

SHRI VAISHNAV INSTITUTE OF TECHNOLOGY & SCIENCE



NARMADA HYDROELECTRIC DEVELOPMENT CORPORATION (NHDC)

(13-01-05 to 20-01-05)



**Submitted as a
Vocational Training Report for
Degree of Bachelors of Engineering**

**Submitted By:
Manish Kataria
0802EE021031**

INTRODUCTION

Indira Sagar Project (ISP)

Location: It is situated 10 Km away from the village Punasa in Khandwa district of Madhya Pradesh at 22° 17' N latitude and 76° 28' E longitude.

Project Type: It is a multipurpose project under construction on the river Narmada with an installed capacity of 1000 MW.

River Narmada: It is the fifth largest river in India; with a river flow length of 1312 Km. It originates from Amarkantak in Shadol district of Madhya Pradesh. It flows westward and is bounded by Vindhya Mountain on its north and Satpura Mountain on its south. River Narmada has 3000 MW hydro-potential in the state of M.P, out of which only 352 MW has been utilized and 1920 MW is under different phases of exploitation.

Dam Features: The ISP envisages construction of concrete gravity dam of length 653 m at top and a maximum height of 92 m. It consists of 12 main spillway blocks and 8 auxiliary spillway blocks.

Power House: The sub-surface power house is situated on the right bank of the river. It houses 8 no. Francis type turbines of 125 MW capacities each.

NARMADA HYDRO-ELECTRIC DEVELOPMENT CORPORATION (NHDC)



Narmada Hydroelectric Development Corporation Ltd. (A Joint Venture of NHPC & Govt. of M.P.) was set up on 1st August 2000 with its Corporate Office at Bhopal. NHDC is an ISO 9001-2000 certified company has been entrusted with the construction of Indira Sagar Project (1000 MW) and Omkareshwar Project (520 MW) with the authorized share capital of Rs. 3,000 crores and its assets are of Rs. 3921.29 Crores. NHDC has mastered the technology to complete Hydro Power projects from concept to commissioning within scheduled period. It is the largest organization for Hydropower development in the state of Madhya Pradesh in terms of hydropower capacity. NHDC has also prepared Pre feasibility reports of Three New Projects viz. Bauras (55 MW), Hoshangabad (60 MW) and Handia (51 MW) on river Narmada. Further Survey and Investigation work for preparation of DPR of these projects has also been entrusted to NHDC which is in progress.

WEBSITE:-

<http://www.nhdcindia.com>



INDIRA SAGAR PROJECT



VIEW OF DAM

TRAINING

(DAY 1-2)

DATE: 13-14/01/05

Department: **Power House**

Topics of Study:-

1. Turbine
2. OPU
3. Governor
4. Generator
5. Stator
6. Rotor
7. Compressors
8. Coolers
9. EOT Crane
10. Fire Extinguishing System
11. Testing

Training Under:-

Shri. Prakash Parmar
(Chief Engg.)

DAY 1:

DATE: 13/01/05

1. TURBINE

Turbine is the heart of the generator unit. Hydro turbines convert kinetic energy of water into mechanical energy. There are generally two types of turbines:

i) Impulse Turbine

ii) Reaction Turbine

The turbine installed here at ISP is of Reaction type **Francis Turbine**.

Water from intake structure is taken to power house through eight no. 8 meter diameter Penstocks. 8 nos service gates, grooves for stop log and trash racks have been provided at the inlet of penstocks.

A brief description of major components of Turbine is given below:

1). Inlet pipe & Spiral Casing:

The water from penstock enters to inlet pipe and spiral casing. The diameter of spiral casing which is 7m at its inlet goes on reducing so as to keep the velocity and pressure of water constant.

2). Stay Ring:

The stay ring is fabricated from plate steel. It is designed to support the weight of superimposed structure and parts with spiral empty. It is also designed to withstand safely the upward thrust due to maximum head including the pressure rise. The top ring is designed to carry the top cover and pit liner and the lower ring to carry the foundation ring. The two rings are rigidly tied together by properly shaped stay vanes. The diameter of stay rings is 8560 mm.

3). Foundation Ring:

Foundation ring fabricated from steel plates shall be welded together with stay ring.

