ANNEXURE –

(Detailed Project Report of Karcham Wangtoo HEP in 6 (Six) Volumes)

VOLUME - II

JAIPRAKASH INDUSTRIES LIMITED

HYDRO POWER DIVISION

KARCHAM-WANGTOO HYDRO-ELECTRIC PROJECT (1000 MW)

HIMACHAL PRADESH

PROJECT REPORT

(REVISED)

VOLUME II

ELECTRO-MECHANICAL WORKS

CONSULTANTS

IDEA INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

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KARCHAM WANGTOO HYDROELECTRIC PROJECT
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I N D E X

LIST OF D.P.R. DRAWINGS OF ELECTRO-MECHANICAL WORKS

Sl. No.	Title of Drawing	Drawing No.
[A]	POWER HOUSE & TRANSFORMER HALL CAVERNS	
1	Layout Plan of Power House Works & 400kV Switchyard	1200-2131-001
2	Layout Of Power House & Transformer Halls	1200-2131-002
3	Detailed Cross Section of Power House & TR. Halls	1200-2131-003
4	Cross Section of Power House Through Turbine	1200-2131-004
5	Longitudinal Section of Power House Through Turbine	1200-2131-005
6	Floor Plan of P.H. -- EL 1489 & 1497 (MIV Floor)	1200-2131-006
7	Floor Plan of Power House -- EL 1505.5	1200-2131-007
8	Floor Plan of Power House -- EL 1510.0	1200-2131-008
9	Floor Plan of Power House -- EL 1515.0	1200-2131-009
10	Floor Plans of Control Block	1200-2131-010
11	Floor Plan & Sections of Control Block	1200-2131-011
12	Cross Section Of Transformer Hall	1200-2131-012
13	Cross Section of P.H./TR. Halls incl. Bus Duct 400kV SF_6 Duct Tunnel/Shafts	1200-2131-013
14	Plan & Longitudinal Section of Underground 400kV G.I.S. HALL	1200-2131-014
[B]	BUTTER-FLY VALVE [B.F.V.] CHAMBER	
15	Plan & Section of B.F.V. Chamber	1200-2137-001
[C]	OUTDOOR SWITCHYARD/POTYARD	
16	Layout & Section of Outdoor Gas Insulated Switchyard	1200-2133-001

Chapter - 1

GENERATING PLANT EQUIPMENT

1.1 GENERAL

.1 Karcham-Wangtoo Hydro Electric Project is a run-of-the river scheme, with provision for diurnal storage for meeting peak load demand, utilising the hydro potential of river Satluj for power generation. The project is envisaged to generate 1000 MW at generator terminals, when all the units are in operation, and each turbine shall be capable of producing rated output of 250 MW at generator terminals when operating at rated net head and at 90% wicket gate opening. During high inflow periods during monsoon, all the turbines are expected to generate maximum output continuously 24 hours/day, while in non-monsoon period units will be expected to meet peak load as per grid requirement. The minimum peaking capacity of the station shall be 1000 MW for 4 hours.

.2 Generating plant equipment comprising turbines, main inlet valves, generators and auxiliaries shall be installed in an underground cavity 143m long, 21m wide and 49m high. The main unit transformers shall be single phase 93 MVA, 15.75/400/$\sqrt{3}$ kV capacity installed in a separate cavity 143m long, 15.5m wide and 25m high, parallel to the main Power House Cavity.

.3 The generation of power is proposed at 15.75 kV which shall be stepped up to 400 kV through main generator transformers. Due to severe space constraint 400 kV switchgear of SF_6 gas insulated type shall be provided.

1.2 HYDRAULIC AND OTHER DATA

The design of main plant equipment shall be based on the following basic parameters :

•	Maximum Reservoir level	El. 1810.00m
•	Minimum draw down level	El. 1799.00m
•	Average Reservoir level	El. 1804.50m

- Tail water level

  - Maximum (Flood) — El. 1516.25m
  - Normal (4 unit discharge) — El. 1508.00m
  - Minimum — El. 1506.50m

- Design discharge for 1 unit — 104.25 Cumec
- Design head — 273.5m
- Maximum head — 303.5m
- Minimum head — 268.30m
- Maximum surge level — El. 1848.88m
- Minimum surge level — El. 1717.103m

- Maximum speed rise at rated load and 100% load rejection — 42 Percent

- Maximum penstock pressure rise at rated load and 100% load rejection — 16 Percent excluding upsurge

- Cooling water temprature — 0°C to +20°C

- Ambient temperature
  - inside cavity — 20°C to 25°C
  - outside cavity — -10°C to 30°C

- Relative Humidity — 100 %

- Elevation of Power house — El. 1488 to 1537m

- Seismic forces — 0.23g - horizontal
  0.154g - vertical

1.3 OPTIMUM STATION CAPACITY

The following aspects as discussed under `Power Planning' have been considered for deciding the station installed capacity :-

- 90% and 50% dependable discharge calculated from available hydrological data of site.
- Energy potential
- Cost of energy generation
- Cost of Incremental energy
- Net annual benefits
- Cost-benefit ratio
- Incremental benefit-cost ratio.

Based on the above factors, the capacity of the station has been kept as 1000 MW.

1.4 NUMBER AND CAPACITY OF GENERATING UNITS

.1 For station installed capacity of 1000 MW, two alternatives were considered -

- 6 x 165 MW units
- 4 x 250 MW units

.2 Transport problem is one of the limiting factors while deciding the unit capacity. Here in both the cases, transport bottleneck exists, and as such road/bridges from Jhakri to Wangtoo have to be modified to meet transport requirements of Wangtoo Equipment.

At present transport limits beyond Jhakri are as under :-

a) Transport payload - 50 tonnes
b) Transport maximum dimensions - 5000 mm (L) x 3000 mm (W) x 3000 mm (H)

At some of the places temporary arrangement for crossing the river and road strengthening have been done. Now the roads and bridges between Jhakri and power House shall be upgraded as per transportation class 70 R.

The heaviest transportation for Karcham Wangtoo shall be transformer, the weight of which is estimated as 62 tonnes. Necessary provisions for modifications of road/bridges from Jhakri to Wangtoo Power House has been made in the estimate with the widening of road and new bridges enroute for transportation of heavy and oversize consignments.

.3 To keep transportation size and weights to minimum, stator core and winding would be built up at site. Spherical and butterfly valves will be transported in three pieces i.e. two halves of body and rotor separately. The stator frame will be transported in 4 segments.

The transport weight of heavy consignments like runner, stator frame segments, generator shaft, spherical valve, transformer etc. will be within planned transport limits. The transformer weight, which, would be the heaviest, is estimated as 62 tonnes approximately.

.4 Integration of unit in system operation

At Nathpa Jhakri 6 (six) units of 250 MW are being installed. By the time Karcham Wangtoo units are commissioned, system will be strong and capable enough to absorb load acceptance/rejection of 250 MW without causing any grid disturbance. As per XV Survey report of CEA, peak load forecast for the Northern grid at end of 10th plan (2006 - 2007) has been estimated as 44009 MW. Karcham Wangtoo unit size, being less than 0.6% of this, no problem is foreseen in integration of the units in the Northern grid.

.5 Four units of 250 MW will have lower installed cost as compared to six units of 165 MW on account of the following:-

- Reduction in cost of civil works on account of reduced civil and hydro-mechanical works for penstocks and pressure shaft, BF valve chamber, draft tube, power house and transformer cavern etc..
- Reduced cost of electro-mechanical works and GIS.

.6 Time for execution of project can be reduced by adopting 4 units.

Keeping the cost economics in view, 4 units of 250 MW have been selected.

1.5 HYDRAULIC TURBINE

.1 Type of Turbine

Maximum head	303.5m	[1810.0-1506.5m]

Minimum head	268.30m	[1799.0-1508m-tunnel losses 22.7m]
Proposed design head	273.5m	

The design head of 273.5m and the head range of 268.30 to 303.50m (98 to 110.97%) is best suited for Francis type turbine from cost and efficiency considerations. As such Francis type turbines have been adopted for this project.

.2 Turbine Parameters

.1 Design head

Average Reservoir level	1804.50m
Normal tail water level (with 4 unit discharge)	1508.00m
Gross head	296.50m
Tunnel losses	22.70m
Net head	273.80m

The design head for this project based on which the basic dimensions of the turbine and the Power House are determined has therefore, been selected as 273.5m.

.2 Speed and specific speed

The speed and specific speed of the machine have been computed based on empirical formula given in USBR monograph 20. Lower specific speed has been preferred for limiting hydro abrasion problem. Selected values as per computer programme enclosed at Annexure I are as under :

Rotational speed	214.3 rpm
Specific speed	113.51 rpm

.3 Runner dimensions

From Annexure I, different diameters of runner computed are as under:

- Entrance Diameter D_1 5220mm
- Minimum Diameter D_2 3870mm
- Discharge Diameter D_3 3870mm
- Maximum Diameter D_m 5130mm

.4 Spiral case Dimensions

The spiral case dimensions based on USBR formula (Annexure I) work out as follows :

A	=	6142mm
B	=	5111mm
C	=	3870mm
E	=	8494mm
F	=	7495mm
G	=	6978mm

The Dimensions are shown in figure 1 enclosed with Annexure I.

.5 Draft tube Dimensions

As per Annexure I, the draft tube dimensions work out as follows:

- Length of draft tube L = 14708mm
- Depth of draft tube N_1 = 10780mm
- Width of draft tube at outlet W = 12170mm
- Depth of draft tube at outlet N_2 = 3890mm

Keeping requirement of runner removal from bottom, the bottom most elevation of Draft tube has been fixed at 1488.00m.

The draft tube dimensions are shown in figure 2 enclosed with Annexure I.

.6 Turbine Setting

As per USBR, (programme attached), the setting is (-) 4.68m i.e. at El. 1501.82m. The centre line of the scroll case has been fixed at El 1501.50m.

.7 Runaway Speed

The runaway speed of the turbine at best efficiency head and full gate opening, as per USBR monograph shall be

$n_r = 0.63\ n(ns)^{1/5}$

$= 0.63 \times 214.3 \times (113.51)^{1/5}$

$= 347.83$ rpm

However, the maximum speed for which the unit shall be designed shall be corresponding to maximum head i.e

$$n_{max} = n_r \left(\frac{hmax}{hd} \right)^{1/2}$$

$$= 347.83 \left(\frac{303.5}{273.5} \right)^{0.5}$$

= 366.41 rpm i.e 1.70 times the normal speed.

.8 Unit Spacing

Considering the lowering of runner from bottom due to silt problem of Satluj basin, a unit spacing of 22m has been considered for this station. A calculation in respect of unit spacing is given at Annexure IV.

.9 Flywheel Effect

The turbine flywheel effect (WR^2) as per USBR formula :

$$WR^2 = 24213 \left(\frac{Pd}{n^{3/2}} \right)^{5/4}$$

where, P_d = Turbine Output, MHP

n = Rated speed, rpm

$$= 24213 \left(\frac{347000}{214.3^{1.5}} \right)^{1.25}$$

= 8685 T-m²

.10 Turbine and Runner Weight

Based on the experience curves given in USBR, the weight of the runner and turbine would approximately be as follows :

- Runner Weight = $607\ (Dmax)^{2.75}$
  = $607\ (5.13)^{2.75}$
  = 54.45 t

- Turbine Weight = $15175\ (Dmax)^{2.33}$
  = $15175\ (5.13)^{2.33}$
  = 685 t

.11 Shaft Diameter

The diameter of the turbine shaft can be estimated from the formula

Shaft diameter = $2.54 \left(\frac{70\ Pd}{n} \right)^{1/3} cm$

= $2.54 \left(\frac{70 \times 347000}{214.3} \right)^{0.333}$

= 122.45 cm

.12 Speed Rise and Pressure Rise

Speed rise of the unit and pressure rise in penstock have been calculated based on servomotor closing time of 8 sec.

The calculated values as per Annexure II are as under.

- Speed Rise 41.6%
- Pressure Rise 16%

This pressure rise does not account for up-surge in the surge tank.

.3 General and Special Features of the Turbine

.1 The turbine shall be of the vertical shaft Francis type capable of producing rated output of 250 MW at generator terminals when

operating at rated net head of 273.5m and at 90% wicket gate opening. This output shall be available at generator terminals under rated minimum net head conditions also. The rated output at turbine shaft shall be 255 MW.

.2 The turbine shall be designed with easy access for inspection and maintenance of the various components and parts. It shall be possible to dismantle the turbine bottom cover, wicket gates and runner from bottom through the draft tube.

.3 The runner shall be 13:4 Ni/Cr stainless steel homologous to the model as per IEC publication no. 193. Provision of a spare runner shall be made.

.4 The turbine shaft shall be forged in one piece with flanges towards the generator shaft and the runner. It shall be of adequate size to operate at any speed upto full runaway speed without vibration. Critical speed will be at least 25 percent higher than the runaway speed at maximum head.

.5 The spiral casing will be in suitable sections (to be welded at site), to meet the transport limitations. Spiral casing with turbine covers and guide vanes will be subject to hydrostatic pressure test at site before embedding the spiral casing in concrete.

.6 Suitable arrangement for automatic air admission below the runner shall be made to minimise the hydraulic oscillations at part load operation.

.7 Due to high silt content in River Satluj, hydro abrasion problem is expected to be encounted. In view of this problem following steps are proposed to be taken :

a) For parts susceptible to hydro-abrasion, 13:4 Ni/Cr stainless steel shall be used. Hard surface protective coating on selected parts i.e guide vanes, wear plate, shall be provided. On runner and labyrinth, hard surface coating will be adopted on one unit with provision for adopting in other units, keeping experience at other power stations viz Nathpa Jhakri in view.

b) Provision for replacement of runner and under water parts from below has been planned for quick and fast replacement.

.8 All instruments equipped with the turbine shall be compatible with Data Acquisition and Control System.

.9 All accessories including steel frames, chequered plates, foundation bolts, anchors and tie rods, walkways/hand rails, mono rail and girders, inspection platform etc. shall be provided with each unit.

.10 Each turbine shall be provided with following ancillary systems and monitoring devices :-

- Penstock drainage system
- Centralised grease lubrication system
- Bearing oil level monitoring devices
- On-line flow measuring devices
- On-line vibration and shaft run-out monitoring devices
- Overspeed devices
- Bearing oil temperature monitoring devices.

.4 Model Test

Model tests as per IEC 60193-1999 shall be conducted to demonstrate that the efficiency and other guarantees offered by the supplier are met with. The tests include among others:

- Performance (output and efficiency) tests under various heads
- Runaway speed tests
- Hydraulic thrust test
- Cavitation phenomena etc.

.5 Field Acceptance Test

Tests for general acceptance and efficiency shall be conducted at site on one unit. The acceptance tests shall be conducted in accordance with the latest edition of IEC 41-1991. Efficiency shall be measured at different heads and wicket gate openings by Thermodynamic method.

.6 Turbine Ratings

The turbine ratings, as discussed above are summarised below :

• Type	Francis
• Rating	255 MW (347,000 MHP)
• Rated speed	214.3 rpm
• Specific speed	113.51
• Design head	273.5 m
• Runner discharge dia	3870 mm
• Turbine setting	(-) 4.68 m

1.6 GOVERNING SYSTEM

.1 Provisions

.1 The governor shall be micro-processor based Electro-hydraulic type complete with all necessary devices for local and remote control, synchronising, load/frequency control, normal start/stop and emergency stop, joint control operation, speed sensing etc. The system shall consist of digital control unit, electro-hydraulic actuator, feed back device, speed measuring devices, speed relays, pressure oil tank, sump tank, oil pumps, air supply unit and leakage oil tank.

.2 The capacity of the governor shall not be less than the capacity of the servomotors for operation of wicket gates. The normal pressure for operation of the oil system shall not be less than 40-50 kg/cm^2. Governor oil pressure system with facility for pumping and maintaining required oil pressure and having sufficient capacity for two close, and one open operation shall be provided without recharging the tank.

.3 The speed signal for the governor and speed switches shall be derived from PMG/SSG mounted on the generator shaft. Alternatively voltage transformer shall be used for providing speed signal.

.4 Compressed Air System with one main, and one standby, compressor shall be provided to cater for the governing system requirement.

.5 All instruments provided with the governing system shall be compatible with Data Acquisition and Control System (DACS).

.2 Operational Characteristics

The governor shall have the following operational characteristics :

- Speed fluctuation due to governor shall not exceed ± 0.15% of the rated speed, with generator running at its rated speed and at part load or no load condition.

- The output fluctuations due to governor shall not exceed ± 1.5% of the rated turbine capacity.

- The governor dead time shall not exceed 0.2 seconds with a sudden load change of 10% or more of the rated capacity of the turbine.

- The dead band adjustment range shall be 0 to ± 0.5 HZ.

- The speed droop shall be adjustable within 0 to 10 percent.

- The governor adjustments shall enable synchronising over the range of 85 to 105 percent of rated speed.

