return valves and a valve.
  - Heating steam condensate is drained from L.P heaters; from one L.P. heaters to another L.P heater, turbine condensate is drained by means of two drip pumps into delivery line of turbine condensate after L.P. heater.
  - Condensate form one H.P. heater is drained in series to H.P. heater or deaerator. To prevent steam over travel, as well as to ensure maxima use of its heat, each H.P. heater is provided with a valve, which regulates condensate leave in the body of the heater.
  - Suction of non-condensing gases from H.P. heaters is performed in series to L.P. heater. Suction of non-condensing gases from L.P. heaters is performed in series to L.P. heater. From L.P. heater suction is made into condenser.

5.6.4 Regulation system and oil system of turbine

- The steam turbine is -provided with an automatic hydraulic control system, which is used for: a) reliable maintaining of electrical load and idle running of turbine at nominal rotation speed; b) insuring smooth shift of regulating valves, if load is changed; c) automatic maintaining of rotation speed of the turbo generator rotor with 4% offset; d) when load is immediately decreased to 0, for maintaining the rotation speed to rotor, which corresponds to maximal steam flow rate, without operating safety device.
- Speed regulation transducer: It regulates r.p.m. of turbine with 4.0 to 4.5% offset, insensibility not over 0.3%.
- A block of slide valves of speed regulator is utilized to transmit control from speed regulator to intermediate slide valve and differentiator. Block of slide valve is also utilized for additional protection against turbine acceleration.
- Synchronizer (turbine control mechanism) is controlled either by means of a hand wheel (in place), or by means of electric motor with a control switch from U.C.B. (remote control). Automatic control is also possible
- The regulating system of turbine incorporates a power limiter, which allows to limit opening of regulating valves.
- In the turbine a solenoid switch is provided, when the latter operates, regulating and stop valves of the turbine close. The solenoid switch is controlled by protection relay of turbine and unit, as well as by key of remote switching off of turbo generator set from the U.C.B. for this purpose a manual switch-off burton is also used, which is installed in the front stool of the turbine.
- Turbine is provided with an electro hydraulic converter (EHC) for a quick-acting introduction of electric control into hydraulic part of the regulating system of the turbine, electro hydraulic converter is intended for forcing short term closing of H.P.C and L.P.C regulating valves, when generator is tripped from the grid.
- Turbine oil T-22 is used as working flued both in the regulating system and lubricating system of turbine bearings.
- Oil is supplied into lubricating system by means of two injectors connected in series. In both pumps working fluid is either oil from main oil pump when turbine is in operation, or oil from starting oil pump when turbine is not running.
- To supply oil both to the regulating system and to lubricating system and to lubricating system during commissioning, starting oil pump is used with desired capacity and flow rate.
- To provide for oil lubricating system, when turbine is out of operation, or during shut-down a stand-by oil pump is used

  (a) Maintained oil pressure on lubrication at the level of .turbine axis and is regulated by means of draining valve;

  (b) To prevent air accumulation in units and oil line of the governing system, when stand-by lubricating oil-pump is in operation, a line is provided, which has a non-return valve for supplying oil into the governing system;

(c) Both stand-by and emergency oil pumps of lubricating system may be put in operation manually by a switch from the UCB panel, as well as automatically from lubrication pressure decrease relay.

- Turbine oil tank is a welded structure with desired working volume. The tank is also provided with an oil level indicator, which has terminals for sending light signals, when oil level in the tank is eighter minimal or maximal. To remove mechanical impurities from oil, fine and coarse nets are installed in the oil tank. On the oil tank cover a fine filter is installed with desired capacity, it is connected in parallel with main flow of lubricating system.

5.6.5 Protections, inter locking and automatic devices

- Protection against over speed of rotor is effected by means of an over speed governor. The design of over speed governor makes it possible to begin opening stop valves, when the governor operates at speed decrease to desired r.p.m. at this speed pins driven by springs will resume their working position.
- Turbine protection against impermissible axial shift is effected by means of a relay. This relay operates, when rotor shift towards the front bearing .in the area of thrust bearing exceeds 1.7 mm, as well as when rotor shift towards the generator exceeds 1.2 mm.
- Protection against oil pressure drop in the lubricating system is effected by means of pressure relay, which disconnects the turbine, if oil pressure decreases to specific parameter. Simultaneously an impulse, prohibiting to
- Protection against loss of vacuum is effected by means of a vacuum relay.
- Emergency warning lights and audible signalling is provided in the protection circuits of the turbine. Signals are also sent to the UCB, when turbine is tripped off and stop valves are closed.
- Auxiliary equipment of the turbo generator set is also provided with local protections and interlocking, which operate, when separate elements fail, these protections and interlockings perform some operations.

5.7 Environmental Aspect, Impact & Controls

Any activity at the plant, whether it is carried out for ensuring quality of service or meeting requirement of the interested parties, there will be some environmental aspects associated with it. It is a requirement of the IMS of BPDB to identify those environmental aspects, evaluate their impact and determine necessary controls.