4). Runner:

Runner is the heart of turbine, which converts the energy of the water into kinetic energy. The runner castings weighing more than 85 tones 13% Cr and 4% Ni stainless steel have been imported from Korea. The diameter of the Francis is 5466 mm which is largest Francis turbine commissioned in India so far.

5). *Turbine Shaft:*

The turbine shaft has been forged from carbon steel having integral flanges at both ends, one for bolting to the runner and another for generator shaft.

Salient features of Francis Turbine at ISP:

Make	BHEL
Type of Turbine	Vertical Francis
Efficiency	95%
Direction of Rotation	Clockwise
Rated Speed	115.4 rpm
Max. Runaway Speed	230 rpm
No. of Runner Blades	15
Weight	85 Tons
Material Composition	13% Cr & 4% Ni Stainless Steel
Head	60 m

6). *GUIDE VANES:*

Guide vanes apparatus consists of 20 No. of guide vanes. It has feather length of 1446 mm. they are made up of high wear resistance cast stainless steel. They are provided with segmented seals on the top and bottom to reduce the leakage of water.

6.1 *Guide Vane Regulating Mechanism:*

The guide vanes are couples to the regulating ring by means of levers and linkages capable of withstanding normal operating forces. A regulating ring made of welded steel and supported on top cover is provided with suitable brushes for guide vanes link pins. Two steel pins are also provided for connection to the guide vane servomotors.

6.2 *Guide Vane Servomotors:*

The opening and closing of guide vanes is controlled by two doubly acting hydraulically operated servomotors. Servomotors turn the regulating ring during regulation of load on turbine and closing/opening of guide apparatus.

Each servomotor includes a cylinder, which houses a steel piston with cast iron piston rings. A lock is provided to lock the guide vanes in closed position.



POWER HOUSE



GENRATOR FLOOR

6.3 Guide Bearing:

Oil immersed, self oil lubricating, pivoted pad type turbine guide bearing is provided above shaft seal.

2. OPU

OPU stands for **Oil Pressure Unit**. It consists of following important parts.

1). P.P Set:

The pressure pumping set is a tank storing a definite amount of oil. This oil is used for operation of servomotors. The oil used is servo 46 oil. It (P.P. set) has a volume of 800 m³. It consists of two motors for pumping the oil.

2). Pressure Receiver Tank:

The oil from P.P. set is then led into the pressure receiver tank by the motors. The oil is pressurized in this tank. The pressure is maintained at 6-7 Kg/cm². This pressurize oil is then used for operating servomotors.

3. GOVERNOR

A HMC (Hydro Mechanical Cabinet) Governor is employed to govern the opening/closing of guide vanes. The governor can be operated automatically or manually. This governor controls the servomotor which in turn governs the guide vanes.

4. GENERATOR

The Indira sagar Project (ISP) encapsulates 8 nos of Hydro generators each of capacity 125 MW. The hydro generators are characterized by small core length and large diameter. They are generally designed for low speed operation.

Specifications:

KW	125000
Power Factor	0.9 lag
KVA	138890
Volts	11000
Current	7290
Voltage Rating	± 10%
Max Continuous Rating	137500 KW
Excitation Voltage	320 V
Excitation Current	1150 A
RPM	115.4
Frequency	50
Phase	3
Connection	Star
Rotation	Clockwise
Insulation Class	F
Type	MGS- 1095/175-52D
Specification	IS-4722
Make	BHEL, Bhopal

5. STATOR

Stator is the stationary part of the hydro generator. It consists of the following three parts:

1). Stator Frame:

The stator frame is built up of weldable steel plates. This frame has adequate depth to prevent distortion during any operating condition. It is designed to carry the weight of top bracket, brush gear assembly, stationary part of flooring.

2). Stator Core:

Stator core is built up of varnished insulated stampings/punchings. These punchings are made up of CRNGO (Cold Rolled Non Grain Oriented) Silicon alloy steel. These are 0.5 mm thick and each punching has 12 slots. Total no. of slots is 576. The diameter of the stator is 10.2m.