1.7 MAIN INLET VALVES

.1 Provisions

.1 With design head of 273.5m, inlet valves of spherical type shall be adopted. The valve of 3200 mm diameter, shall be installed in the Power House cavern, immediately upstream of the turbine and operate during normal starting and stopping of the unit and also operate as shut off valve in case of turbine breakdown and during dewatering and maintenance of the turbine. The valve shall have

flanges for upstream connection to the inlet flange and downstream connection to a dismantling joint, forming a transition between the valve and the turbine spiral casing. The valve shall be automatically operated by means of two single - acting servomotors utilizing oil pressure of governing system. Emergency closing of valve shall be by means of counter weights. The opening and closing time of valve shall be about 60 sec.

.2 All the valve components shall be designed in-accordance with ASME, pressure vessel code.

.3 The valve and its operating mechanism shall be designed for installation and removal by means of Power House E.O.T Crane.

.4 The valve shall be designed to withstand the maximum pressure including water hammer, that might arise during operation including upsurge.

.5 A by-pass valve shall be provided to take care of pressurizing of the spiral casing.

.6 The valve shall be equipped with hydraulically operated, metal to metal type, service and maintenance seals. It will have provision for replacement of the service seal by applying the maintenance seal without dewatering the penstock. Provision of locking of maintenance seal in closed position shall also be provided.

.7 A hand operated air vent valve will be provided at top of the valve body to allow trapped air to escape.

.8 Valve shall be capable of closing at maximum head from 1.5 time rated discharge to zero discharge.

.9 Suitable guard valves for by-pass and other valves shall be provided to facilitate maintenance.

.10 For purpose of transport, the valve shall be split in three sections, each section weighing around 50 tonnes.

.2 Rating

- Type — Spherical
- Rated Head — 365 m w.c.
- Test pressure — 5.5 MPa
- Diameter — 3200 mm
- Estimated valve weight — 150 tonnes

1.8 PENSTOCK BUTTERFLY VALVES

.1 Provisions

.1 Penstock valve shall be located in BFV chamber of size 95m x 10m x 22m. This chamber will have provision for installation of valves for all the four units alongwith all auxilliary equipment i.e. oil pressure unit, local control system etc. A 65/5 ton E.O.T crane will be provided in the chamber for erection and maintenance of equipment. 15m long service-cum-unloading bay has been provided at the entrance of BFV Chamber. General arrangement and plan of BFV chamber is given in the enclosed drawing 1200-2137-001.

.2 The penstock valve installed in a separate underground cavern shall be provided to shut off water in case of MIV failure or penstock rupture and to permit dewatering of the penstock. This shall be Lattice type Butterfly Valve of approx 4000 mm diameter, horizontally mounted at the inlet of the Penstock in BFV cavity.

.3 The operating mechanism shall be oil hydraulic, with two single acting servomotors mounted on the valve body. The pressure oil shall be supplied from a pressure oil system provided separately for each valve. The emergency closing shall be by means of counter weights.

.4 The valve shall have a by-pass system for equalising the pressure on both sides during filling.

.5 For installation and maintenance of Penstock Butterfly valves and its operating mechanism, a 65 Ton E.O.T crane for the Butterfly valve chamber is envisaged.

.6 The valves shall be complete with the following devices :

- Anti vacuum valves
- Penstock protection device causing valve to close when water velocity is higher than a critical value
- Expansion/Dismantling section on the down stream.

.7 Valve disc will have feature of self closing hydraulic bias.

.2 Rating

• Type	Butterfly - Lattice type
• Rated Head	192 mwc
• Test pressure	2.90 MPa
• Diameter	4000 mm
• Opening/closing	Hydraulic, 60 sec.
• Emergency closing	Counter weight
• Estimated weight	85 Tons.

1.9 HYDRO GENERATORS

.1 Type of Generator

The generator shall be vertical shaft A.C. Synchronous generator of semi-umbrella type suitable for direct coupling to the turbine shaft. The generator shall conform to the latest edition of IEC 34.

.2 Selection of Design Parameters

.1 Rated output

The generator output is selected so as to match the output of turbine at 90% gate opening and rated head and shall be 277.77 MVA (at 0.9 p.f. lagging) corresponding to turbine rated output of 255 MW (or 347,000 M.H.P) at shaft coupling without exceeding the permissible temperature rise as per IEC 34.1 at site altitude.

.2 Generation Voltage

With thumb rule of "generation voltage = (MVA) $^{0.5}$ for MVA > 200", the generation voltage for 277.77 MVA generator capacity works

out as 16.67 kV. The nearest to this is 15.75 kV, which has been used in India on machines of similar rating like Nathpa Jhakri, Koyna Stage IV etc. A generation voltage of 15.75 kV is accordingly proposed for Karcham Wangtoo also.

.3 Frequency

The generator frequency shall be 50 Hz with a permitted variation of ± 5%.

.4 Power Factor

The optimum value of Power factor for a hydro-generator of this magnitude is usually 0.9 lagging in generating mode.

.5 Short Circuit Ratio (S.C.R)

The S.C.R, which is the ratio of field current required to produce rated voltage at rated speed and no load to the field current required to produce rated armature current under sustained three phase short circuit, is generally decided on the basis of system stability studies. Normal value of S.C.R exceeding 1.0 is envisaged at this stage. Detailed system studies will be conducted to determine the optimum short circuit ratio which will be adopted at the time of ordering the equipment.

.6 Type of cooling

Conventional closed air-circuit, water cooled ventilation system shall be provided for the generator. Cooling of air shall be achieved by means of air coolers fixed on the periphery of stator frame with water as the cooling medium. Air shall be circulated through the generator by means of fans mounted above and below the rotor or fanning action of rotor spider.

.7 Insulation of Stator and Rotor

Epoxy type class F insulation both for stator as well as rotor shall be adopted because of its higher dielectric strength, lower tan delta value and higher temperature withstand capability, as compared to

bitumen insulation. The temperature rise limits for generator shall, however, be limited to class B insulation to keep adequate margin.

.8 Speed

The speed of the generator is selected as 214.3 rpm to match with the turbine. Accordingly the number of poles shall be 28.

.9 Line Charging Capacity

The generator shall have an inherent line charging capacity of the order of 70-80% of rated output i.e. approximately 222.2 MVA, which will flow through the generator during line charging. The Capacity is adequate to charge single circuit 400 kV line upto Koladm.

.10 Flywheel Effect

The flywheel effect of generator shall be approximately 14,433 t-m² as calculated from the formula given below :

$$GD^2 = \frac{(MVA)^{1.25} \quad 2p \quad (2p-3)}{55 \times \left(\frac{f}{50}\right)^2}$$ 2p is no.of poles

$$= \frac{(277.77)^{1.25} \times 28 \times 25}{55 \times \left(\frac{50}{50}\right)^2}$$

= 14433 t-m² i.e 14.433 x 10^6 kg-m²

.11 Inertia Constant

The inertia constant, which gives the value of stored energy relative to rated kVA works out to :

$$H = \frac{.37 \times 10^{-6} \times GD^2 \times N^2}{kVA} \quad kW\text{-}Sec/k$$

$$= \frac{1.37 \times 10^{-6} \times 14.433 \times 10^6 \times 214.3^2}{277777}$$

= 3.27 kW - Sec/kVA

.12 Weight of Generator Rotor

The weight of rotor, as worked out from the following empirical formula shall be approximately 454 t

$$W_R = 50 \times \left(\frac{MVA}{n^{0.5}} \right)^{0.75}$$

$$= 50 \times \left(\frac{277.77}{\sqrt{214.3}} \right)^{0.75}$$

$$= 454 \text{ t}$$

As per computer programme enclosed at Annexure III, total rotor weight, however, works out 491 tonnes.

Two cranes of 275 t operating in tandem shall be required for lifting the assembled rotor, taking into account weight of lifting beam and lifting tackles.

.3 Dimensioning of Generator

Major dimensions of generator have been worked out as per computer programme enclosed at Annexure III. The salient dimensions are given below:

Air Gap Diameter, D_g	6.51m
Outer Core Diameter, D_o	7.24m
Stator Frame Diameter, D_i	8.44m
Inner Diameter of Generator barrel, D_b	10.24m
Weight of generator Rotor	491 t

.4 General and Special Features

.1 Stator/Rotor

The stator frame shall be in 4 sections as permitted by transport limitations. The stator winding, comprising bar type single turn coils is proposed to be done at site. The stator winding shall be Wye connected having suitable number of parallel paths, per phase, and have 3 terminals each at line and neutral ends. Both

stator and rotor shall be insulated with epoxy type class F insulation.

.2 Bearing Arrangement

For a generator of this magnitude (277.7 MVA) with rated speed of 214.3 rpm a semi-umbrella type arrangement, which is most common, has been adopted. This arrangement provides a thrust-cum-lower guide bearing below the rotor and a guide bearing above the rotor. The thrust bearing shall have ample capacity to support the combined weight of the rotating parts of the generator and turbine, including thrust forces of the turbine runner. The bearings shall be self-lubricated, and shall be adequately insulated against stray currents.

.3 High Pressure Oil System

The thrust bearings shall be provided with an oil injection pump system (3 phase, 415 V, AC), for providing external high pressure oil to the bearing surface during starting, stopping as well as during creeping of the machine.

.4 Dynamic Electric Braking

Provision of dynamic electrical braking is envisaged in addition to mechanical brakes to achieve efficient and fast stopping of machine. In case of any electrical fault however, this mode of braking will be by-passed, and only mechanical brakes shall be applied at 30 percent rated speed.

.5 Creep Detector

A creep detector compatible with DACS shall be provided for remote indication of shaft rotation. Its contact shall be used for disengaging brakes in automatic operation and/or start up HP lub pump as per logic.

.6 Shaft Current Monitor

A suitable shaft brush shall be provided supported from bearing

housing for monitoring shaft voltage/current. It shall be compatible with DACS.

.7 Vibration Monitor

Vibration monitoring system complete with pick up transducers, cables, monitor having indication, alarm and trip facilities shall be provided.

.8 Bearing Oil Moisture Detector

Solid state moisture detector shall be provided with transducers/ probe in bearing oil reservoir. It shall detect moisture content of more than 10 ppm in oil.

.9 Fire protection system

The generator being located underground, water sprinkler system of manual/automatic type is contemplated for providing fire protection of the generators.

.10 On-line Partial Discharge Analyser

A partial discharge analyser with permanent couplers mounted on the stator winding shall be provided to monitor on-line condition of the stator insulation.

.11 Protection

Various protective relays for protection of the generator are described under chapter 4 dealing with DACS and covered therein.

.5 Field Acceptance Test

The following acceptance tests are proposed to be carried out at site on any one of the units :

- Efficiency test at 50, 75 and 100% rated output as per provisions of ANSI
- Maximum temperature rise of various parts at rated conditions

- 3 phase short circuit tests for not more than 1 sec
- Runaway speed test.

All instruments and testing devices for field acceptance test shall be rented by the generator supplier.

.6 Ratings

Based on the above discussions, the generator ratings are summarised below:

• Type	Vertical shaft, semi umbrella, synchronous generator
• Rated Output	277,778 kVA
• Rated Voltage	15.75 kV with a variation range of ± 10%
• Rated Frequency	50 Hz ± 5%
• Power Factor	0.9 lagging
• Insulation	Class F
• S.C.R	> 1.0
• Speed	214.3 rpm (28 poles)
• Flywheel Effect (GD^2)	14.43 x 10^5 kg-m^2
• Interlia Constant (H)	3.27 kW-Sec/kVA

1.10 EXCITATION SYSTEM

.1 Provisions

.1 The excitation system for the generator shall be static type comprising a dry type excitation transformer, micro-processor based digital control and regulation system, thyristor controlled rectifiers, field flashing arrangement, field breaker etc. The power supply for the excitation system shall be taken directly from the generator A.C. terminals through excitation transformer. Supply for initial excitation for field flashing shall be obtained through 415 V, 50 Hz 3 phase supply or alternatively through 220 V D.C supply.

.2 The excitation system shall have an overcapacity margin of approx. 10% and shall meet the following performance requirement:
- Nominal excitation system response not less than 2.
- Ceiling voltage of exciter not less than 1.8 p.u.

.3 The digital regulation system shall meet the following requirements:

- Range of voltage control in Auto mode 75-110%
- Range of voltage control in Manual mode, not less than 25-110%
- Max. change in generator voltage for transfer from auto to manual or vice versa ± 1%
- Regulator response time not more than 20 ms

.4 The digital AVR shall have all standard features like :

- Over excitation current limiter
- Rotor angle limiter
- Stator current limiter
- Volts/Hz Control to prevent over-fluxing of generator transformer
- Transformer/line drop compensation
- Power factor regulation
- Power system stabilisation
- Rotor temperature calculations etc.

.5 The regulator shall be compatible with DACS and shall be equipped with suitable interface for :

- Communication with processing unit on line
- Facility of adjustment of limit values or control algorithm
- Testing facilities
- Provision for connection of a printer for recording regulator and excitation system response.

.2 Rating

The excitation system ratings envisaged are summarised below :

- Type of Excitation Static
- Type of Voltage Regulation 15.75 kV with a variation range of ± 10%
- Nominal Excitation system response Not less than 2
- Ceiling Voltage Not less than 1.8 p.u.
- Regulator response time Not more than 20 msec.
- Type of Excitation Transformer Dry type.

Chapter - 2

GENERATOR - TRANSFORMERS

2.1 GENERAL

The power generated at 15.75 kV shall be stepped up to 400 kV through independent unit generator-transformers connected directly with each unit. There will be total thirteen (13) Nos. of single phase transformers including one spare transformer installed inside a separate cavity, 143 m (long) x 15.5 m (wide) x 25m (high), parallel to the main power house cavity. The transformer 400 kV side shall be directly connected to 400 kV SF_6 gas insulated switchgear, installed at El. 1526.0 m floor just above the transformers, through SF_6 busducts. The primary side of transformer shall be connected with the generator through isolated phase busducts installed in the gallery interconnecting main power house and transformer caverns.

2.2 LAYOUT AND GENERAL ARRANGEMENT

.1 The transformer shall be installed underground inside a cavity parallel to the main Power House cavity. Layout and general arrangement drawing for the transformers are enclosed as under:

- Drawing No.1200-2131-002 Layout of Power House and Transformer Halls.
- Drawing No.1200-2131-012 Cross Section of Transformer Hall.

.2 Transformers shall be installed in individual cabins in transformer hall having fire brick wall partition and fire doors.

.3 Proper provision for ventilation and smoke exhaust shall be made under ventilation system.

.4 Transformers shall be provided with emulsifier fire protection system which is covered under Fire Protection System (Chapter - 6).

.5 Suitably designed soak pit shall be provided below the transformer foundation to take the spillage oil and drain it to drainage sump.

.6 Transformers shall be assembled in erection bay and transported to its cabins on rails. For attending minor problems, suitable lifting hooks shall be provided in the roof.

.7 An erection bay in transformer hall, equipped with facilities for handling of bushing etc., shall also be provided to facilitate erection and maintenance.

2.3 BASIC PROVISIONS

.1 The transformers shall conform to IS:2026/IEC 76.

.2 It shall be capable of withstanding, without injury, the mechanical and thermal stresses produced by external short circuits on the terminal of any winding for a duration of 3 seconds. It shall be designed for short circuit withstand capability of 50000 MVA.

.3 The transformers shall be capable of operating at full load for 10 minutes after failure of the oil/and or water circulating pumps without calculated winding hot spot temperature exceeding 150°C.

.4 Due to sudden disconnection of the load, transformers shall be capable of operating at a voltage approximately 25 per cent above the rated voltage for a period of 1 minute and 40 per cent above the rated voltage for a period of 5 seconds.

.5 The transformer tank shall be capable of withstanding without leakage or distortion, an internal gas pressure specified in IEC Standards as well as full vacuum.

.6 The noise level of transformers shall not be more than 5 dB above the NEMA standard publication TR-1.

.7 The maximum flux density in any part of the core and yokes shall not exceed 1.9 Tesla.

.8 Transformer shall be capable of withstanding seismic forces given under Chapter 1.

.9 Each transformer shall be subject to routine tests as per relevant standards. Type tests and special tests on one transformer shall also be conducted.

.10 Protective Relays/Devices

The following protective relays/devices shall be provided for each of the transformers :

- Overall differential current relay covering transformer as well as generator
- Restricted Earth fault relay on HV side
- Overfluxing relay
- Neutral overcurrent relay
- Buchholz relay with alarm and trip contact
- Oil temperature indicator with alarm and trip contact
- Winding temperature indicator with alarm and trip contact
- Magnetic oil gauge with low level alarm contact
- Pressure relief device with trip contact
- Oil flow indicator with alarm contact
- Water flow indicator with alarm contact.

The protective relays indicated above shall be included in the protective relay package for generating units.

.11 Cooling Arrangement

The transformer shall be provided with OFWF or ODWF type of cooling. Each transformer shall be provided with two motor driven oil pumps to circulate the oil through any one of the two oil-to-water heat exchangers provided and mounted on the transformer. The cooling tubes shall be stainless steel/cupro-nickel. The two heat exchangers and oil pumps shall be piped and valved in such a manner that either pump can operate with either heat exchanger. Suitable rated pressure reducers shall be provided in the cooling water system.

.12 Fittings and Accessories

All standard fittings and accessories as per IS/IEC and as per the present trend being followed for 400 kV class transformers shall be

provided. The HV bushings shall be oil/SF_6 type suitable for direct connection with 400 kV G.I.S and the LT bushings shall be suitable for IPB (15.75 kV) terminations.