While carrying out the activities and operation, the employees of BPDB need to exercise appropriate and predetermined controls so as to prevent or mitigate any adverse impact that may be associated with the activity or the process.
Some examples of environmental aspects associated with the procedure for Operation & Control of Auxiliary Systems-Gas Steam Power Plant are as below:

Sl Nos.	Aspect	Impact	Controls
1.	Electricity Consumption	Global Warming	1. Ensure Components are running efficiently
2.	Use of lubricant	Soil Pollution	1. Follow the waste management plan 2. Work and dispose as per the chemical disposal plan
3.	Oil Leakage	Soil Pollution	1 . Regular Inspection and monitoring
4.	Water Use for Cooling	Water Use	1. Ensure that therer is no leakage for water delivery
5.	Paper Use	Natural resource Depletion	1. Reuse of Paper with the blank side
6.	Recruitment of incompetent people	Inadequate knowledge on operation and environmental management may lead to unnecessary environmental pollution	1. Awareness training given periodically to relevant staffs on environmental management issues 2. On-job training related to environmental awareness given to staffs and workers.

The table above provides examples only. The IMS team of each site needs to identify the aspect impact and controls related to specific activities and ensures that the environmental performance of the organization is effectively maintained. For this purpose, the procedure “Environmental Aspect Impact Assessment Procedure” is to be followed and forms “Environmental Aspect Impact Register” is to be filled up by the IMS team.

5.8 OHS Hazard, Risk & Controls

Any activity at the plant, whether it is carried out for ensuring quality of service or meeting requirement of the interested parties, there will be some occupational hazards with it related to the occupational health and safety (OHS) to the workers and employees. It is a requirement of the IMS of BPDB to identify those OHS hazards and determine necessary controls.

While carrying out the activities and operation, the employees of BPDB need to exercise appropriate and predetermined controls so as to prevent or mitigate any adverse consequence that may be associated with the activity or the process.
Some examples of OHS hazards and with the procedure for Operation & Control of Auxiliary Systems-Gas Steam Power Plant are as below:

Sl Nos.	OHS Hazard	Controls
1.	High Noise Level	1. Staff must wear Earmuff whilst in the Engine room
2.	Slipping due to water spillage on floors	1. Maintain adequate housekeeping. 2. Maintain signage if there is any spill.
3.	dropping / falling object	1. Maintain adequate PPE (e.g. Helmet) whilst at worksite
4.	Electric shock / Electric Arc	1. Ensure a Permit to Work is issued as per guidance before personnel is sent for work 2. Maintain LoTo Procedure 3. Maintain adequate PPE whilst at worksite
5.	Fire / Explosion at worksite	1. Follow the 'Prevention of Fire and Explosion' Procedure
6.	Heat Stress	1. Ensure Heat Stress Training for all the employees 2. Ensure a good work plan
7.	Getting Stuck in moving / Rotating Parts	1. Ensure protocols are maintained, such as not leave loose long hair, or loose long dress 2. Proper signage 3. Maintain barrier / mark area so that when personnel enter that zone, he/she is obliged to take adequate precautions
8.	Chemical Spillage / Burn	1. Provide Necessary Training 2. Maintain adequate PPE whilst at worksite 3. Ensure good House Keeping
9.	Burn from contact with hot surface	1. Use of Guards to ensure contact can't be made directly 2. Provide Caution Sign 3. Maintain adequate PPE whilst at worksite
10.	Fumes and gases	1. Maintain adequate PPE whilst at worksite 2. Ensure a Permit to Work is issued as per guidance before personnel is sent for work
11.	Light from welding	1. Provide Necessary Training 2. Maintain adequate PPE whilst at worksite 3. Proper Supervision
12.	Unhygienic work environment e.g. canteen,	1. Maintain adequate housekeeping.

	toilet etc.	
13.	Cuts from Material Handling / movement	1. Maintain Material handling Procedure 2. Ensure a Permit to Work is issued as per guidance before personnel is sent for work
14.	Poor Visibility due to improper lighting	1. Maintain adequate housekeeping. 2. Installing adequate Lighting
15.	Lifting heavy objects	1. Maintain Material handling Procedure 2. Ensure a Permit to Work is issued as per guidance before personnel is sent for work
16.	Dusty environment	1. Ensure adequate housekeeping
17.	Leaking Gas Supply Pipeline	1. Check LEL detector Status
18.	Possibility of flamable gases/fumes in engine room chamber	1. Follow the 'Prevention of Fire and Explosion' Procedure
19.	Fire on transformer	1. Regular Inspection and maintenance 2. Follow the 'Prevention of Fire and Explosion' Procedure
20.	Steam leaking from pipe	1. Regular Inspection and maintenance

The table above provides examples only. The IMS team of each site needs to identify the OHS hazards and necessary controls related to specific activities and ensures that the environmental performance of the organization is effectively maintained. For this, the procedure Hazard Identification and Risk Assessment Procedure is to be followed and Hazard Identification and Risk Assessment Register is to be filled up by the IMS team.

6.0 References

None

7.0 Appendix

None

8.0 Revision History

Sl No.	Revision Number	Section	Change Made	Date of Revision

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