Specifications of Stator:

Class of Insulation	F
Outside Diameter of Frame	12200 mm
Air Gap	22 mm
Flux Density at Rated Voltage	1.71 Tesla
Weight of Copper in Winding	17.1 Tons
Complete Weight of Stator	210 Tons

3). *Stator Winding:*

The stator winding is of double layer wave connected bar type wound in open slot. The bars are insulated with resiflex insulation system. The stator winding has class F type insulation. Two bars are housed in each slot and are separated by insulators. The heads of the bars are brazed.

DAY 2:

DATE: 14/01/05

6. ROTOR

It is the rotating part of the generator. The rotor assembly consists of following three parts named as below:

- i) Spider Arms**
- ii) Rim**
- iii) Poles**

The rotor is designed to safely withstand all mechanical stresses imposed by the maximum runaway speed. Fifty two nos field poles are provided with adequate damper winding to improve stability under fault condition. It is possible to replace the field poles without removing the rotor. Two insulated brush holders and Copper brushes shall be provided with each generator rotor for measuring the voltage across the slip rings. A suitable temperature indication for the rotor is provided with suitable contacts for alarm and tripping of the machine.

Rotor Specifications:

No of Poles	52
Class of Insulation	F
Weight of Complete Rotor	360 Tons
Diameter of Assembled Rotor	10156 mm

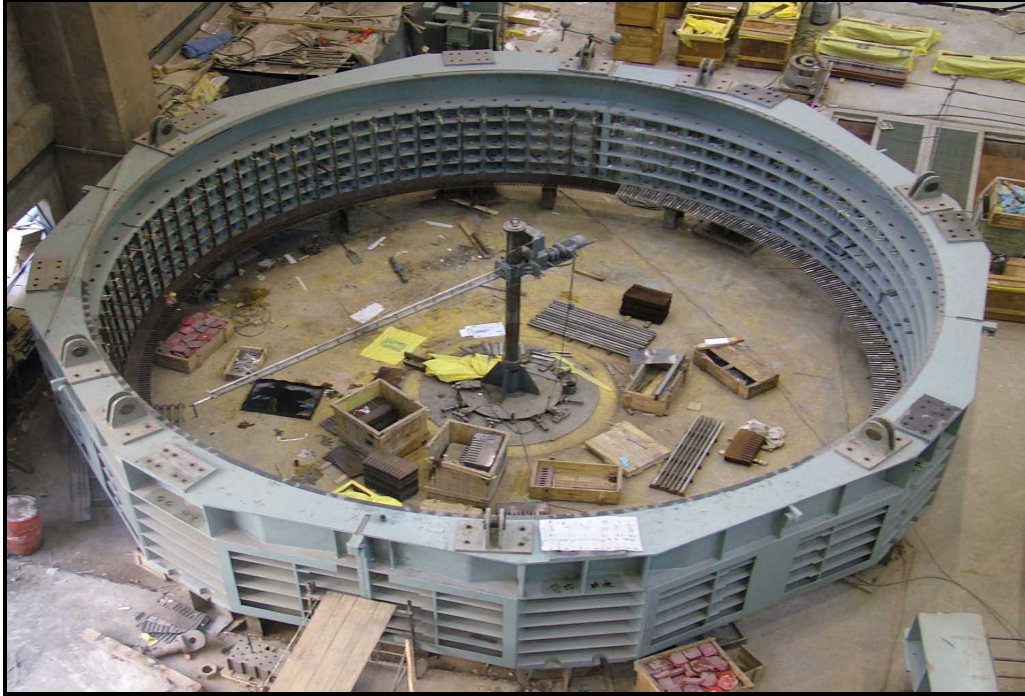
7. COMPRESSORS

Two types of compressors are installed in the power house at the turbine floor. One is high pressure (6 to 7 Kg/cm²) or HP compressor and another is low pressure (1 Kg/cm²) or LP compressor.