.13 Transformer Neutral Current Transformers

Transformer neutrals shall be interconnected through neutral bus duct. Independent cores of current transformer for restricted and neutral overcurrent protection shall be provided to match current transformers provided in the gas-insulated switchgear.

.14 Local Control Cabinet

Each transformer shall be provided with a local control cabinet (Marshalling box) with standard facilities not limited to the following :

- Local/Remote selection of pumps
- Local/Automatic pump operation
- Status indications for pumps operation/failure
- Local/Remote winding/Oil temperature indications
- Facility for remote indication/annunciation as required.

2.4 TRANSPORTATION

Estimated transport dimension and weight of transformer are as under:

Length	4.5 m
Width	3.1 m
Height	4.0 m
Weight	62 tons

This will require 70 tons Tractor trailer unit for transportation. Similar transformers are being transported by NJPC upto Jhakri, and as such no difficulty is foreseen for transportation upto Jhakri. Necessary widening of roads and bridges for transportation of equipment from Jhakri onwards upto Karcham Wangtoo would be required.

2.5 TYPE AND RATINGS

Single phase transformers are envisaged because of transport limitations en-route. Three single phase transformers shall form a three phase bank, each

bank serving one generating unit. The transformers, installed at an altitude of El.1515m, shall have following ratings :

•	Service	Indoor	
•	Type	Two winding, single phase oil immersed transformer	
•	Rated MVA	3 x 93 MVA	
•	Rated Voltage	HV 400/√3 kV LV 15.75 kV	
•	Highest voltage for equipment	420 kV	
•	HV neutral earthing	Effectively earthed	
•	Type of cooling	OFWF or ODWF	
•	Vector Group	YNd11	
•	Tappings	Off load tappings (+) 2½% to (-)7.5% in steps of 2.5%	
•	Percentage Impedance	12.5%	
•	Insulation Levels	HV	LV
	- Lightning Impulse withstand level	1300 kVp	95 kVp
	- Switching Impulse withstand level	1050 kVp	N/A
	- Power frequency withstand level	N/A	38 kV rms

Chapter - 3

ISOLATED PHASE BUSDUCTS AND TERMINAL EQUIPMENT

3.1 GENERAL

.1 The power generated at 13.8 kV or higher voltage shall be stepped up to 400 kV through unit generator - transformers (banks of single phase units) located in a cavity parallel to the main machine hall. The transformers shall be connected to generator through isolated phase bus ducts.

.2 In addition to connecting generator and transformer Isolated phase busduct shall also serve as under :

- Formation of generator neutral and connection with neutral grounding cubicle (NGC)
- Tap off connections to unit auxiliary transformer, excitation transformer and lightning arrester voltage transformer (LAVT) cubicles.
- Mounting and connection of current transformers for protection and metering.

The approximate length of single phase main, delta and tap off busduct per unit shall be as under :

Main Bus duct	15000 Amp	84 m
Delta Bus duct	8000 Amp	42 m
Tap off duct	1000 Amp	30 m

.3 The busducts shall satisfy the following technical requirements:

a) Adherance to specified temperature limits
b) Adequate short circuit strength (thermal and mechanical strength in the event of short circuits)

c) Adequate magnetic screening
d) Safe insulation i.e. protection against overvoltage, moisture and contamination.

3.2 TYPE OF BUS DUCT AND FEATURES

The busduct shall be :

- Isolated phase type, with each phase conductor and all other circuit components of each phase completely enclosed in a metallic enclosure separate from the enclosures of other two phases.

- Continuous type in which the phase enclosures are effectively welded and connected at the two ends to other phase enclosures to form a low resistance path, adequate to carry current of the same order as the busbar.

- Natural cooled.

- Shock proof against contact.

- Protected against dirt and moisture, maintenance being limited to visual inspection.

- Free from magnetic field outside the enclosure (no inductive losses in nearby conducting material such as grills, railings, concrete reinforcements, pipes, etc.).

- Less prone to earth faults and short circuits.

3.3 BUSDUCT PARAMETERS

.1 Voltage Rating

Corresponding to generation voltage of 13.8 kV, the voltage rating of busduct shall be 15 kV.

.2 **Rated Current**

The rated current of main busduct at rated MVA, and minimum (-10%) voltage works out to 12,913 Amp. As per the preferred current ratings given in relevant standards, the busduct curent rating has been selected as 15,000 Amp. The current rating of delta busducts shall accordingly be 8,000 Amp.

.3 **Short circuit current rating of busducts**

For a fault in the main duct at any location, the fault current shall flow from genrator as well as transformer side upto the fault point. The main duct shall be designed for higher of these two fault currents. For a fault in the tap-off ducts, however, the current adds up from transformer and generator side and accordingly the tap off ducts are designed for sum of the two fault currents. Assuming the 400 kV system fault level as 20,000 MVA, transformer impedance as 12.5% and generator reactance (x_d") as 21%, the fault levels of main and tap off IPBs work out as follows :

- Fault level of main and delta busducts — 100 kA (symm) and 250 kA (Asymm)
- Fault level of Tap off duct — 160 kA (symm) and 400 kA (Asymm)

.4 **Temperature Rise**

The temperature rise limits for busducts as per relevant standards shall be as follows :

Bus conductor	30°C
Bolted joints	50°C
Silver coated bolted joints/Aluminium welded joints	65°C
Enclosure	30°C

3.4 PROVISIONS

.1 Bus Conductors

The bus conductors shall be of high conductivity Aluminium alloy, supported symmetrically with respect to the enclosure by use of one or more cast resin post insulators. The bus conductors shall be connected to the terminals of generators, generator - transformers, excitation transformers, unit auxiliary transformer, LAVT through flexible braid connectors, which shall also serve as disconnecting links.

.2 Bus Enclosure

The bus enclosure shall be of Aluminium, dust tight, water tight and self cooled. The enclosure sections shall be welded together and grounded. It shall be provided with :

- Filter type drain plugs at the bottom for condensed moisture
- Openings with gasketed covers for inspection of insulators
- Bellows for expansion and contraction due to temperature variation.

The bus duct shall be obtained in suitable length to facilitate transportation and erection, and welded together at site as per requirement.

.3 Insulating devices

- Seal off bushings shall be used, wherever required to prevent air flow from one section to the other.
- A baffle shall be provided at junction of Power House and Busduct Gallery, to prevent air from passing between the two portions of the bus enclosure.

.4 Short Circuiting device

A set of bolted type shorting jumpers rated for the busduct current shall be

provided for the purpose of drying out of the equipment before commissioning and for carrying out short circuit test on the equipment. Suitable support insulators shall be provided.

.5 LAVT Cubicle

The LAVT Cubicle shall include surge capacitors, lightning arresters, voltage transformers and accessories. The surge protection equipment shall provide protection of generator against lightning surges transferred through inter-winding capacitance of main transformers. The voltage transformers shall be withdrawable, epoxy resin cast dry type and be used for metering, protection and AVR. These VTs shall be single phase units combined into 3 phase groups connected in star both on high voltage and low voltage sides. On the secondary side of voltage transformers, a miniature circuit braker shall be provided.

.6 Neutral Grounding Cubicle

The generator neutral grounding cubicle shall include a dry type distribution transformer, a disconnecting switch, a resistor and accessories, mounted in a single, ventilated, metal enclosed cubicle.

.7 Current Transformers

The current transformers for metering and protection shall be provided both on line side as well as neutral side. These CTs shall be of epoxy cast resin type with single secondaries installed inside the generator terminal housing and neutral housing respectively.

.8 Tests

All design tests, production tests and field tests shall be conducted on busducts as per relevant IS/IEEE standards. Relevant routine and type tests on current and voltage transformers, surge protection equipment, neutral grounding equipment, control and secondary wiring in the cubicles shall also

be conducted as per standards.

3.5 LAYOUT AND GENERAL ARRANGEMENT

The layout and general arrangement of busducts and terminal equipment are shown in the following drawings appended with the DPR :

Drg. No. 1200-2131-002	Layout of Power House and Transformer Halls
Drg. No. 1200-2131-004	Cross section of Power House through Turbine
Drg. No. 1200-2131-008	Floor Plan of Power House - El.1510.0m
Drg. No. 1200-2132-001	Protective Relaying and Metering Diagram (Generator side)

3.6 RATINGS

The following ratings are envisaged for the busducts and terminal equipments :

- **Busduct**

- Type	Continuous
- Rated voltage	15 kV
- Rated current	15000 A (main duct) 8000 A (delta duct)
- Max. operating temperature at rated load	
• Bus Conductors with silver contact surfaces	105°C
• Outside surface of enclosure	80°C
- Power frequency withstand voltage	38 kV

- Lightning Impulse withstand voltage — 95 kVp
- Type of cooling — Self Cooled

- Short Circuit Ratings (Symmetrical)
  - Main/Delta bus duct — 100 kA (rms)
  - Tap off busduct — 160 kA (rms)

- Ambient temperature outside enclosure — 30°C

- **LAVT Cubicle**

- **Lightning Arrester**

Type	Station class, Valve type
Rated voltage	15 kV
Discharge Current	10 kA

- **Surge Capacitor** — 0.25 micro-farad

- **Voltage Transformer**

	VT-A	VT-B	
Voltage ratio	$\frac{13.8}{\sqrt{3}} kV / \frac{110}{\sqrt{3}} V$	$\frac{13.8}{\sqrt{3}} kV / \frac{110}{\sqrt{3}} V / \frac{110}{\sqrt{3}} V$	
Accuracy class	1.0	0.2	3P
VA burden	30	30	50
Purpose	AVR	Metering	Protection

- **Current Transformers**

- **Netural side**

Current Ratio	15000/5 A	
No.of CTs	5 per phase	
Accuracy	PS/5P10	for protection

	0.5	for metering
- **Line side**		
Current ratio	15000/5 A	
No.of CTs	3 per phase	
Accuracy	3 for AVR	
	PS for protection	
- UAT Tee off }		
}	As per requirement	
- EX Tr. Tee off }		

- **Neutral Grounding Cubicle**

Distribution Transformer	13.8 kV/220 or 250 V
	Cast resin, Dry type

Chapter - 4

DATA ACQUISITION, CONTROL SYSTEM AND PROTECTIVE RELAYING AND METERING EQUIPMENT

4.1 DATA ACQUISITION AND CONTROL SYSTEM (DACS)

.1 Basic Components

The computerised Data Acquisition and Control System proposed for this station shall be distributed type, built up on the following components :

- Workstation/Plant Computer for programming and central control and supervision of the power plant.
- Unit Level Input/Output controllers.
- Communication network allowing the data interchange between the automation cells and the computer system.
- Operator stations for man-machine interface.

.2 Architecture of the Proposed System

.1 The architecture of the proposed system shall generally be in line with the drawing no. 1200-2132-013 appended with DPR and comprise the following sub-systems :

a) Six (6) automation cells for the local data acquisition and control comprising :

- 4 - unit level dual controllers
- 1 - station auxiliaries dual controller

- 1 - 400 kV switchgear dual controller

b) One (1) dam gate controller for access to remote gate data input.

c) One (1) gateway dual controller for mimic board.

d) One (1) PC based operator console for off-line training system.

e) One (1) Programming console (Portable).

.2 Each dual controller shall comprise 2 CPUs and 2 communication ports connected to the dual communication network.

.3 The dual computer shall be distributed around a local network, and each shall have two dedicated operator stations, a data server station and a system maintenance station. This will provide following facilities:-

- Individual or overall control of the units in individual or joint control mode using mimics & control views
- Printing reports
- Graphic displays
- Fault Annunciation and Alarm Management
- Logging facilities
- Power generation control as per river discharge.

.4 **Unit Level Controller**

The programmable dedicated logic controller at unit level shall perform the following functions :

- programmable as per unit start/stop, emergency shutdown logic control scheme.

- acquire the logic and analog signals from the process comprising turbine, governor, valve, generator and auxiliaries.

- operate the process actuators and perform automatic control sequence in response to process signals or to orders from the other controllers or from the protective equipment in control room.

- monitor the process and initiate alarm annunciation as applicable with a printout of alarms.

- send to the control room the essential information (status signals, grouped alarms, etc.) about the process.

- can be hooked up with a portable programming console for test start.

.5 Station Auxiliary Controller

This programmable logic controller for station auxiliaries shall perform the following functions :-

- communicate with the control room through the data communication network.

- The controller shall be provided with enough input/output modules to deal with the following signals to and from the process (including spare):

  - logic input signals from the process
  - logic output commands to the process
  - analog signals from the process (4 to 20 mA)

- acquires logic information required to control the 415V ac power supply including change over of supplies from station auxiliary to unit auxiliary transformer and vice versa.

- acquires logic information required to control the 11/22kV switchgear.

- acquires logic information required to control and monitor the drainage & dewatering pumping station.

- acquires logic information for control/monitoring of ventilation and air conditioning system for P.H.

- acquires logic information for control of compressors for synchronous condenser operation.

- acquires logic information for control and monitoring of d.c. supply system.

- control of other station systems as per requirement

Provision for security relaying for emergency action shall be made.

.6 **Mosaic Mimic Board**

A common mosaic mimic board shall be provided in the control room with following features:-

- Mimic diagram for each unit with semaphore indicators/indicating lamps for circuit breaker, isolators and earthing switch, field circuit breaker and 415V breaker for unit auxiliary supply etc. to represent the relevant switching conditions.

- Mimic diagram for each feeder with semaphore indicators/ON/ OFF indication lamps as per requirement

- Mimic diagram for bus coupler bay with semaphore indicators /ON/OFF indication lamps as per requirement

- Mimic diagram for hydraulic system showing status of gates/ valves, levels of main reservoir and tailrace.

.7 **Switchyard Station Dual Control**

It shall acquire logic information of status of various 400 kV gas-insulated switchgear equipment and analogue/digital data for control and monitoring of isolators/breakers in manual/automatic mode, mimic display etc.

.8 **Dam Gate Control**

It shall acquire all logic information from dam site. Its output shall be displayed and output commands as per system requirement shall be provided.

.9 **Input/Output Capacity of the System**

Input/Output capacity of various controllers shall be as per system requirement with 3 to 5% spare input/output provision.

.3 **Plant Computer**

.1 The centralised processor/computer system with 100% redundancy shall be located in the control room & perform the following functions:-

- Acquisition of data inputs coming from the local automation cells
- Processing of the data inputs in order to update its real time data base
- Processing of the output to control the power plant
- Screen based man machine interface
- Printer outputs management
- Computation functions
- Joint control and power optimisation.

It shall comprise the following components :

- Plant computer system for the real time database management

and the specific computation and hydraulic application functions.

- 2 operator stations (video stations) for man/machine interface. Each station shall be equipped with two graphic CRTs and keyboard.
- A system maintenance workstation with printer.
- A colour hard copy printer for the copy of any one of the four operator CRT's.

.2 Features of Plant Computer

The centralised computer system shall have following facilities :-

- Display Functions
  - Alarm display
  - Group display
  - Bar chart display
  - Trend curve display
  - Profile display
  - Plant schematic display
  - Mimic display
- Recording Functions
  - Alarm log
  - Post Trip log
  - Trend log
  - Plant status logs
- Supervisory Functions
  - Maintenance log
  - Hourly/Daily log
  - Shift log
  - Calculation functions

- System Customisation Start up and maintenance

.4 Specific Hydraulic Application Function

A plant control real time software, integrated into the system shall allow the automatic joint control of the units with the overall power and water optimisation. The following functions shall be provided :

- Acquisition of the set points

The operator can introduce the overall plant active and reactive power from an operator station.

- Active power joint control

To follow the overall active power, the software manages the unit start/stop commands and determines the optimised load of each unit. The main modules shall be as under :

- Unit status and control mode acquisition
- Load capability of each unit
- Active power sharing between the units according to optimisation criteria (efficiency and head losses)
- Choice of the unit to be started or stopped
- Start/stop command transmission and execution checking

- Individual active power set point transmission to each unit and execution checking
- Reactive power joint control.

To follow the overall reactive power introduced by the operator, the software shall provide the following functions:

- Reactive power capability of each unit
- Reactive power sharing between the units in proportion to their

capability

- Individual reactive power set point transmission to each unit and execution checking.

.5 Training Facilities

A PC based training system shall be provided which shall be independent of the main control and monitoring system. It shall comprise a PC based operator workstation and a single controller. The controller shall be connected to a PC allowing the simulation of inputs and outputs.

.6 Control Philosophy

.1 Unit Control

Following provisions shall be made for operational control and monitoring of the units from Control Room :

a) Starting, stopping and emergency shutdown of the machine in automatic, or step by step control, or manual modes.

b) Manual and automatic synchronisation.

c) Status indication of unit including excitation system, governor system and 400kV breaker.

d) Metering for MW, MVar, PF, voltage, current, speed, field current, field voltage etc. of the unit.

e) Speed control of the unit.

f) Voltage control of the unit.

In addition following control shall also be provided :

i) Joint power output control as per optimum efficiency requirement.

ii) Protection signal from applicable protection relay shall interrupt unit start up and initiate shutdown ensuring precedence of protection signal.

For control of unit/station auxiliaries, local control panels shall be provided. It shall be possible to start the auxiliary from local with permission from operator's station. Local control panel shall have facility for control, protection & metering as per requirement. Local control panels shall be supplied along with the equipment.

I/O controllers shall be provided at unit level for interface with turbine, generator, valves and auxiliaries. At unit level, man/machine interface is not provided. If required for testing, or other purposes, programming console can be hooked up and unit control can be done from I/O controller panel installed at unit level.

Unit can be started from local control panels, if required, under permission from central control. Sequence shall be to start auxiliary one by one as per approved sequence. Unit can be started from governor cubicle and voltage built up from regulation cubicle.

.2 Feeder and Bus Coupler Control

Following control philosophy for 400 kV feeders, bus couplers shall be adopted:-

a) Manual opening/closing of circuit breakers and isolators with permission from central processor. These controls with proper interlocks shall also be feasible from central processor.

b) Tripping of circuit breakers under fault conditions.

c) Initiation of unit shutdown under fault conditions as per logic.

d) Auto closing of circuit breaker from auto-synchroniser.

e) Tripping of UAT incoming breaker and field breaker as per logic.

Monitoring Functions

Status indication of switchgear equipment i.e. isolators, breakers.

4.2 PROTECTION AND METERING PANELS

.1 General

.1 The proposed layout of control room is shown in drawing number 1200-2131-010. The protection panels shall be of simplex type fabricated from sheet of not less than 3 mm thickness for weight bearing members and 2 mm for other portions. The enclosure protection shall be standard IP:42. All equipments on and inside panels shall be mounted and completely wired to the terminal blocks ready for external connections. All control wiring shall be carried out with 650 V grade, single core, stranded copper conductor of size 1.5/2.5 mm^2 cables.

.2 The protection and metering shall be provided as per enclosed drawings: 'Protective, Metering and Relaying Diagram' (1200-2132-001, 1200-2132-002 and 1200-2132-004).

.2 Protection Relays/Metering Panels-Generator & Generator Transformer

Metering Functions

To provide metering instruments for following functions :

- Active and reactive power, generated by each generator
- Active and reactive energy meters for each generator of class 1.0 accuracy with printer
- Generator voltage and current
- Exciter voltage and current

- Frequency
- Power Factor
- Remote temperature indication of generator-transformer oil and winding
- Governor limit/position indication
- Other metering as per requirement

Protective Relaying Equipment

Each set for one unit shall be provided with the following protective relays:

• 100% Stator earth fault protection	64 S
• Negative Phase Sequence Protection	46 G
• Rotor E/F protection	64 F
• Loss of field protection	40 G
• PT fuse failure protection (2 nos.)	60
• Reverse Power Protection	32 G
• Generator Over Voltage Protection, IDMT & instantaneous type	59 & 59 I
• Generator Under Voltage Protection	27 G
• Impedence Back up Protection	21 G
• Generator Differential Protection	87 G
• Generator - Transformer overall Differential Protection	87 GT
• Transformer over fluxing protection	99 GT
• Transformer oil temp. rise protection (3 nos.)	49 O
• Transformer winding temperature rise protection (3 nos.)	49 W
• Transformer oil surge protection (3 nos.)	63S
• Breaker failure protection	50 BF

•	Buchholz relay protection (3 nos.)	63
•	Transformer O/C ground fault relay	51 N
•	Transformer restricted E/F protection	64 GTR
•	Auxiliary high speed trip relays	12 Nos.
•	Master trip relays for Controlled action trip, emergency trip, and electrical trip	3 Nos.
•	Contact Multiplier relays/Auxiliary relays/Aux. CT's/test block/ Metrosils/Stabilising resistance and other items for completeness of scheme	As per requirement
•	Overcurrent protection (UAT)	50/51
	Restricted E/F protection (UAT)	64 UTR
•	Overcurrent protection (Excitation transformer)	50/51
•	Trip Relays for mechanical fault, about 25 nos. for each unit	

.3 **Protection and Metering Panel - 400 kV Feeders**

Metering Functions

To provide metering instruments for following functions :

- 1 Set Active and Reactive power flow with MDI hand reset.
- 2 Sets Active and reactive energy meters for each feeder of class 0.2 accuracy with cyclometer registers and connected to a common printer.
- 1 Set Line current and voltage.

Protective Relaying Equipment - 400 kV lines

•	Carrier accelerated distance protection with power swing blocking/travelling wave/phase comparison (Main 1)	21

- Carrier aided distance protection (Main 2) 21/78
- Auto reclose relay 79
- Overvoltage protection (2 stage) 59 L
- Breaker failure 50 BF
- Line distance to fault locator FL
- Fault & disturbance recorder F&D

.4 **Protection and Metering Panels Bus Bar**

Metering Functions

To provide metering instruments for :

- Bus bar voltage, frequency indication and recorders

Protective Relaying Equipment :

- Main Bus I protection 87 B 1
- Main Bus II protection 87 B 2
- Check bus protection 87 CH

.5 **Tie Breaker Protection and Metering Panel**

Metering Functions

To provide metering instrument for measurement of :

- Tie circuit current

Protective Relaying Equipment :

- Breaker failure 50 BF
- Overcurrent protection 50/51

.6 **Synchronising Equipment Panel**

i) Automatic Synchronising Equipment

The automatic synchronising equipment shall permit automatic control of turbine speed, voltage, and breaker closing for the purpose of connecting the generator to a running system with a minimum of disturbance to the machine or the system.

The automatic synchroniser shall include the following units:

- Voltage acceptor
- Speed matcher
- Voltage matcher
- Synchronism checking device

The synchronising scheme shall allow the relay to close only when the following conditions are satisfied :

- The generator breaker is open.
- The voltage acceptor module gives a release signal indicating that the generator and bus voltages are within required limits.
- The rate at which the systems are approaching synchronism is such as to allow the breaker to close at exact phase coincidence with minimum disturbance to the system.

ii) Manual Synchronising Equipment

In case the automatic synchroniser is out of order, the units will be synchronised by the operator using the manual synchronising equipment.

The manual synchronising panel shall comprise :

- Incoming and running voltmeter
- Incoming and running frequency meter
- Synchroscope with synchronising lamps
- Synchronising pulse sent indication light (green) separately

- Check Synchronising relay with indication and by pass switch.

.7 **Remote Control & Metering Panel for A.C. Auxiliaries**

i) Control Tasks

- Remote closing/opening of all 415V A.C. circuit breakers
- Remote closing/opening of all 11kV breakers

The control is from Data Acquisition & Control System desk.

ii) Monitoring and Metering Tasks

- Position status of all 415V and 11kV A.C. circuit breakers
- UAT incomer voltages of three units
- 415V Station Service incomer voltage
- 11kV A.C. Incomer Voltage

- Visual & Audio alarm in case of tripping of any circuit breaker and in case of supply change over etc.

Above functions will be from DACS.

.8 **Sequential Event Recorder Panel**

The event recorder panel shall also include a separate operator's desk, incorporating printer/key board, a colour CRT and printer.

The recorder shall contain the modular microprocessor based control logic, scanner and sequential memory operating system, input and output terminations, power supplies and interfaces etc.

The SER shall be used in conjunction with the audio/visual annunciations located in all control metering and relaying panel to provide an optimised alarm reporting system and will differentiate in the following manner :

- Critical alarm
- Non critical alarm
- Operating events such as unit start/stop, C.B. tripped/closed etc.

It will monitor all the Six (6) line feeders.

.9 **Panel for metering of dam intake, spillway gates and tail race level**

Following meters/indicators shall be provided on this panel :

- Head water and tail race water level indicator & recorder.
- Opening position indicators for spillway gates and intake gate.
- Position indicators for draft tube gates.

Suitable provision for telemetering digital/analogue values for dam site to power house is included in the scope. The interfaces for centralised control and indication shall be provided.

.10 **General Provision**

.1 In addition to the equipment already described, each Panel shall be equipped with the following as per requirement :

- Anti condensation heaters with thermostat
- Illumination with door operated switches
- Three Pin 15A Power socket with switch
- Fuses, terminal blocks, MCBs
- Cable glands
- Annunciation relays
- Flasher relay
- Contact multiplication relays
- Bell/hooter for fault annunciation
- Misc. auxiliary relays as per requirement

The MW meter shall have feature of MDI hand reset.

Loose auxiliary relays for remote end of 400kV lines shall be provided as per requirement.

Necessary provision for power output control from the control room shall be provided.

.2 Based on the nature of fault, tripping action in event of a fault shall be grouped as under :

- Electrical shutdown (Tripping of breakers and field breaking shutdown).
- Controlled action shutdown (for mechanical faults and Normal shutdown).
- Immediate shutdown (All electrical and mechanical fault emergency conditions) requiring immediate shutdown.

Shutdown relays shall directly act on control devices to ensure positive shutdown.

DACS would be interfaced to monitor and control shutdown sequence.

.3 Automatic voltage regulator and governor shall have local control from panels and remote control provision from DACS.

.4 Annunciation system having adequate number of ways with facility to accept, reset and test, for various fault conditions or abnormal running conditions shall be provided. The alarms shall be grouped as trip alarms and non trip alarms having different audible tones. Flasher relay will be provided so that new alarm is easily identified.

.5 Transformer Cooler Control Logic

Transformer cooler control shall have following provisions :

i) Local control from local control cabinet and remote control from remote control panel / DACS.

ii) One oil circulation pump shall work as main and the second pump shall act as standby. Local/remote, auto/manual selection, start/stop selection of any pump as main or standby shall be provided. Necessary control switches, start/stop push buttons shall be provided.

iii) It shall be possible to start any set of coolers from local/remote panels. Status indication for running/stop/fail shall be provided.

iv) Interlock of cooling pump shall be provided with circuit breaker.

v) Annunciation for cooling water and oil pump failure will be provided.

vi) Normally cooling water supply valves to both the coolers would be on. When unit is to be started, cooling water pump would be started and with that cooling water supply to heat exchangers would be available. Any of the pump can be selected as main. As soon as circuit breaker is closed, main oil circulation pump shall start. In case of failure of main pump, standby pump shall automatically start.

.6 Logging Functions

Provision for logging of temperature of generators, transformers, bearing etc. shall be made as required. Besides logging of important levels, pressures power shall also be done.

.7 Remote Control & Metering from AC auxiliaries

Necessary control and metering functions shall be provided.

.8 Sequential Event Recorder

Sequential event recording shall be provided for 96 events with accuracy of 1 ms. resolution.

.9 Panel of Intake, Spillway Gates

Necessary provisions shall be made for I/O units for gate data as per requirement.

.10 Testing Instruments

All special equipment, tools, instruments and devices required for testing all types of relays during commissioning and future maintenance shall be provided.

Chapter - 5

ELECTRICAL AUXILIARIES

5.1 GENERAL

The electrical operational auxiliaries associated with turbine-generating unit e.g. oil pressure system, centralised grease lubrication system, H.P. lub oil system, stator heaters etc. are covered under the main generating plant equipment (Chapter - 1). The other electrical auxiliary equipment required to be provided on station basis are discussed hereunder.

5.2 A.C. STATION POWER SUPPLY SYSTEM

.1 General

.1 All the station service and unit auxiliaries shall be suitable for operation with either 415 V, 3 phase, 4 wire, 50 HZ or single phase 240 V AC system. The A.C. supply for power house shall be obtained through :

- 15.75 kV/415 V, 1000 kVA, unit auxiliary transformers (UAT)
- 22 kV/415 V, 1000 kVA, station service transformers (SST)
- 1000 kVA, 11 kV Diesel Generating sets
- 11/22 kV, 1000 kVA, step up transformer.

.2 The proposed scheme for A.C. Station Power Supply System is shown in appended drawing 1200-2132-007. The main A.C. supply system for Power House shall comprise :

- One unit Auxiliary Board for each unit having interconnection facility as per drg. 1200-2132-007.
- One Station Service Board having two sections connected by a bus coupler as per the drawing.

.3 The A.C. supply for dam site, shall be catered through the transformer and DG set installed at site, i.e. :

- 22kV/415 V, 500 kVA distribution transformer
- 250 kVA, 415 V Diesel generating set.

For A.C. supply to dam site one 22 kV line from Nathpa - to Kilba will be tapped at Dam Site. D.G. set will provide required standby supply for operation of the gates.

.4 A.C. supply for surge shaft shall be made available through suitable 22 kV line tapped off from Nathpa - Kilba line. 22 kV voltage shall be stepped down to 415 volts and will meet all station load at these places.

.5 The A.C. supply for BFV chamber shall be made available from Power House through 22 kV/0.415 kV distribution transformer.

.2 Control Logic

.1 Each unit auxiliary board, during start and normal running of the unit shall meet the power requirement of unit auxiliaries associated with the turbine-generator receiving power from their respective unit auxiliary transformers.

.2 In case of failure of any of the unit auxiliary transformers, the power requirement of the associated unit auxiliary board shall be met from the station service board, which will receive supply from 2 nos. SEB'S 22 kV feeders.

.3 The normal power requirement of the station auxiliaries shall be met from station service board.

.4 In case of failure of station service transformer, the power requirements of the station service board shall be met from the unit auxiliary board.

.5 In case of failure of 22kV supply system, essential unit and station loads shall be supplied by 2 nos 1000 kVA DG sets connected to 22 kV switchboard through 11 kV/22 kV transformers. Station will thus have black start capability.

.6 Suitable interlocking scheme shall be provided to achieve the required automatic changeover logic from unit supply to station supply and vice versa for power house boards.

.3 Unit/Station Transformers

The Unit Auxiliary/Station service transformers shall be cast resin dry type and shall have the characteristics given under clause 5.2.7. Capacity of the transformers has been so selected that each transformer can supply load of at least two units or one unit and station auxiliaries.

With each transformer suitable current transformers shall be provided for over current and earth fault protection. For differential protection of generator-transformer matching CTs shall be provided, mounted in the busduct UAT tap off.

.4 22 kV Switchgear

The 22 kV Switchgear panel shall consist of switchboard, vacuum/SF_6 circuit breakers, instrument transformers and the necessary metering and protection equipment. The switchgear shall have two sections of 22kV bus, each section having drawout type 22kV breakers as per enclosed single line diagram (1200-2132-007). A bus coupler breaker which under normal operating condition will remain open, will enable both sections of the switchgear to be connected together. Two standby diesel generating sets rated 11kV will be connected to 22kV bus through 11/22 kV transformers. The switchgear shall conform to the requirements of IS:3427/IEC:298 and 694.

.5 415 Volts Power Distribution Boards

The 415V power distribution boards shall be indoor, metal clad, factory assembled and compartmentalised to house the switchgear. Circuit breakers and other switchgear components shall be arranged in compartments vertically in a multi-tier formation. Each board shall have sufficient number of air circuit breakers for incoming supplies as shown in single line diagram. For supply to various loads, moulded case circuit breaker shall be provided. The interconnection between the unit auxiliary boards, and between unit auxiliary board and station service board, shall be made by means of 415V TPN non-segregated aluminium bus duct.

.6 D.G. Sets

- Two nos. 1000 kVA, 11 kV D.G sets shall be provided for emergency supply to unit and station auxiliaries for black start of the station during failure of the grid.

- For emergency supply at dam site, one no. 250 kVA, 415 V D.G set shall be installed.

.7 Ratings

a) Unit Auxiliary/Station service Transformer

Type	EPOXY cast resin
kVA Ratings/voltage ratio	1000 kVA, 15.75/0.415 kV UATs, & 1000 kVA, 22/0.415 kV SSTs
Impulse withstand voltage for 15.75/22 kV	95 kV (peak)/125 kV (peak)
P.f withstand voltage for 15.75/22 kV	38kV (rms)/50 kV (rms)
Insulation class	F or H
Winding material	Copper
Taps	± 5% in step of 2.5%
Vector group	DY1
Percent Impedance	5%
System Earthing	Solidly earthed
Cooling	AN

b) 22 kV Circuit breakers

Type	Vacuum/SF_6, drawout type
Rated normal continuous current	630 A
Rated S.C. breaking current (rms)	10 kA
Rated duration of S.C. breaking current	1 sec
Rated short circuit making current	25 kA
Rated power frequency withstand voltage	50 kV (rms)
Rated voltage impulse withstand voltage	125 kV (peak)

c) 415 V air circuit breaker

Type	Air insulated drawout type, motor operated

Type of operating mechanism	Spring charged stored energy type
No.of poles	3
Rated voltage/frequency	415V / 50 Hz
Normal current	1600 A
Rated S.C. breaking current	50 kA for 1 sec.

d) 415 V Moulded Case Circuit Breaker

Type	Moulded Case
No.of poles	3 / 1
Rated voltage/frequency	415V/50 Hz
Rated S.C. breaking current	50 kA for 1 sec.
Normal Current	as per requirement

5.3 D.C. SUPPLY SYSTEM

.1 General

The D.C. supply system for the station shall cater to the following types of loads in the Power house and switchyard :

- Continuous loads
  - indicating lights
  - continuously energised coils of relays
  - annunciation loads
- Momentary loads
  - switchgear operations
  - field flashing of generators
- Emergency loads (during A.C. outage)
  - emergency lighting
  - standby D.C. motor loads

.2 Design Consideration

a) While selecting battery capacity size, following factors have been considered :

- Battery load cycle for typical loads as per para 5.3.1
- Compensation for age to account for derating
- Design margin to take care of unforeseen additions to the D.C. system
- Temperature correction factor
- End-of-discharge cell voltage 1.75 volt per cell
- Emergency lighting load for 1 hour
- 8 hour discharge rate.

b) Plante and lead calcium cells have longer life as compared to tubular lead acid batteries and accordingly provision for Plante type / calcium batteries has been made.