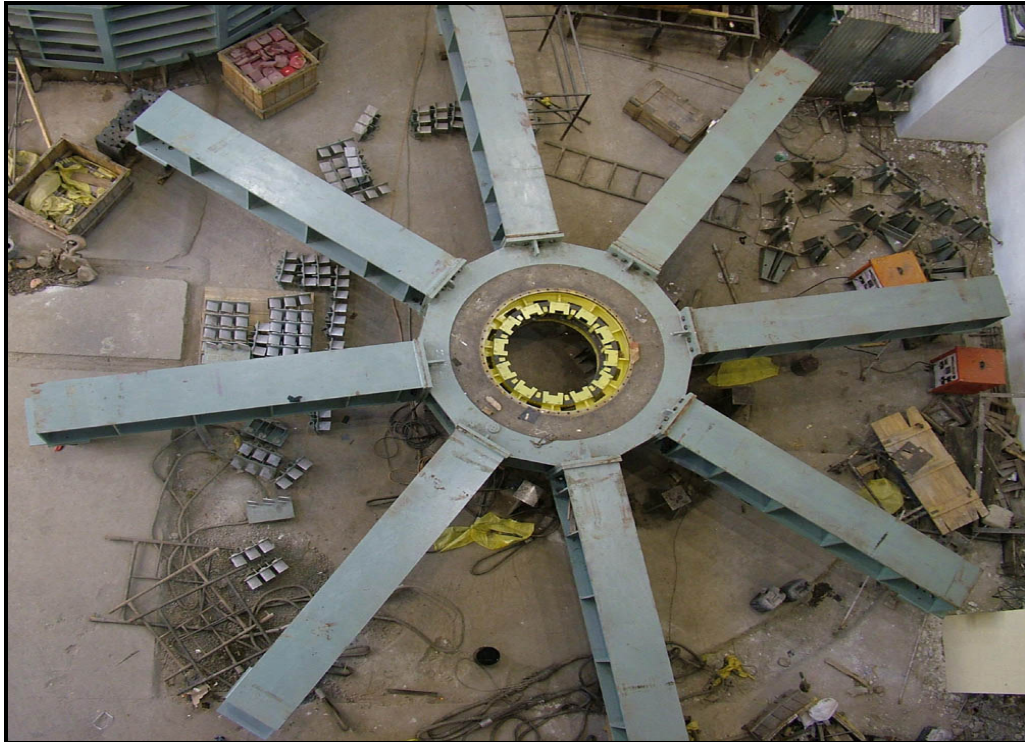
The main function of the HP compressor is to pressurize the oil for the operation of servomotors.

The LP compressor has the following functions:

- i) It is used for braking & jacking of the machine.**
- ii) For filling air into the maintenance seal (shaft seal).**
- iii) For cleaning purpose.**



Stator Frame



Rotor with Spider Arms

8. COOLING SYSTEM

The cooling system for stator is air and water based. The stator consists of radial fans which circulates air inside the stator to keep it cool. But this system is not very efficient & is a mere auxiliary cooling system.

The main cooling for the stator is provided by water. There are 16 nos of coolers are fixed to stator frame for dissipating losses in the generator stator. Each cooler unit consists of a rectangular nest of tubes between two water chambers arranged for the air to flow over water through the tubes. Water header box shall be fitted at each end of the tube nest, one header box having flanged inlet & outlet water branches. A tapping is taken from the inlet to the turbine. This fills the cooling water header which has a diameter of 600 mm. This header runs straightaway from unit 1st to unit 8th

The water cooling is also provided for cooling of generator transformer. Generally all the bearings are cooled by oil.

9. EOT CRANE

Specifications:

1. Capacity:

Main Hook	200 Tons
Auxiliary Hook	30 Tons

2. Span:

Span	20 m
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3. Total Lift:

Main Hook	30650 mm
Auxiliary Hook	43150 mm

4. Speed:

Main Hook	1 m/min
Auxiliary Hook	5 m/min
Cross Travel	10 m/min
Long travel	20 m/min



EOT Crane Installed at Power House



EOT CRANE
AT
GENRATOR FLOOR (POWER HOUSE)

5. Rails:

CT Rail Span	7200 mm
Overall width	11600 mm
Rails	CR-120

10. FIRE PROTECTION

An automatic fire protection system (CO2 System) is installed for all generators. In the event of fire, smoke detectors shall first operate to give early warning signal to the operator/official on duty at control room. For deep fires of hazardous nature release of CO2 gas will be initiated by the temperature thermostat detectors. The system will be interlocked with the generator barrel door remain open. All the needed alarm & indication is available on CO2 panel.