.3 Provisions

a) Two sets of 220 V batteries of capacity 1600 AH each have been provided for Power House and switchgear. The battery alongwith their respective float and boost chargers will be installed in Power House battery room.

b) Similarly two sets of 48 V battery of 500 AH capacity each have been provided for communication system. These sets of battery alongwith charger will be installed suitably in the Power House.

c) For DACS one set of battery, 24 volt, 400 AH has been provided. Provision has also been made for 20 kVA capacity UPS for DACS.

d) One main D.C. distribution board has been provided which will have facility for selection and change over of battery.

e) Branch distribution boards with ACB/MCCB incomers and adequate number of outgoing MCCBs of different ratings, as per requirement, shall be provided for each system i.e. 220V, 48V and 24V D.C.

f) Two sets of 20 kVA capacity UPS has also been envisaged for emergency lighting and emergency cooling water system for bearings.

5.4 POWER AND CONTROL CABLES

.1 General Requirement

The following types of cables would be required :-

- 22 kV, 3 core, Aluminium conductor, XLPE insulated, armoured, PVC sheathed cable from 22 kV lines to 22 kV switchboard and from switchboard to station transformers

- 11 kV, 3 core, Aluminium conductor, XLPE insulated, armoured, PVC sheathed cable for connecting diesel sets to the step up transformer (11/22 kV).

- 415 V, power cables (with copper conductor upto 16 mm^2 Cross section and Aluminium conductor over 16 mm^2) of 650/1100V grade, PVC or XLPE insulated, fire resistant low smoke (FRLS), PVC sheathed for feeding motor and other loads as per requirement.

- Multicore, 1.1 kV grade, PVC or XLPE insulated, copper conductor, FRLS, PVC insulated, armoured control cables for feeding control circuits of switchgear, relays etc.

- 650 V, twin copper conductor, 1.5 mm^2, PVC insulated, PVC sheathed, screened, FRLS type instrumentation cables for transducers, RTD and thermo couple devices, communication system etc.

.2 Other Provisions

- Suitable sized cable glands/epoxy termination kits shall be provided at terminating ends as per requirement.

- For routing of cables following arrangement shall be followed :-

i) Cable shall be laid on perforated cable trays mounted on hangers/support on roof/wall/trenches/free standing steel structures. Cable shall be clamped by suitable FRLS PVC coated aluminium strips.

ii) Wherever necessary, GI pipes shall be provided for crossing wall etc. or on walls where cables are less.

- Control and DC cables laid near to SF_6 busduct/GIS shall be shielded, having coaxial type cable glands and have the cable shields grounded at both ends to avoid interference from 400 kV potential.

- In order to minimise magnetic and electrostatic interference, all instrumentation cables shall have twisted pair or triad conductors either individually shielded or having an overall shield as per requirement. Number of Conductors and type of cable will depend on functional requirement of the system.

- Suitable accessories for cable termination i.e. lugs, identification ferrules for individual core, cable identification tags etc as per requirement shall be provided.

  Fire barriers at suitable interval shall be provided.

- FRLS PVC sheathed cables will be conforming to the relevant Indian/IEC Standards in general with the following properties:-

  i) Oxygen index of the outer sheath not less than 30 when tested as per ASTMD - 2863.

  ii) The temperature index of the outer sheath shall not be less than 250°C when tested as per ASTMD-2863.

  iii) Halogen acid content in outer sheath shall not be more than 20% when tested as per IEC-754.

  iv) Smoke generation not more than 60% obscuration when tested as per ASTMD-2843.

v) Swedish Chimney test as per SS 4241475 class F3, and ladder test for flammability as per IEEE 383.

5.5 ILLUMINATION SYSTEM

.1 General

A comprehensive Illumination system for entire plant covering Power House, Transformer/GIS Hall, GI duct tunnel, access tunnel, Ventilation tunnel, surge shaft, B.F Valve chamber, outdoor switchyard area and dam area comprising the following shall be provided :-

- Indoor lighting system
- Outdoor lighting system
- D.C. Emergency lighting system
- Power outlets at various locations

.2 Provisions

a) The Indoor lighting shall mainly cover the following areas:

- Power house cavern
- Transformer/GIS cavern
- G.I. duct tunnel
- Access tunnels to Power house/Transformer Cavern
- BFV cavern and approach adit
- Offices, workshop and stores inside P.H., BFV etc.
- Dam control room
- DG. set rooms for Power house & Dam area
- All galleries in dam area
- Sedimentation chamber gates & adits
- Draft tube gallery and adits

b) The outdoor lighting system shall cover the following areas :

- Outside area of power house access tunnel entrance, approach road to power house upto 300 metres on each side.
- Outdoor switchyard area including approach road upto 300 metres
- Dam road, gates including adjoining reservoir area and working areas.

- Approach roads to dam upto 300 metres on each side.

c) For unimportant areas lower level of illumination as per practice shall be adopted.

d) The normal lighting shall be catered by MCB controlled lighting Distribution boards, which shall be fed from the main station lighting board. The Emergency lighting will get its supply from an emergency lighting board which in turn shall get its incoming supply from the DC Distribution board (220 V) through 20 kVA, 1 phase Inverter/UPS.

e) Ordinary/Decorative Fluorescent tubes, HPMV/Sodium Vapour lamps, Flood lights, tungsten filament lamps and other luminaries with good efficiency shall be provided as per required illumination levels for a particular area.

f) The illumination levels in various areas shall be generally as per IS:3646-1966 (Part 2).

g) 5/15A Convenience outlets shall be provided in various areas of the power station as per requirement. 32 A and 63 A industrial type socket shall also be provided as per requirement.

h) Suitable lighting distribution boards, sub-distribution board and local control board shall be provided in a distributed mode.

i) Illumination level to the tune of 5% of normal illumination level will be provided in case of A.C. failure by D.C. battery.

j) A few emergency lamps working on D.C. shall be provided at important locations i.e. control rooms on continuous basis.

k) Incandescent lamp fitting at suitable point shall be provided in addition to fluroscent tubes/HPMV lamps to avoid total darkness on account of glow up time of such luminaries.

l) Lighting system design shall take into account the values of maintenance factors, co-efficient of utilisation, reflection factors for floor/wall/ceiling etc. The fixtures shall be properly selected to

achieve the desired minimum illumination level specified in standards. The reflection factors for all areas shall be taken as 10/30/30 except for toilets, passage, corridors, stairs etc., for which it shall be taken as 10/50/50. The maintenance factor for transformers hall, control room shall be taken as 0.8 and for remaining areas as 0.7.

m) The road lighting of the complete project area shall be carried out as required using HPSV lamps. The illumination level of roads shall be 10 lux. At crossings and important locations the illumination shall be 20 lux.

n) Loads shall be balanced equally on all the three phases. The starting current shall not interrupt the circuit in case of sub circuits supplying HPSV lamps.

o) For sub-circuit wiring of lighting fixtures and receptacles, 650 V grade single core aluminium stranded conductor, PVC insulated, PVC sheathed, colour coded viz, white for phase and black for neutral wires of size not less than 2.5 sq. mm shall be provided. The cable for sub circuit wiring shall be laid in not less than 19mm GI conduits. However PVC concealed conduits shall be used for control rooms and office areas.

p) All equipments shall be properly earthed using G.I. wire. Earth wire shall run inside along the entire length of the conduit between fixture and corresponding LDB where it will be conducted to station Earth as per relevant standard.

5.6 COMMUNICATION SYSTEM AND PUBLIC ADDRESS SYSTEM

.1 General Requirements

Communication system for the Project shall cover the following means of communication:-

a) Satellite communication system between power house site and head office at Delhi.

b) VHF communication system (MARR) for communication between power house and dam site and between power house and colony.

c) Internal communication system at power house, dam site and the colony.

System shall have facility of both speech and data communication.

Long distances satellite communication system for transmission of speech and data between power house and head quarters shall be provided. This will have provision for two channels out of which one channel will be reserved for speech.

Digital type VHF communication system shall be provided to have reliable communication between power house, dam site and colony. The general arrangement is shown in schematic drawing no. 1200-2132-012 enclosed with the DPR.

EPABX is proposed to be provided for internal communication and to have access to satellite communication/VHF communication/P&T lines. The capacities of the EPABX are envisaged as under:-

- Power house : 96 extensions and 16 P&T lines
- Dam site : 24 extensions and 4 P&T lines
- Colony : 48 extensions and 8 P&T lines.

In power house, public address system is proposed to be provided which will be used for any emergency call, fire instructions etc. The system shall be inter-connected to the EPABX with necessary interface.

System shall be complete with cable distribution network, interface modems and other accessories.

.2 Provisions for Communication system

The following provisions are envisaged for communication system at the Project site :-

a) 2 sets of long distance satellite communication system (one terminal for each end)

Suitable for CFM SCPC channels (with 2.4 m Antenna Reflector) with necessary software and hardware.

b) Digital type MARR VHF communication system having facilities for transmission of two speech and two data channels between power house, dam site and colony, complete with one set of base station unit and required sets of remote radio subscriber unit, directional antenna, feeder cables, power supply units as per drawing no. 1200-2132-012 enclosed.

c) The following EPABX with operator console, Main Distribution frame (MDF) and power supply unit (battery and battery charger) :-

- One (1) set EPABX equipped with 24 extensions and 4 P&T lines for dam site.

- One (1) set EPABX equipped with 48 extensions and 8 P&T lines for site colonies.

- One (1) set EPABX equipped with 96 extensions and 16 P&T lines for Power House complex.

- Required no. (approx 200) push button telephones.

d) The following types of communication cables as per requirement:-

- 0.50 mm x 5 pairs/10 pairs/20 pairs armoured jelly filled underground telephone cables.

- Self-supporting, PVC insulated, B.S.W./Drop wire with fibre glass roving as strength member.

- PVC insulated, single pair, twin, indoor type V.F. cable.

e) Three (3) sets of UPS, 3 kVA with 2 hour battery back-up.

.3 Public Address System

A public address system for fire/emergency warning in the Power House comprising the following is envisaged for the Project :-

i) One (1) Power amplifier station for public address system with radio, cassette tape and record player and power supply unit, rated 240 V, 50 Hz.

ii) One (1) Master Control Unit with microphone, mixer and selection panel for public address system.

iii) Fifty (50) loud speakers indoor type for public address system.

iv) Five (5) Loudspeakers outdoor type for public address system.

Complete set of cables, fixing and erection material, tools, handling devices, testing instruments etc. for erection, testing and maintenance of the complete system shall be provided.

5.7 EARTHING SYSTEM FOR POWER HOUSE, OUTDOOR SWITCHYARD AND DAM

.1 General

For System grounding, the earthing system shall mainly consist of two independent earthing system corresponding to respective geographical areas comprising:

a) An earthing grid of Mild Steel conductors buried in the ground in Power House, Transformer/GIS Cavern, extended suitably as required in the areas of draft tube, collection chamber and tail race.

b) An earthing grid of M.S. conductors buried in the ground in outdoor switchyard and adjoining area.

The two earthing systems shall be interconnected.

.2 Method of Earthing

A suitable ground grid shall be provided for grounding of equipments and structures maintaining the step and touch potentials. An earthmat would be laid in and around the power station. This mat would be buried at a suitable depth below the ground and provided with ground electrodes/ conductors at suitable spacing. All metallic parts of equipment supposed to be at earth potential will be connected to the

ground mat. Buildings, structures, plant rail road tracks, the perimeter fencing etc. will also be connected to the grounding mat.

.3 For equipment grounding, an interconnected above-ground/above-floor main earthing network at the power house, GIS, Switchyard, the dam and to other places where needed shall be laid. From this network the earthing conductor shall be run to all machinery, equipment and other parts which are to be earthed by vertical risers and horizontal runners.

.4 Provisions

a) The earth system shall provide:

i) Adequate protection of personnel against dangerous voltages, current and arcs.

ii) Safe touch and step voltages.

iii) A low earthing impedance for the transformer neutrals and the generator neutrals, and a sufficiently low neutral conductor impedance.

iv) Limitation of the induced, or capacitively transformed voltage on low-voltage, weak current and electronic cables, circuits, panels and other equipment.

v) Short-circuit, earth-fault and double earth-fault currents will flow through the earthing system and not through other conducting parts or building constructions to a hazardous extent.

Provisions of IEEE 80/1986 shall be followed where applicable in design of earthing system.

b) The earth-electrode system as well as other earthing network shall be designed and constructed for the operating voltages, having short-circuit capacities corresponding to short-circuit and earth-fault current levels.

c) The earthing conductors shall be dimensioned for carrying earth-fault current in any of the plant for at least 1 (one) second without any harm to the conductors. Earth conductor in ground shall be welded with each other.

d) Suitable earth resistivity test stations in power house and switchyard shall be provided.

e) The earthing system shall be designed to comply with the requirements of the applicable standards and connected equipment.

5.8 ELECTRICAL TEST LABORATORY EQUIPMENTS

The Power House shall have an electrical test laboratory equipped with following equipments and testing devices :-

.1 Workshop Tools Comprising but not limited to the following :

- Stationary drilling machine
- Electrical hand drilling machines of different capacities and speeds
- Double grinding machine
- Electrical hand piercing saw
- Portable welding transformers
- Resistance brazing set for stator coil ends
- Crimping tool - Manual and hydraulic
- Standard tool comprising wrenches, screw drivers, box spanners
- Coil winding machine
- Short circuiting devices (25 mm^2 copper) etc.

.2 Testing and Measuring Instruments Comprising but not limited to the following :

- Voltage testers
- DC Insulation testers, 0-500 mega ohms
- AC Insulation testers, motorised 0-7500 mega ohms, 1 kV-5kV
- Portable universal bridge
- Multimeters (AC & DC)
- Universal Digital voltmeter and frequency meter
- Phase sequence and Phase Angle meters

- Portable temperature measuring instruments
- Portable vibration meter
- Portable earthing resistance measuring devices
- Hook on Volt-ammeter
- Vibration cum balancing equipment
- Portable dual beam CRO
- U.V. Recorder
- High Voltage AC testing set, 500 kVA, 50 HZ, 0-40 kV
- High Voltage DC testing set, 0-80 kV
- Cables and Instruments for field checking of transformer turn ratios
- Universal laboratory work bench fitted with general purpose measuring instruments, indicating lamps, switch socket, push button etc.
- Oil testing kit BDV 0-100 kV
- Primary and Secondary Current Injection set for relays
- Tan delta measuring equipment
- V.F/H.F transmitter and measuring set for PLCC
- Miscellaneous instruments like Hydrometer, Anemometer, pH meter, Vacuum tester, thermo scanner, partial discharge detector, Earth/ground tester, Battery Condition monitoring device etc.

Chapter - 6

MECHANICAL AUXILIARIES

6.1 GENERAL

The mechanical operational and maintenance auxiliaries envisaged for the station are discussed below.

6.2 E.O.T. CRANES

.1 Power House E.O.T. Cranes

To facilitate erection of generating plant equipment and subsequent maintenance in power house cavern, two nos. class 2, electrically operated overhead travelling cranes of 275 t capacity main hoist, 40 t auxiliary hoist and 10 t mono-rail hoist for a span of 20.2 m, shall be provided. Both the cranes shall be coupled for tandem operation for handling of generator rotor, the weight of which alongwith lifting beam is estimated as 540 tonnes.

The vertical movement of the hoists shall be adequate for handling all equipment from the lowest point in the Power House.

Both main and auxiliary hoists shall be provided with creep drive for operation at 10% of speed of respective hoists.

Main hoist and auxiliary hoists shall be mounted on the trolley running on the bridge girder and the 10 t mono-rail hoist with beam and control shall be hung from the underside of the bridge, to provide larger end reaches. The bridges shall be of box girder structure. The girder shall be in more than one section depending on the transport limitation.

The main hoist shall have a double hook of Ramshorn type, whereas the

auxiliary and mono-rail hoist hooks shall be plain shank type with a safety latch

All motions shall be provided with limit switches at extreme ends of travel on both sides.

The Master controllers shall be located in the operator's cabin.

.2 BFV Cavern E.O.T. Crane

One no. E.O.T. crane of 65/5 t capacity suitable for 9.2 m span, with features similar to the main Power House Crane, shall be provided in the B.F.V. Cavern for installation and maintenance of penstock Butterfly Valves.

.3 GIS Cavern E.O.T. Crane

One no.E.O.T. Crane as described above but with single hook having 10 t capacity, 14.7 m span, controlled from floor through pendant push button shall be provided in the GIS Cavern for installation and maintenance of 400 kv gas-insulated switchgear bays.

.4 Hoists

In addition to the above, suitable hoists will be required for installation of SF_6 bus duct (in shaft tunnel), drainage dewatering pumps, CWS etc. A 10 ton hoist is also to be provided in transformer hall for handling small parts of transformer. These shall be provided as per requirement.

6.3 POWER HOUSE, DAM SITE AND CABLE LIFTS

.1 Power House Lift

One no. 10-passenger (680 Kg.) lift with 7 landings from El.1497 to El.1526.5m shall be provided in the Power House to serve all the floors

between valve gallery and the top floor level. The lift shall be complete with landing doors, structural steel car, wooden PVC lined floor, control and operating machinery, guide rails, counter weights, anchor bolts, embedded parts, safety devices, alarms, lighting etc.

The lifts shall be suitable for operation at 415 V, 3 phase, 50 Hz supply and have D.C. thyristor control.

The lift shall have modern aesthetically pleasing appearance. All motions shall take place smoothly and positively with no slippages, jerks or vibrations.

.2 Dam Lift

One no. 10-passenger (680 Kg), passenger cum freight elevator having three landings shall be provided for the dam to serve all galleries from foundation gallery to the top of the dam. Total lift travel is from El.1769.5 m to El.1813.0m. The lift shall have features for protection against moisture.

.3 SF_6 Duct Shaft Lift

This lift will be suitable for 2(two)-passengers and will serve from El.1552.0m to El.1845.0 with landing platform at each 18 meters (i.e. 17 landings). General arrangement of lift is shown in drawing number 1200-2131-013.

6.4 COOLING WATER SYSTEM

.1 Provisions

a) Cooling water system shall meet the cooling water requirements of the generator air coolers, upper guide bearing, thrust and guide bearing, turbine guide bearing, turbine shaft seal, transformer coolers and ventilation and air conditioning system at a suitable pressure and

maximum temperature rise of 5°C. Estimated cooling water requirement for each unit is as under :

General Air Coolers	:	150 lps
Thrust and Guide Bearing Coolers	:	40 lps
Transformer Coolers	:	55 lps
Governor shaft seal etc.	:	5 lps

b) The proposed system envisages tapping of cooling water from draft tube tunnel of each unit. Cooling water from draft tube tunnel will be tapped through M.S. pipes. Suitable capacity strainers, pumps, filters shall be provided.

c) General schematic of cooling water system as envisaged is given in drawing no. 1200-2132-011 appended with the DPR.

The system shall provide 100% redundancy operation of the unit pumps with Cooling water requirement of one unit being met with by one pump and the second pump of the unit acting as standby. Cooling water after passing through pump delivery and cyclone separator/filtration system shall be distributed through a common header feeding the requirement of each unit. The water after passing through the cooling circuit shall be discharged into the collection chamber at El 1521 m.

Filters and strainers shall be designed for 1½ time unit capacity. A cyclone separator having capacity equivalent to 375 lps shall be provided for silt free water to the various cooling circuits. The header shall be provided with sectionalizers arranged to meet the cooling water requirement of any unit with any pump in operation. The duplex basket strainers shall be installed on the suction side of the pumps.

Reversal of the flow arrangement shall be made for cooling circuits i.e. generator air coolers and bearings. For others flushing facility is envisaged. Flow measuring devices and instruments shall be provided for each circuit as indicated in the drawing 1200-2132-011.

A tapping shall be provided on the main header for feeding water into a fine filtration plant for supply to shaft seal. The fine filtration plant shall be of sand bed pressure filters, or any other suitable type, to provide clean water for the shaft seal. The system shall have back flushing facilities.

Motorized control valves shall be provided in supply/discharge line of each unit which shall open on signal to start of that particular unit.

Temperature detectors, flow meters, flow indicators as per schematic PID drawing 1200-2132-011 shall be provided in each unit header.

Wedge gate valves, non return valves, flow control orifice plates, vents etc. shall be provided wherever sectionalisation, isolation, check and flow control is required. Test tapping for fixing pressure gauges shall be provided in each branch circuit as per P.I.D. drawing enclosed.

Piping shall be complete with adequate number of bends, elbows, tees, vents, gaskets, bolts, nuts and washers and other hardware necessary for completion of piping.

.2 **Requirement**

As per preliminary design, the following equipment is envisaged for the Cooling water system :

a) Eight (8) nos. centrifugal or vertical turbine pumps for cooling water supply to the four (4) generating units alongwith suction piping, valves, non-return valve, Motor, Starter Cum Control panels with provision for remote control etc. directly installed on the header at El 1502 m connected to downstream water reservoir having maximum and minimum water levels as 1510 m and 1519.5 m respectively. The tentative ratings are as follows :

Pump Capacity	=	250 lit/sec
Gross Head	=	32 m

Suction Head	=	1.5 m to 13.5 m
Delivery Head	=	33.5 m

b) Eight (8) sets of duplex strainer, rated capacity 375 lit/sec, suitable for removing foreign particles above 200 microns size. The strainers shall have stainless steel baskets of sufficient area and shall have provision for changeover from one strainer to the other through changeover valves. The strainers shall have provision for cleaning by back flushing operation. The system shall be complete with necessary valves, pressure indicators, differential pressure indicators etc.

c) Cyclone separator suitable for 375 l/sec capacity, 3 kg/cm² pressure having provision for automatic filtering of the solid particles in water to about 50 microns. Separator will have facility for automatic flushing out of the solids. The Separator shall be complete with :-

- Booster pump
- Flanged inlet and outlet connections
- Pneumatic or other suitable continuous bleeding/purging system.

d) Fine filtering system for shaft seal

Complete set of M.S. Welded (piping), cast steel wedge gate valves, Cast steel non return valves, Pressure reducing valves, instruments compatible to DACS (where applicable), special tools, devices for assembly, dismantling and testing shall be provided to complete the system.

6.5 DRAINAGE AND DEWATERING SYSTEM

.1 General Design and Requirements

.1 Dewatering System

General arrangement for the dewatering system envisaged is shown in

schematic drawing no.1200-2132-006 enclosed with the DPR.

Dewatering header shall be laid in dewatering gallery at an elevation of 1889.0m. Each draft tube shall be interconnected to the header by a valve operated from the valve floor. i.e. El.1490.0m. The header terminates in a dry sump at erection bay end of the cavity. Three suitable capacity vertical turbine pumps shall be installed in the sump at El.1511.0m to dewater in 3 hours. Two pumps one main and one standby will be used to discharge water through a common header to the collection chamber. Third pump shall act as emergency pump and will be used for dewatering when tail water level is high.

Provision is made for discharge into wet pit when draft tube pressure drops.

Gate valves, check valves and flap valves shall be provided as per requirement.

.2 Drainage System

The drainage system proposed has been schematically indicated in drawing no. 1200-2132-005 enclosed with DPR.

It is envisaged that any leakage from rock face upto El.1516.0 will be routed to sump at El.1515.0. From this sump drain water will be routed by gravity to collection chamber. The sump will have two submersible pumps/centrifugal pumps to pump water to collection chamber if tail water level is high.

The above sump will also cater for transformer cooling water discharge.

Drainage from rock faces/tunnel below 1516.0m shall be routed to drainage sump/wet pit of drainage/dewatering sump. Capacity of the pump is based on following:

i) Rate of seepage flow in underground cavern and tunnels @ 1 lpm/6 sq.m. of projected wall face areas.

ii) Pumps will be designed for 100 percent leakage flow.

iii) Pumps will have sufficient capacity to cater 100 percent discharge of shaft gland etc. under normal operating conditions.

iv) Duty cycle of the pumps shall be 30 min on - 30 min off.

One pump will work as main and other as standby. One emergency pump will also be provided.

Submersible or vertical turbine pumps of adequate discharge and head will be provided.

The operation of the pumps and level control of the sump shall be monitored by data acquisition and system control and all instrumentation shall be DACS compatible.

Complete piping work shall be properly supported on supports, anchors, brackets and frames as per requirement and all hardware gaskets and packing shall be provided. The pump-motor shall have a rating of 1.1 times the rated capacity.

The pump will withstand corrosion and wearing by abrasive motors within reasonable limits.

The submersible pump and motor will be contained in the same casing and designed as a package unit with incorporated suction strainer. The flow channels will preferably be epoxy lined.

On one pump, performance test shall be conducted as per relevant standard.

.2 Provisions

- Based on preliminary design the requirement of drainage and dewatering system works out as follows :

  a) Dewatering Pumps
     - 2 nos, 30,000 LPM vertical turbine pumps suitable for a head of 26.5m.
     - 1 nos 30,000 LPM, vertical turbine pump, suitable for a head of 32m.

  b) Drainage Pumps
     - 2 nos, 25000 LPM centrifugal pumps suitable for a suction and delivery head of 6m and 11m respectively (for transformer hall drainage sump)
     - 3 nos, 5000 LPM vertical turbine pumps, suitable for a head of 27 to 34m (for Power House drainage sump).

- The drainage and dewatering system shall be provided with the following:

  - Flanged welded M.S. pipes complete with gaskets, bends, elbows, tees, bolts, washers and other hardware material
  - Suitable pipe supports, hangers, structural steel etc.
  - Cast steel wedge gate valves
  - Cast steel non-return valves
  - Level control, auto start stop control system compatible with DACS for wet sumps
  - Pressurestat for dewatering header
  - Starter panels suitable for remote monitoring and control
  - Instruments comprising level transducers, flow relays, manometers etc. Compatible with DACS
  - Mono-rail hoists of adequate capacity for handling of pumps during erection, maintenance
  - Tools, devices for installation and maintenance of the pumps and spares for 5 years normal operation.

6.6 VENTILATION SYSTEM

.1 General

.1 The ventilation system proposed for the station shall generally be as per schematic drawing nos. 1200-2132-009.& 010 enclosed in DPR.

.2 The ventilation system shall maintain workable temperature and humidity conditions within the power house cavern and non air-conditioned area of power house. The normal air temperature in the power house shall be between 25°C and 32°C at a maximum relative humidity of 60%. Proper air-changes as per relevant standards shall be ensured at all working places in the power house.

.2 Provisions

.1 Air Intakes

- A fresh air intake having capacity of about 5,25,000 cu.m./hr. shall be made at the entrance of construction adit to power house/transformer hall. In the air intake, provision will be made for inlet air control louvres and air filter.

  Fine filters of 4,00,000 cu.m./hr. capacity shall also be provided before coolers in power house blower room and fine filter of 1,30,000 cu.m./hr. shall be provided before coolers in transformer/GIS hall, blower room.

- A fresh air intake having capacity of about 25,000 cu.m./hr. shall be made in the blower room at adit to collection gallery. In the air intake, provision will be made for inlet air control louvres and air filter.

- A fresh air intake having capacity of about 25,000 cu.m./hr. shall be made in the blower room at adit to BFV chamber. In the air intake, provision will be made for inlet air control louvres and air filter.

.2 **Blowers**

- One blower room shall be provided at El 1530.5 m on the top of the control block. The blower room shall have fine air filters, heat exchangers for cooling the fresh air and 3 no. blowers of 2,00,000 cu.m./hr. capacity each. Out of the three blowers, two blowers will normally work and the third will work as standby. The air shall be distributed to the various floors in power house, control block and bus duct galleries through a network of air supply ducts having adjustable dampers etc.

- Transformer hall blower room shall be provided at El 1526.0 m on the GIS floor. The blower room shall have fine air filters, heat exchangers for cooling the fresh air and 3 no. blowers of 65,000 cu.m./hr. capacity. Out of the three blowers, two blowers will normally work and the third will work as standby. The air shall be distributed to the GIS floor, transformer cabins and gallery through a network of air supply ducts having dampers etc.

- One blower room shall be provided at El 1540 m near the adit of collection gallery tunnel. The blower room shall have fine air filters and 2 no. blowers of 25,000 cu.m./hr. capacity. Out of the two blowers, one blower will normally work and the other will work as standby. The air shall be distributed in the collection gallery through a network of air supply ducts having dampers etc.

- One blower room shall be provided at El 1667 m near the adit of BFV chamber. The blower room shall have fine air filters and 2 no. blowers of 25,000 cu.m./hr. capacity. Out of the two blowers, one blower will normally work and the other will work as standby. The air shall be distributed in the BFV chamber through a network of air supply ducts having dampers etc.

- Exhaust blower room for smoke from P.H. cavity shall be provided at El 1537 m near the power house tunnel adit. The blower room shall have 2 blowers each of 25,000 cu.m./hr. capacity. Out of the two

blowers, one blower will normally work and the other will work as standby. Exhaust duct shall be laid in arch portion of power house cavity and connected through an exhaust duct to exhaust blowers.

- Exhaust blower room for smoke from Transformer Hall cavity shall be provided at El 1845 m near the outdoor GIS room. The blower room shall have 2 no. exhaust blowers of 25,000 cu.m./hr. capacity. Out of the two blowers, one blower will normally work and the other will work as standby. Transformer cabins will be interconnected through common duct and interconnected to exhaust blowers through shaft. Dampers in transformer hall shall be remote controlled and, in case of fire, dampers in other cubicles will close to prevent spread of smoke.

.3 Instruments Comprising Digital and Analogue type Anemometer, Hygrometer etc. shall be provided for monitoring.

.4 Cooling water piping comprising M.S. Pipe, Valves, bends, elbows, tees etc as per requirement of the system shall be provided.

.5 The system shall be provided with all the necessary control equipment for automatic unattended operation and, particularly, for automatic setting of air-changes and over pressure in accordance with the ambient inlet temperature of air, tools/devices and spare for 5 year normal operation.

.3 Design Requirement

.1 Air velocities shall not exceed 2.5 m/s in the inlet, 5 m/s in the supply points and 3 m/s at the exhaust.

.2 The blower fans shall be centrifugal type backward curved fans conforming to AMCA code and complete with TEFC squirrel cage induction motor.

.3 Motor shall be provided with necessary starter panel having provision for remote control.

.4 A gravity type Damper shall be provided at the outlet of each fan.

.5 Supply air grills/diffusers shall be of GI sheets complete with individual adjustable type volume regulating damper and designed for air discharging velocities of about 250 to 300 m/min.

.6 Inlet/Exhaust air grills/diffusers shall be of GI sheets (equal to duct gauge for louvres) but without volume regulating damper designed for air inlet velocities of about 160 to 230 m/min.

.7 The main damper for intake of fresh air, installed at the switchyard end of ventilation tunnel shall be remote control motor operated type, complete with necessary electric operated damper motors, linkages and local/remote control and push buttons.

.8 The Filter at inlet end of ventilation tunnel shall be double layer of 1/16" square mesh GI with M.S. mounting frame.

.9 Dry and washable panel type metallic air filters 50 mm (2") thick of approx. 600 mm x 600 mm (24" x 24") size panels designed and made from several layers of 1/16" square mesh GI wire screens complete with M.S. mounting frame shall be provided in front of ventilation fan in the collection chamber, transformer/GIS Hall and BFV chamber.

.10 Remote controlled dampers shall be provided in exhaust duct at each transformer hall cavity opening. In the event of fire, these dampers shall automatically close.

.11 Battery and sanitary rooms shall be ventilated from the system but exhausted through separate duct work.

6.7 AIR CONDITIONING SYSTEM

.1 General

.1 The Air Conditioning equipment shall be installed in the control block at El.1522.5m.

.2 The air-conditioning system shall provide conditioned air in power house control room and office area located in the power house. The system shall be designed to maintain a temperature of 24° ± 1°C at relative humidity of 50% + 5% in all the air conditioned areas.

.3 During the winter season when the temperature is below 24°C heating requirement in the control rooms and offices shall be met with by a combination of duct heaters and base board heaters.

.4 The system shall draw fresh air from power house ventilation system.

.5 The motor operated air dampers shall be provided in the main duct to prevent the circulation of smoke in the event of fire. Suitable type of smoke / fire detectors will be installed in the ducting at the required locations to control the dampers and initiate an alarm in the control room.

.6 In determining air conditioning load (TR) equipment heat load shall also be taken into account besides lighting and transmission gain.

.2 Provisions

The following provisions are envisaged :

.1 Three nos. 20 TR nominal capacity, (2 main and 1 standby) condensing units comprising reciprocating compressor driven by motor and 1 no. condenser shall be provided. This condensing unit shall be connected to AHU through M.S. refrigerant piping. The Compressor motor units shall be sealed type.

The units shall be complete with necessary supply and return air grills, strip heater fixing for winter heating.

Cooling water shall be supplied from the station cooling water system.

.2 GSS ducting with supply and return air grills, duct insulation, hangers etc. shall be provided, complete in all respects to cover an area of about 1000 sq.m. on two floors.

.3 Cooling water inlet and discharge piping complete with unions/flanges, hardware, gaskets, vents, hangers/pipe supports, isolating valves etc. shall be provided.

.4 Electrical control panel comprising starters and necessary controls for local/remote operation, special tools, test devices etc. for installation, testing, commissioning and dismantling etc. and spares for 5 year normal operation shall be provided.

6.8 STATION COMPRESSED AIR SYSTEM

.1 General Requirement

.1 Station compressed air system for the power house shall be equipped with low pressure air compressor system for station services and generator braking system. The system shall have a nominal pressure of 7 to 10 bars and will meet the service air requirements for:

- operation of pneumatic tools during maintenance
- service air for cleaning and misc. use
- for generator braking system
- for air pilot lines for fire protection system and instrument air
- for purging operation of cyclone separator etc.