11. TESTING

Following tests are performed on the generator before its commissioning:

- i) High voltage Test.**
- ii) Open Circuit Test.**
- iii) Short Circuit Test.**
- iv) Dry Test (On Windings).**
- v) Trial run.**

(DAY 3)

DATE: 15/01/05

Department: **Power House (Civil)**

Topics of Study:-

1. Works Galleries
2. Dewatering

Training Under:-

Shri. S Sanyal
(Chief Engg. Civil)

DAY 3:

DATE: 15/01/05

Department: **Power House (Civil Works)**

1. WORK GALLARIES

There are three work galleries in the Power house. Work galleries are provided for inspecting and maintaining any seepage or leakage of the water.

The leakage/seepage water is collected at these galleries and is then drained to the drainage sump located near unit I which is also at the lowest level. The water thus collected in this sump is then pumped out with the help of motors into the tail race channel.

Salient Features of Power house:

Type	Sub-surface
Length of Hall	202 m
Width of Hall	23 m
Height of Hall	53 m
Design Head	60 m
Installed capacity	8*125 MW

2. DEWATREING SYSTEM

The water from the units which have been just stopped is then drained to the drainage/dewatering sump. This water is then pumped out with the help of motors in the Tail Race Channel (TRC).

(DAY 4)

DATE: 16/01/05

Department: **Dam**

Topics of Study:-

1. Dam
2. Intake
3. HRC & TRC
4. Diversion Tunnel

Training Under:-

Shri. B Rao

DAY 4:

DATE: 16/01/05

Department: **Dam**

Salient Features of Indira Sagar Dam:

1. Hydrology

Catchments Area	61642 Sq. Km
Rainfall (Max)	1879 mm
Rainfall (Min)	603 mm
Average Rainfall	1288 mm

2. Dimensions

Length of Dam	653 m
Max Height of Dam	92 m
Type of Dam	Concrete Arc Gravity Dam
Design Discharge	368 cumecs

3. Storage Capacity

Gross	12.22 bn m³
Live	9.75 bn m³
Dead	2.47 bn m³

4. Length

Total Length	653 m
Non-Overflow	158 m
Overflow portion Spillway	495 m

5. Diversion Tunnel

Length	390 m
Diameter	8 m
Design Discharge	368 cumecs
Type	Goose Neck

UP-STREAM VIEW



DOWN-STREAM VIEW



VIEW OF GATES ON DAM

6. Reservoir Level

Top Bridge Level (TBL)	267 m
Max Water Level(MWL)	263.35 m
Full Reservoir Level (FRL)	262.13 m
Max Draw Down Level (MDDL)	243.23 m
Crest Level	245.13 m
Water Spread Area at FRL	913.48 Sq. Km

7. Radial Crest Gates

Number	20
Length	20 m
Height	17 m
Type of Hoisting System	Hydraulic Operation

8. Head Race Channel

Length	530 m
Width	75 m (Avg.)
Bed Level	222.43 m
Discharge Capacity	2200 cumecs

9. Tail Race Channel

Length	850 m
Width	30 m (Avg.)
Bed Level	172 m

10. Intake Structure

Length	208 m
Intake Gates	8
Size of Gates	5792 mm * 8871 mm

11. Water Conductor System

Penstock	8 No
Diameter of Penstock	8 m



TAIL POOL



TAIL RACE CHANNEL
(TRC)



D/S VIEW OF DAM



HEAD RACE CHANNEL
(HRC)

(DAY 5)

DATE: 17/01/05

Department: **Hydro Mechanical**

Topics of Study:-

1. Gates

Training Under:-

Shri. S Kalgaokar
(Chief Engg. Hydro Mechanical)

Shri S P Mukhargee
(Chief Engg.)

DAY 5:

DATE: 17/01/05

Department: **Hydro Mechanical**

1. GATES

There are two type of gates installed here at the Indira sagar DAM. They are:

i) Radial Gates.

ii) Stop log gates or Vertical Gates.

1). RADIAL GATES

There are 20 radial gates installed here at ISP. These gates are hydraulically operated. These radial gates are largest in area commissioned so far in India. It is also at the second position height wise.

These gates are operated by hydraulic means. Two cylinders are needed for closing and opening of a gate. These cylinders are filled with hydraulic oil (HPL 46). The pressure inside the cylinder is 195 bar.