.2 The main L.P. air header shall be laid on each floor of power house. Suitable no. of air tapping points shall be taken on upstream and

downstream sides in front of each unit and at other places for use of service air for cleaning.

.3 Adequate no. of tapping shall be provided in the erection bay, transformer cavern, access tunnels, GIS room etc.

.4 Two identical electrically driven compressor units with motor, starter, base plate air dryer, suction silencer, cleanable air filter, pressure gauges, check valves, unloader valves, isolating valves, complete control system etc. shall be provided.

.5 The control system shall provide for the following:-

- Selector switch for manual/automatic operation
- Selector switch for compressor no. 1/2
- On/Off push buttons and indications for compressor unit 1
- On/Off push button & indications for compressor unit 2
- High & Low pressure alarms

.6 The air receiver of adequate capacity shall be designed and constructed in accordance with ASME pressure vessel code. The Air receiver shall be provided with:

- One hermetically sealed manhole
- One safety valve
- Pressure gauges, pressure switches etc.
- Necessary relays for operation of compressors.

.7 Suitable snap connection hose coupling shall be provided.

.2 Provisions

The following provisions are envisaged

.1 Two (2) nos. compressor units, pedestal mounted, 122 cfm capacity and 10 kg/cm^2 pressure, complete with motor, starter control panel, inter

connected piping, valves, safety devices, gauges, indicating instruments, suction filter, air dryer, moisture separators, couplings, non return valves etc. shall be provided.

.2 One (1) air receiver of 3 m^3 capacity complete with pressure switches, safety relief valves, isolating valves, moisture trap, indicating instruments etc. shall be provided for storing the pressurised air.

.3 One (1) set piping, fittings, supports/hangers, valves, tapping points suitable for quick coupling, for entire power house area, access tunnel etc. along with special tools and devices for assembly and dismantling of compressor units and spares for 5 year normal operation shall be provided.

6.9 FIRE PROTECTION, DETECTION AND ALARM SYSTEM

.1 General Requirement

.1 The fire protection system shall be designed as per the requirement of Tariff Advisory Committee of India. Wherever TAC Rules do not exist relevant NFPA (USA)/FOC (UK) Rules will be followed.

.2 The following systems are envisaged for the fire protection of the power station areas:-

- **Fire Water Reservoir and Pump House**

  A water storage tank of 600 cu.m. at El 1581-1600 m shall be provided to meet the requirement of fire water as shown in schematic drawing no. 1200-2132-008 enclosed.

  Two pumps of 6000 lit/m capacity shall be installed to fill water in the tank. The water shall be pumped from the tail race. The pump tank shall have two sections which will be interconnected as indicated in

the drawing. The size of tank has been selected based on hydrant and emulsifier fire protection requirement as under :-

Hydrant @ 171 m^3/hr for 2 hrs	=	340 m^3
Transformer @ 150m^3/hr for 30 min	=	75 m^3
Total	=	**415 m^3**

Considering filling margin, 600 m^3 capacity has been adopted

- **Hydrant System**

Hydrant system shall comprise piping, indoor and outdoor hydrants, valves, instrumentation, hoses, nozzles and other necessary fittings covering the entire power station area including ancillaries and buildings of the power station.

- **High Velocity Water Spray System**

Automatic/manual high velocity water spray system shall be provided for all the transformers located in transformer hall, turbine oil tank and lube oil purification system.

- **Medium Velocity Spray System**

Automatic/manually operated medium velocity spray system shall be provided for cable galleries. The tanks shall also be provided with fixed foam injection system internally.

- **Fire Alarm System**

A computerized addressable analog type early warning system shall be provided throughout the power plant. Following type of fire detection system would be employed:

a)	Control room, control equipment room etc.	Ionization and photo-electric type smoke detectors.
b)	Cable areas	Ionization and photo-electric type smoke detectors, linear heat sensing cables.

The above systems shall be designed as per the recommendations of Tariff Advisory Committee (TAC) of Insurance Companies of India or wherever TAC rules are not existing, relevant NFPA-USA, FOC-UK rules shall be followed.

- **Portable Fire Extinguishers**

Portable and mobile fire extinguishers of CO_2 type, foam type, dry chemical powder type, BCT type shall be located at strategic locations throughout the plant.

- **Partition Wall**

Fire barrier walls, fire proof doors and cable penetration seals of suitable rating shall be provided to isolate/segregate the fire zones.

- **Fire Station Services**

A fire station shall be located near the plant area. The station shall be provided with 1 no. each of water type fire tenders, 2 nos. fire jeeps (four wheeled drive), 4 nos. fire suits, 10 nos. breathing apparatus, first aid kits, telescopic ladders, fibre glass fire blankets and facilities for drill of fire squad.

.2 Design and Operation

.1 The system shall consist of M.S./cast steel pipes water distribution system kept charged by an overhead water storage tank of about 600 cu.m.

capacity. The overhead tank shall be filled by pumps. The second pump shall act as standby. The capacity of each pump shall be 273 m^3/hr which is standard TAC Rating.

.2 The water distribution system shall extend throughout the power house/transformer gallery and GIS room. The water system shall also supply water to hose stations for providing general protection to the power house, transformer gallery, G.I.S. room and outdoor switchyard areas. Wet pipe sprinkler system shall be provided. Each sprinkler system shall consist of electrically monitored isolating valves, normally wet distribution piping, flow switch and sprinkler which automatically activate at rated temperature.

.3 Hand held portable extinguishers shall be located at each hose station at various elevations in power house, transformer room, G.I.S. room and access tunnels etc. Various types of portable extinguishers shall be selected depending on specific requirements.

.4 The capacity of the overhead water storage tank shall be sufficient to hold water for 4 hours for the largest single demand of deluge flow or 600 cu.m., whichever is higher.

.3 Provisions

The following provisions are envisaged for the fire protection system :

.1 One (1) no. overhead tank of 600 cu.m. capacity complete with fittings, overflows, drain pipings, valves and fittings, level switches etc. along with two (2) nos. water pumps of 273 m^3/hr, 105m head capacity complete with motor, starter panel, piping, fittings, valves, controls, pressure gauges, pressure switches, flow switches etc. for its filling.

.2 Thirteen (13) nos. mulsifier systems complete with deluge valves, pilot valves, detectors, nozzles, control panel, spray piping, valves, fittings etc. suitable for 93 MVA single phase transformer (L x B x H = 6.5 x 4.0 x

9.0). Provision shall be made to cover roof and walls of transformer hall cavity also. One (1) set of water distribution piping from overhead tank to transformer water spray system shall be provided.

.3 Four (4) sets of fire hydrant and control system for generators alongwith necessary piping, fitting, valves, hydrant cubicle with alarm system, auto/manual control deluge valve.

.4 One (1) set fire fighting hydrant system complete with hose cabinets, hose pipes, quick coupling unions, isolating valves, hose racks, spanners, piping, valves, fittings etc. for power house, transformer cavern, GIS room, switchyard area, diesel engine room etc.

.5 One (1) set of portable fire extinguishers comprising the following shall be provided :

Halon F.E./CO_2 F.E.	2 kg capacity
Halon F.E./CO_2 F.E.	5 kg capacity
CO_2 F.E.	9 kg capacity
Dry chemical powder F.E.	10 kg capacity
Foam type F.E.	50 litre capacity
Soda acid F.E.	9 litre capacity

.6 Thirteen (13) sets 2 m x 2.4 m fire doors for the transformers having 1½ hour fire survival capacity. Door shall have provision for automatic closing in the event of a fire or manual control. Fire detectors shall be provided to close the door as well as initiate suitable alarm.

.7 One (1) set of fire alarm system as per para 9.1.2 comprising smoke detectors (covering an area of about 10,000 sq.m. divided in about 20 fire alarm zones), zone indication and alarm panel, relays, power supply battery back up, cables and other associated equipment/ accessories shall be provided.

.8 One (1) set of special tools, devices, instruments for assemblies, testing of the system, spares for 5 year normal operation shall be provided.

6.10 OIL HANDLING SYSTEM

.1 General

.1 The station type oil handling equipment shall be installed outside the cavern to avoid any fire hazard in the power house. An oil handling area with the purification plant for Insulating/lubricating oil will be set up near the portal of the access tunnel/potyard area. Oil purification will be carried out in this area before transporting it into the power house for filling in the equipments. Mobile tanks for carrying oil into and out from the power house shall also be provided.

.2 Station type insulating oil treatment plant shall be complete with strainer, feed pump, thermostatically controlled heaters, edge filter, vacuum chamber, ionic reactor column, vacuum pump, discharge pump, control panel, instrumentation and all accessories and be capable of providing clean filtered oil after single pass having the following characteristics:

Gas Contents	less than 0.1% by volume
Moisture content	less than 5 PPM
Suspended particles size	less than 1 micron
Dielectric strength	35 kV/mm
Power factor (Tan delta 90°C)	0.0005

.3 Centrifugal oil purifier shall be provided for governor/bearing lubricating oil.

.2 Provisions

The following provisions are envisaged for the oil handling system :

.1 One (1) no. outdoor station centrifuge type governor/lubricating oil purifier of 10,000 LPH capacity to purify the complete oil in less than 24 hours,

complete with motorised pumps, electric heaters, thermostatic control, instruments, starters panel etc.

.2 Two (2) nos. oil storage tanks of 40 cu.m. capacity for lubricating oil complete with manhole with hermetically sealed cover, oil inlet and outlet pipe connections, connection for oil purification and drying equipment, drain connections, level gauges, piping for interconnection shall be provided. The oil tanks shall be painted inside and outside with oil resistant paint after degreasing and sanding.

.3 One (1) no. mobile centrifuge type lubricating oil purifying unit of 5000 LPH capacity suitable for centrifuging above oil volume in less than 8 hours. Unit shall be complete with all associated accessories, oil pump, oil heater, thermostatic control, discharge pump, control panel, piping, fittings, 2 nos. flexible pipes with fittings 20 m long etc.

.4 One (1) outdoor station type insulating oil treatment plant of 4000 LPH capacity complete with feeding pump, oil heater, thermostatic control, filtering compartment, vacuum pump, dehydrating compartment, discharge pump, control panel, piping, fittings, etc. for treatment of transformer oil within a reasonable time.

.5 Two (2) mobile insulating oil treatment plants of 4000 LPH capacity complete with feeding pump, oil heater, thermostatic control, filtering compartment, vacuum pump, dehydrating compartment, discharge pump, control panel, piping, fittings, etc. for treatment of transformer oil within a reasonable time.

.6 Two (2) nos. oil storage tanks of 10 cu.m. capacity for insulating oil complete with manhole with hermetically sealed cover, oil inlet and outlet pipe connections, connection for oil purification and drying equipment, drain connections, level gauges, piping for interconnection etc. shall be provided. The oil tanks shall be painted inside and outside with oil resistant paint after degreasing and sanding.

.7 Two (2) nos. mobile oil transfer pumps for filling the clean oil in drums for transfer to tank/unit.

.8 Two (2) nos. mobile oil tankers of 5 to 10 cum. capacity with provision for towing of the tanker on wheels.

.9 One (1) set special tools, devices etc. for assembly and dismantling of various components of oil handling system and spares for 5 years normal operation.

6.11 MECHANICAL WORKSHOP

.1 General

A mechanical workshop shall be provided in the Power House at El.1515.0m for routine maintenance work.

.2 Provisions

The provision of following machines is envisaged for the mechanical workshop:

.1 One (1) no. each universal milling machine for horizontal and vertical milling with table size suitable for machining of guide vanes (length about 1.5 m) complete with all accessories including arbors, vices, rotary tables, tools and tackles etc.

.2 One (1) no. hollow spindle centre lathe with bed suitable for turning of guide vanes (length about 1.5 m) complete with travelling and fixed steadies, taper turning attachment 3 and 4 jaw chucks, dead and live centres, change wheels for metric threads, tools and tackles, accessories etc.

.3 One (1) no. hollow spindle centre lathe with bed length of 1200 mm and swing over bed of 390 mm diameter, with travelling and fixed steadies, 3

and 4 jaw chucks, dead and live centres, change wheels for metric threads, tools and tackles, accessories etc.

.4 One (1) no. shaping machine with table suitable for guide vanes with vices, tools and tackles, accessories etc.

.5 One (1) no., radial drilling machine suitable for 40 mm diameter capacity complete with vices, chucks, tilting table tapping attachments, tools and tackles, accessories etc.

.6 One (1) power hacksaw of capacity 210 mm diameter with adjustable angle vices, automatic cutout, coolant system etc.

.7 One (1) no. double ended pedestal grinder suitable for 300 mm diameter wheels, front and hide work rests eye shield, wheel guards etc.

.8 Two (2) no. mobile welding generators of 400 Amp capacity complete with welding leads, welding holders, welding helmet, goggles, electrode oven etc.

.9 Two (2) nos. brazing set suitable for brazing copper strands of stator winding.

6.12 PLANT HANDLING EQUIPMENT

For transportation of heavy equipment i.e. transformers, stator segments, runners etc, special provisions are necessary. All equipment from sea port / Ex-works India will be transported to Kalka by Rail or Road. Kalka will be main trans shipment point. Thereafter all equipment shall be transported to site stores to be established near power house site. From site stores, equipment will be sent to power house erection bay/switchyard as per requirement. Because of hilly road with sharp curves, bends, special low bed trailers, high bed trailer, cranes for loading and unloading shall be required as under :

a) 120 Ton low bed trailer and 160/200 ton tractor Unit:

A tractor of 120 ton pay load with tractor unit for pulling trailer having 160/200 ton pulling capacity for the steep gradients involved is proposed to be provided. The trailer will have following features :-

- Low deck having about 650 mm deck height.
- Jeep Dolly for interconnection to tractor unit.
- Hydraulic operated type goose neck for easy manoeuvrability.
- Manual steering on rear axle for increasing manoeuvrability for sharp turns.
- Hydraulic suspension for raising and lowering platforms by 150 mm.

b) 80 Ton high bed trailer and 100 ton tractor Unit

For heavy, low height equipment, a high bed trailer having payload capacity of 80 tons and 100 ton tractor unit shall be provided. Trailer shall be complete with rear dolly and detachable goose neck.

c) 50 Ton and 20 Ton high bed trailers

To meet out transportation requirement for medium sized packages, provision has been made for one 50 ton and one 20 ton high bed trailer.

d) 100 Ton Crawler Crane

Provision of 1 number 100 ton crawler type crane has been made to facilitate unloading and loading at site stores. Provision for one no 30 ton tyre mounted crane has also been made for meeting requirement of package of upto 30 Ton capacity.

e) Storage Sheds

For storage of equipment, covered storage sheds having 2000 sqm. area has been provided. This will be necessary for storage of costly plant equipment indoors. After commissioning of the units these facilities will be used for meeting maintenance requirements.

Chapter - 7

HIGH VOLTAGE SWITCHGEAR

7.1 GENERAL

The 400 kV high voltage switchgear shall be SF_6 gas-insulated type comprising 11 (eleven) bays as per details given below :

- Incoming bays for generator and gen.-transformer — 4 nos
- Transmission line bays — 6 nos
- Bus coupler bay — 1 no

These switchgear will have to be imported as these are not available indigenously.

7.2 LAYOUT AND GENERAL ARRANGEMENT

.1 The Switchgear shall be arranged in two parts :

- The incoming GIS bays for 4 nos. generator/transformer and the bus coupler bay shall be installed underground (in the transformer hall) at El.1526.0m floor just above the generator-transformers, as shown in 1200-2131-014. The transformer 400 kV bushings shall be directly connected with the switchgear through SF_6 busducts.

- The 6 feeder bays (gas-insulated) shall be installed overground, outdoors at El. 1845 m, as shown in 1200-2133-001.

.2 The 400 kV double busbars of underground GIS shall be extended through two three phase circuits of SF_6 busduct to the outdoor gas-insulated double busbars comprising 6 feeder bays. 400 kV SF_6 bus duct will be routed through 6 (six) m dia vertical shaft and 5 m D shaped tunnel, as shown in drawing no. 1200-2131-013. The vertical shaft shall have following provisions for erection and maintenance :-

- Service platform at 9 m interval
- Service lift suitable for 2 persons having landing at each about 18m. In all 16 landings will be provided
- Ladders interconnecting each service platform
- Devices for gas monitoring as per requirement.

.3 The general arrangement of Indoor/Outdoor GIS and the routing of G.I. duct tunnel are shown in the following drawings appended with the DPR.

• Drg. No. 1200-2131-002	Layout of P.H./Transformer halls
• Drg. No. 1200-2131-012	Cross section of Transformer/GIS hall
• Drg. No. 1200-2131-013	Cross section of P.H./Transformer Hall and G.I. Duct tunnel
• Drg. No. 1200-2131-014	Plan and Longitudinal section of Underground 400 kV G.I.S. Hall
• Drg. No. 1200-2133-001	Plan and section 400 kV Outdoor GIS
• Drg. No. 1200-2132-002	Protective relaying and Metering diagram
• Drg. No. 1200-2132-003	Single line diagram for GIS interconnection
• Drg. No. 1200-2132-004	Legend, Device Nos. and Abbreviations

7.3 PROVISIONS

.1 The metal enclosed gas-insulated switchgear shall be single phase enclosed conforming to IEC:517.