Salient Features:

Number	20
Length	20m
Height	17m
Type of Hoisting System	Hydraulic Operation
Weight of Radial Gate	200 Tons

2). STOP LOG GATES

These gates are generally required when maintenance of radial gats is to be done. It consists of 9 racks of steel structure. Only two stop log gates are needed.

Advantages of Radial Gates:

- i) Fine regulation of water.
- ii) Easy in operation.

3). DOGGING DEVICE

The Dogging device serves as a parking for radial gates and stop log gates. They hold the radial gates in their open position.

4). POWER PACK

Power packs are the instrument which is used to operate the opening closing of the radial gates. These are installed at the topmost location of each pier. They are also 20 in numbers i.e. one for each gate. Power packs actually consist of motors for opening and closing of gates.

(DAY 6)

DATE: 18/01/05

Department: **Switch Yard**

Topics of Study:-

1. Protection Provided
2. PLCC
3. Equipment Rating
4. DG Set

Training Under:-

Shri. P K Ghoshal

DAY 6:

DATE: 18/01/05

Department: **Switch Yard**

The voltage which is generated by the generator is 11kV. This voltage is then step up to 400 kV by generator transformers. This stepped up voltage is then fed to the switchyard. The switchyard, here, consist of 14 number of bay. They are

Bay No. 1	Nagda feeder bay
Bay No. 2	Indore-1 feeder bay
Bay No. 3	Generator 1 bay
Bay No. 4	Generator 2 bay
Bay No. 5	Generator 3 bay
Bay No. 6	Generator 4 bay
Bay No. 7	Bus coupler bay
Bay No. 8	Generator 5 bay
Bay No. 9	Generator 6 bay
Bay No. 10	Generator 7 bay
Bay No. 11	Generator 8 bay
Bay No. 12	Indore-2 feeder bay
Bay No. 13	Sarni feeder
Bay No. 14	Transfer bus bay

In general there are two Main Bus and one transfer bus.

1. PROTECTION PROVIDED

1). Distance Protection Relay

The Distance Protection Relay (DPR) is the protection of the transmission line against phase to phase or phase to ground fault. This relay works on the principle of the change in impedance.

Main Bus I	Numerical Relay REL521
Main Bus II	Static Relay LZ96(ABB)



SWITCHYARD



GENRATING TRANSFORMER
&
BUS DUCT

2). Over Voltage Relay

This relay works in two stages.

Stage I	110 % for 5 sec.
Stage II	125 % Instantaneous

3). Under Frequency Relay

If generated frequency falls below the 47.5 Hz the Relay is such designed that it will trip the system.

4). Time delayed Over Current Relay

This relay can hold current of 110 % of the rated value for 10 seconds.

2. PLCC

PLCC stands for Power Line Carrier Communication. It involves modulation of speech signals with the transmitted power through transmission lines. Main functions of PLCC are:

- i) To establish speech communication between the two ends.**
- ii) To transfer the protection carrier either way.**

3. EQUIPMENT RATINGS

1). Circuit Breaker

Type	SF6
Voltage	420 kV
Current	2000 A
Short Ckt. Current	40 kA for 3 sec

2). Isolators

- i. Pantograph Isolators
- ii. Horizontal Circuit Breaker Isolators

3). Current Transformer (C.T.)

Voltage	420kV
Current	2000 A, 1000 A, 500 A / 1 A
Short circuit Current	40 kV for 1 sec

4). Capacitive Voltage Transformer (C.V.T.)

Voltage	420 kV / 110 V
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4. DG SET

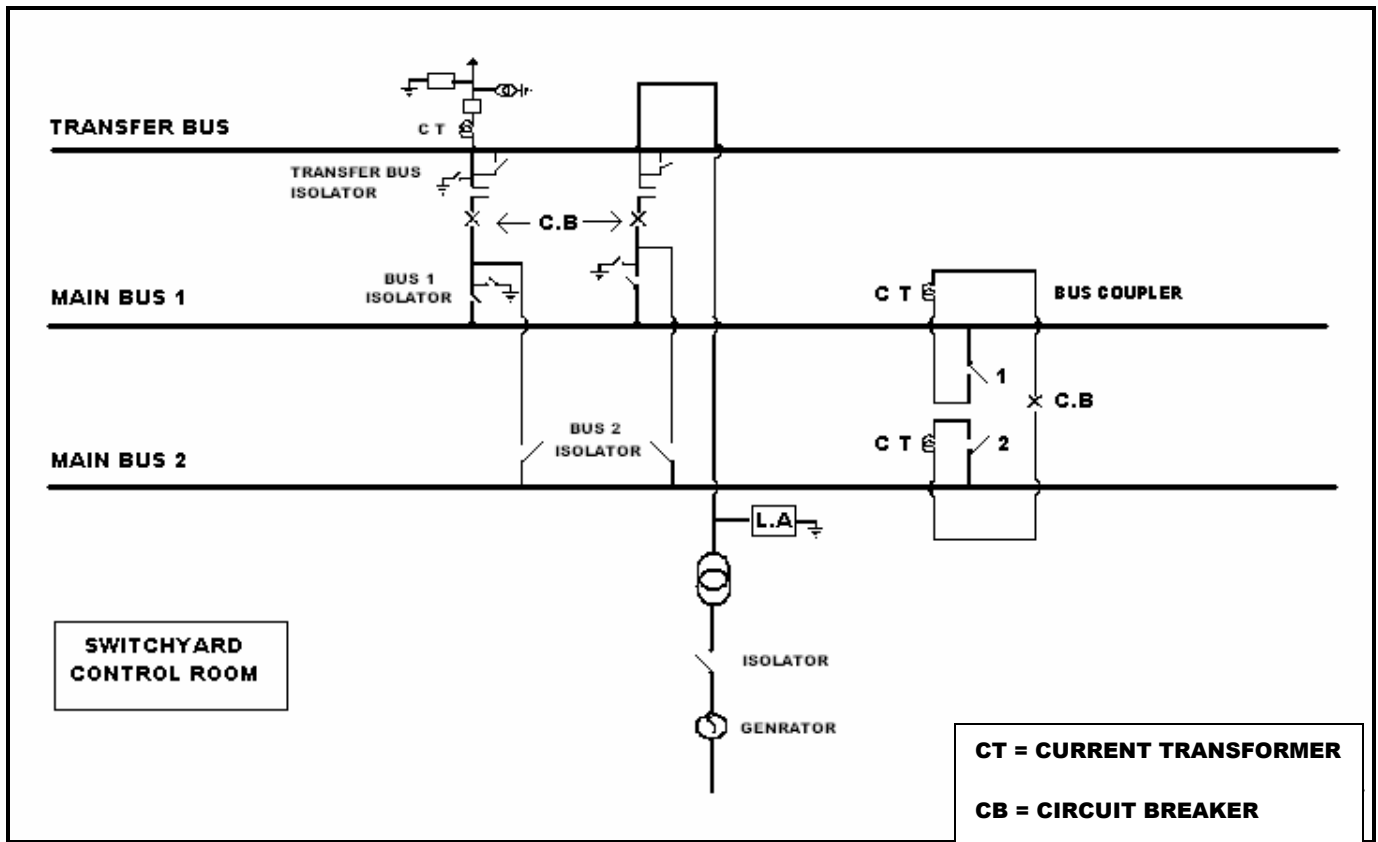
The Indira Sagar Project takes/imports power from M.P.S.E.B. In case there is a power failure the DG sets provided serves as a backup and provides power to the Dam site, Switchyard and Power house.

There are two synchronous generators (DG sets) installed. One set is standby or may be used synchronizing with the other when more power is needed.

Salient Features of AC Generator (DG sets)

Rating	SI to IS 4722
Excitation	Brushless
Kva	1000
Insulation Class	F
ALTD	1000 m
RPM	1500
Frequency	50 Hz
Volts	11 kV
Amperes	52.5 A
Phase	3
Power factor	0.8
Connection	Star
Excitation voltage	24 V
Fuel	Diesel
Starting Motor	DC Motor

LAYOUT OF 400 KV SWITCHYARD AT ISP



(DAY 7-8)

DATE: 19-20/01/05

Department: **Power House and O & M**

Topics of Study:-

1. Generator Transformer
2. General Auxiliary
3. Bus Duct
4. UAT
5. SST
6. UAB
7. Excitation System
8. DC System
9. Control Panel
10. Synchronization

Training Under:-

Shri. P K Ghoshal
Shri. M K Gokhale

DAY 7:

DATE: 19/01/05

Department: **Power House and O & M**

1. GENERATOR TRANSFORMER

There are eight generator transformers and one spare unit. These transformers are connected to the stator winding ends through Bus-Duct.

Salient Features:

Phase	3
kVA	16000
Vector Group	YNd11
Frequency	50 Hz
HV Rated Voltage	420 kV
LV Rated Voltage	11 kV
Oil Capacity	53670 Lt.
Cooling	ODWF
Rated Power	HV 154 LV 154
Rated Current	HV 211.69 A LV 8082.90 A
Make	ABB

2. GENERAL AUXILIARIES

Auxiliaries are the supporting equipments and instruments needed for the operation of the generator. They are as follows:

1. Governor oil pumps motor A&B.
2. Oil leakage pumps motor.
3. H.P. lubrication pumps motor.
4. Top cover drainage pump motor.
5. Cooling water valve motor A & B.
6. Generator stator heater motor.
7. Cooling pump motor for generator transformer.
8. Field flashing supply.
9. AC supply for CO2 panel.

3. BUS DUCT

The stator winding terminals are connected to the generator transformers by means of bus duct. These bus ducts are also known as Isolated Bus Duct.

Salient Features:

Rated Voltage	12 kV
Rated Current	10000 A(Main), 150 A (Tap Off)
Rated Frequency	50 Hz
Rated Insulation Level	35 kV rms / 75 kV peak
Rated Short Time Rating	62.5 kA rms for 1 sec. (main) 102 kA rms for 1 sec (Tap Off)

DAY 8:

DATE: 20/01/05

Department: **Power House and O & M**

1. UAT

UAT stands for Unit Auxiliary Transformer. This transformer is used to supply power to the auxiliaries of a single unit. When the machine (generator) has been synchronized with the bus bar, then the power needed to drive the auxiliaries of this machine is drawn from itself. A tapping is provided from the bus duct to UAT.

Salient Features:

Type	Dry Type Cast Resin Transformer
Make	BHEL
Type of Cooling	AN
Rating	800 kVA
No. of Phases	3
Frequency	50 Hz
Vector Group	DyN11
Insulation Class	F
Weight	4200 Kg
Rated Voltage	HV 11 kV LV 433 V
Rated Current	HV 41.99 A LV 1066.7 A

2. SST

SST stands for the service station transformer. It is used to step down the supply voltage coming from the M.P.S.E.B. These are two in numbers. They are installed at the control room. These are of 11 kV / 433 V type transformers.

3. EXT

EXT stands for the Excitation Transformer. When the generator is ON then the needed excitation voltage is taken from the generated voltage. A tapping from bus duct is taken to the EXT. It steps down the voltage to a level of 320 V and is the feed back to the field winding on the rotor through slip rings. Before feeding, this ac voltage is converted to DC by means of Thyristor Bridge. This DC voltage is then fed to the rotor poles by means of slip rings.

4. EXCITATION SYSTEM

The excitation system used here for all the units of ISP is Static Excitation. In static excitation the generated voltage is tapped out and then step down to desire level & then converted to DC by means of static devices such as thyristors.

5. CONTROL PANEL

At EL- 201 i.e. the generator floor, the control panels for each of the unit is as follows.

- i) Unit Alarm Annunciation Panel.
- ii) Temperature Measurement Panel I
- iii) Temperature Measurement Panel II
- iv) Auto Sequencer Equipment Relay Panel
- v) Electronic Panel
- vi) Control & Metering Panel
- vii) Turbine & Generator Gauge Panel I
- viii) Turbine & Generator Gauge Panel II
- ix) Electro-hydraulic Governor Controller.
- x) Unit Auxiliary Board (UAB)

6. SYNCRONISATION

In order to synchronize the generator with bus bar the following three conditions must be fulfilled:

- i) The terminal voltage of the generator and that of bus bar must be same.
- ii) The frequency of the generator and bus bar must be same.
- iii) The phase sequence of the generated voltage and that of bus bar must be same.

When these conditions are satisfied machine may be synchronized with the bus bar.

The machine may achieve synchronization either manually or automatically. Generally machine is put in Auto mode to synchronize with the bus bar.