.2 The switchgear shall be of modular design, free-standing and self supporting with all high-voltage equipment installed inside gas-insulated, metallic gas-tight earthed enclosure, suitably sub-divided into individual arc and gas-proof compartments, at least for bus bars, bus bar disconnector, circuit breaker, line disconnectors etc.

.3 Each gas compartment shall be fitted with :

- One humidity absorber
- One rupturing disk
- One gas filling/draining valve
- One gas density switch

.4 The pressure loss within each individual gas filled compartment shall not be more than one percent per year.

.5 The switchgear shall be suitable for future extension on either end without dislocating or moving the existing switchgear.

.6 The material and thickness of the enclosures shall be designed to withstand internal flashover without a burn through for a period long enough to enable the back up relay protection to clear the fault. The enclosure design shall comply with the requirements of applicable pressure vessel codes of the country of origin.

.7 The actual position of disconnector and grounding switches shall be positively displayed by mechanical indicators visible from the operating position.

.8 A SF_6 gas processing unit, self contained with all accessories, instruments, etc. shall be provided for evacuation/filling of SF_6 gas, transfer of SF_6 gas from a system to the storage tank, liquefying of SF_6 gas etc.

.9 The enclosures of GIS shall be grounded at several points so that there shall be a grounded gauge around all live parts.

.10 Each switchgear bay module shall have a control cabinet with following provisions :-

- remote/local control transfer switch for circuit breaker and isolator switch
- normal/maintenance control transfer switch for isolation of remote electrical controls
- mimic diagram of the switchgear bay complete with semaphore indicators, control switches etc.

- annuniciation windows
- all instruments and devices required for supervision, control of GIS.

7.4 COMPONENTS OF THE GAS-INSULATED SWITCHGEAR

.1 Circuit Breakers

The single phase SF_6 circuit breakers shall be of single pressure (puffer) type with one or more interrupters per phase. It shall conform to IEC:56 and have a reliable hydraulic or pneumatic operating mechanism. The storage cylinders shall have sufficient capacity to accomplish the circuit breaker switching sequence following the loss of supply to the main energy storage system. The line breakers shall have single phase and 3 - phase auto reclosing facilities.

.2 Current Transformers

The current transformers conforming to IEC 185, shall be metal enclosed type with multi-cores and multi-ratio, which shall be changeable by means of taps on the secondary side. The secondary leads shall be brought out through a gas tight bushing plate into the secondary terminal box. Alternatively ring type current transformers fitted externally to the enclosure can also be provided.

.3 Voltage Transformers

The gas-insulated voltage transformers on the double bus shall be inductive type conforming to IEC 186. It shall be effectively shielded against high frequency electromagnetic transients.

.4 Disconnecting Switches

The disconnecting switches shall be motor driven, 3 phase, single pole group operated type, conforming to IEC 129. Opening and closing of the

disconnectors shall be either locally from bay module control cabinet or remotely from Power House control room. The switch shall be interlocked with associated circuit breakers. Each disconnector shall be fitted with an optical indicator per pole so that open or closed contacts of disconnector are visible from the floor level. The disconnectors shall be provided with a manual operating mechanism also for emergency use.

.5 Earthing Switches

a) The maintenance earthing switches shall be motor driven 3 pole, group operated type. Each earthing switch shall be electrically and mechanically interlocked with its associated disconnecting switch. Its operation shall be locally only from the bay module control cabinet.

b) A high speed fault making earthing switch shall be provided at the entrance of the transmission line to discharge the respective charging currents in addition to their safety grounding function. These earthing switches shall also be capable of interrupting the inductive and capacitive currents and to withstand the associated TRV. These single phase earthing switches shall be motor driven group operated type.

.6 Surge Arresters

SF_6 gas insulated, metal enclosed surge arresters of gapless ZnO, heavy duty, station type shall be installed on H.V. side of generator transformers and on the bus bars. At line ends open type metal oxide arrester shall be provided.

.7 SF_6-To-Air Bushings/SF_6-To-Oil Bushings

The SF_6-to-air bushings shall be suitable for outdoor ambient conditions. SF_6-to-Oil bushings with flexible connection shall be provided for transformer end.

.8 Bus Bars and Bus Ducts

The single phase encapsulated double busbars and bus ducts connecting the indoor and outdoor GIS shall be mounted in horizontal/vertical configuration to suit the switchgear G.I. Duct tunnel layout. The conductors of busbars/busducts shall be fabricated of Aluminium tubular sections of cross sectional area suitable to meet the current rating requirements. The tubular bus sections shall be housed in steel or aluminium enclosures filled with pressurised SF_6 gas.

7.5 TESTS ON G.I.S.

.1 Routine Tests

Each shipping assembly/sub-assembly shall be subjected to routine tests as per IEC 517 in the shop. One 3 phase transmission line switchgear bay module shall be completely assembled including a representative section of SF_6 gas-insulated bus duct and one SF_6/Air bushing. All control and terminal boxes shall be temporarily connected with all power supply control, interlocking and alarm wiring and piping so that the complete switchgear bay module may be tested in the shop as per IEC 517 before shipment.

Switchgear components forming part of the GIS, namely current and voltage transformers, surge arresters and SF_6/Air bushings, which have routine tests covered under other relevant IEC standards shall have the relevant mechanical/electrical tests performed before being assembled into the switchgear assembly.

.2 Type Tests

Generally the type tests as specified in IEC, will not be repeated. The test reports previously made on equipment of the same design, same insulation level and same rating shall be accepted. If any of the type tests has however, not been carried out, the same shall be conducted and the rate for the same shall be obtained from the supplier.

.3 Field Tests

On completion of the erection of GIS, the following tests shall be conducted at site to demonstrate that all guarantees have been met and in addition that the entire equipment, including all auxiliary equipment and accessories, are properly erected, installed and correctly adjusted :-

- high voltage tests for the main circuits at 80% rated test voltage
- lightning impulse and switching impulse test with the help of oscillating impulse generator at reduced BIL
- voltage tests for the auxiliary and control circuits
- tests to verify the resistance of the main circuits
- operation tests for various components
- gas leakage tests
- calibration of SF_6 gas pressure/density switches
- measurement of moisture
- any other test recommended by manufacturer/IEEE

7.6 RATING

The following ratings shall be adopted for G.I.S :-

.1 General Ratings

- Type of GIS	Single phase enclosed
- Nominal system voltage	400 kV
- Rated voltage	420 kV
- No.of busbars	Double
- Rated continuous current	2000 A for feeders 4000 A for busbars
- Rated S.C. current	40 kA for 1 sec
- Rated Lightning Impulse withstand voltage	1425 kVp
- Rated switching impulse withstand voltage	1050 kVp

-	Rated p.f. withstand voltage	520 kVp
-	Rated s.c. making current	100 kAp
-	Material of enclosure	Aluminium/steel
-	Material of busbar	Aluminium
-	Partial discharge level	10 pc or less
-	Auxiliary supply	220 V D.C./415 V phase/240 V single phase, 50 Hz A.C.

.2 **Circuit breaker**

-	Rated s.c. breaking capacity	40 kA
-	Normal current rating	2000 A
-	Rated operating duty cycle	
	• Line breakers	0-0.3S-CO-3 min-CO
	• Generator feeder & tie breakers	0-3 min-CO-3 min-CO
-	Operating mechanism	Pneumatic/Hydraulic

.3 **Current Transformer**

-	No.of Cores	6 (for generator and line feeders) 2 (for tie breaker bay)
-	Rated primary current	2000 A
-	Ratio (for each core)	2000-1000-500/1A
-	Rated burden	30 VA
-	Accuracy class	PS/5P 20 for protection and 0.5 for metering.

.4 **Bus Voltage Transformer**

-	Voltage Ratio	$\frac{400}{\sqrt{3}}\ kV\ /\ \frac{110}{\sqrt{3}}\ kV$
-	Accuracy Class	0.5
-	No.of secondary winding	2
-	Purpose	Synchronising and metering
-	Voltage factor	1.5 for 30 sec.

.5 **Disconnect Switches**

-	Power freq. withstand voltage	610 kV
-	Lightning Impulse withstand	

	voltage	(1425 + 240) kVp
	- Switching Impulse withstand voltage	(900 + 345) kVp
	- Rated magnetising current, capacitive current make and break capacity	0.7 A

.6 **High speed Grounding switch**

- Max. make and carry current for 1 sec	100 kAp/40 kA rms
- Rated Inductive breaking current	200 A
- Rated capacitive breaking current	15 A

.7 **Surge Arresters (ZnO)**

- Rated Voltage	312 kV rms
- Type	Heavy duty, Class 3, SF_6 gas insulated, ZnO.
- Nominal discharge current	10 kA

.8 **SF_6/Air Bushings**

- Rated continuous current	2000 A
- Minimum Creepage distance	10500 mm
- Partial discharge level	10 pc.

Chapter - 8

LAYOUT OF ELECTRO-MECHANICAL WORKS

8.1 UNDERGROUND POWER HOUSE - GENERAL ARRANGEMENT

.1 Location of the Power House

The main Power House cavity is located on the right bank of river Satluj near the junction point where the river Bhaba meets the river Satluj. The cavity lies in a massive granitic gneiss having a cover of over 200m.

.2 Number of Cavities

- Two parallel cavities, one for generating plant equipment and spherical valve, and the other one for generator-transformers and 400 kV GIS, are envisaged. These cavities shall be parallel to each other interconnected by respective busduct tunnels of each unit. This arrangement, as compared to the other alternative of a single cavity, with either back to back arrangement of generating unit and transformers or the transformers placed at one end of the cavity, offers the following advantages :

  - width of the Power House cavity is reduced which is desirable from the stability considerations of the rock.

  - transformers being in separate cavity, it offers less fire risk.

- In addition to the above, a separate cavity is also provided for installation of 4 nos. penstock butterfly valves.

The dimensions of the cavities selected are as follows :-

- P.H. Cavity - 143m (L) x 21m (W) x 49m (H)
- Transformer/GIS Cavity - 143m (L) x 15.5m (W) x 25m (H)
- B.F.V. Cavity - 95m (L) x 10m (W) x 22m (H)

.3 Approach Adits

The approach to the main powerhouse cavity and transformer hall cavity shall be through a 305m long, 8.5m D-shaped tunnel to the service bay at El.1515m. The size of the tunnel selected is optimum keeping in view transportation of heaviest packages from NH22 (at El.1537) to inside the cavity.

Another adit of 6.5m, D-shaped will provide approach to the control block at El.1530.5. This adit will take off from the main access adit but subsequently be connected to NH 22 at El.1537.0m.

A 7.5m D shaped adit will take off from the main access adit and will provide access to the bottom of pressure shafts for carrying out the excavation and erection of penstock liners from the bottom.

.4 Busduct Tunnels/Shaft

- The air-insulated, 13.8 kV, Isolated phase busducts connecting generator and transformer shall be routed through individual, 5.6m D, shaped, busduct galleries.

- The 400 kV, SF_6 gas insulated busducts, connecting the indoor and outdoor GIS shall be routed horizontally through a 5.6m, D shaped tunnel and then vertically through a 6m shaft to the outdoor switchyard. The tunnel shall originate from the transformer hall at El.1540m.

The proposed routing of these busduct tunnels/shaft is shown in DPR drawing nos. 1200-2131-001 and 1200-2131-013.

8.2 POWER HOUSE LAYOUT

.1 General Layout And Dimensioning of Power House Complex

Following factors have been considered while evolving the layout and dimensioning of power house, caverns and adits :-

- Proper access to power house for maximum dimensioned and maximum transport weight packages from rail head/ware house to power house.
- Adequate space for assembly and erection of plant equipment.
- Proper access of crane approach for lifting, handling, erection and maintenance.
- Adequate space for erection, maintenance and safety clearance around various equipment.
- Facilities for execution of erection and maintenance sequence in shortest time.
- Safety of equipment and manpower.
- Minimum losses in the system.
- Energy conservation.
- Adequate facilities for erection, operation and maintenance.
- Safety against highest flood level and normal operating levels.

.2 Layout Drawings

Keeping above factors in view, layouts have been developed as shown in following drawings appended with the DPR :-

Drg. No. : 1200-2131-001	Layout plan of P.H. Works and 400kV Switchyard
Drg. No. : 1200-2132-002	Layout of Power House Transformer Halls
Drg. No. : 1200-2131-003	Detailed Cross Section of P.H./ Transformer Halls
Drg. No. : 1200-2131-004	Cross Section of Power House
Drg. No. : 1200-2131-005	Longitudinal Section of Power House
Drg. No. : 1200-2131-006	Floor plan of P.H. at El.1489 & El.1497.0m
Drg. No. : 1200-2131-007	Floor plan of P.H. at El.1505.5m
Drg. No. : 1200-2131-008	Floor plan of P.H. at El.1510m
Drg. No. : 1200-2131-009	Floor plan of P.H. at El.1515m
Drg. No. : 1200-2131-010	Layout plan of Control Block
Drg. No. : 1200-2131-011	Plan and Sections of Control Block
Drg. No. : 1200-2131-012	Cross Section of Transformer Halls
Drg. No. : 1200-2131-013	Cross Section of P.H./Transformer Halls, incl. GI Duct Tunnel/Shafts
Drg. No. : 1200-2131-014	Plan and Longitudinal Section of Underground GIS Hall
Drg. No. : 1200-2137-001	Plan and Section of BFV Chamber
Drg. No. : 1200-2133-001	Layout and Section of Outdoor Switchyard.

.3 Number of Floors

Four floors are proposed for the station with respect to the turbine setting at El. 1501.5m :

- MIV floor at El.1497.0m
- Turbine floor at El.1505.5m

- Generator floor at El.1510m
- Machine hall floor at El. 1515m

The floors are shown in appended drawing no. 1200-2131-004 showing cross section of the Power House. The control block located at one the end of the machine hall shall be provided with 6 floors at:

- El. 1510m
- El. 1515m
- El. 1519m
- El. 1522.5m
- El. 1526.5m
- El. 1530.5m

The control block floors as shown in appended drawing nos. 1200-2131-010 and 1200-2131-011 shall be used for auxiliary equipment like LT switchgear, station transformers, workshop, model room, stores, canteen, offices, Visitor's room, battery charger and D.C. distribution boards, ventilation and air conditioning etc. The main control room of the Power House and switchyard shall be at El. 1526.5m.

.4 Unit Spacing

A unit spacing of 22m has been selected. With this spacing the length of the Power House has been adopted as 143m.

.5 Erection/Service bay

The erection bay is proposed to be provided at machine hall floor at El. 1515m. The length of the erection bay has been kept as 30m which is approx. 1.36 times the unit spacing.

The erection bay shall have facility of loading/unloading, assembly/disassembly of various equipments including stator, rotor, runner, pit liner etc.

The erection bay shall be connected with the transformer hall with a 8m dia D shaped tunnel to bring the transformer to the erection bay for servicing/untanking etc.

.6 **Hatches/Openings**

One hatch (6000 x 4000m), has been provided for each unit separately on the upstream side of the power house at El. 1515, 1510 and 1505.5m for lifting of main inlet valve to the erection bay for repair/maintenance. These hatches shall be used for erection and servicing of various equipment/cubicles from the machine hall floor to the lower floors, where they are installed.

Another hatch opening (4500 x 300mm) has been provided for removal of the runner from the bottom and then lifting it to the erection bay.

Hatch openings have also be provided in the Control block at El.1519.0, 1522.5 and 1526.5m floors for installation and servicing of various equipments/cubicles located at the auxiliary floors, and for cabling and ventilation systems.

.7 **Lift/Stair Cases**

One 10-passenger lift and a staircase will be provided in the Control Room Block, covering all floors of the control block.

The normal staircases shall be provided centrally one each between 2 units to serve the floors at El.1505.5 to El.1515m.

One staircase is envisaged in each turbine pit for approach to Power House floor at El.1505.5m.

One lift suitable for 2 persons shall also be provided in the 400 kV gas insulated busduct shaft for approach from El.1548 to El.1845m, where outdoor GIS is proposed.

.8 **Runner Removal from Bottom**

In view of high silt content with substantial percentage of particles with hardness above 6 to Mohr scale, considerable hydro abrasion problem is foreseen. To facilitate, inspection and maintenance of runners which would be required more frequently, provision of runner removal from bottom has been kept. Runner shall be dismantled from below and carted on a trolley outside pit on rails. From there, runner shall be lifted through hatch covers with the help of E.O.T. crane.

.9 **Utility Services**

For the convenience of operating personnel in the power house, provision of one WC toilet has been made on each floor of the Control Block.

8.3 EQUIPMENT AT VARIOUS FLOORS

The various equipments/panels are proposed to be located in the Power House at elevations given below:-

A) **Power House Floors**

1.	Main Inlet Valve	El.1497.0
2.	Cooling Water pumps	El.1505.5
3.	Oil pressure unit	El.1510.0
4.	Oil pressure receiver	El.1510.0
5.	Gov. Actuator Cubicle	El.1510.0
6.	H.P. Compressor for Gov.	El.1510.0
7.	N.G. Cubicle	El.1510.0
8.	LAVT Cubicle	El.1510.0

9.	Static Excitation Cubicles	El.1515.0
10.	DACS	El.1515.0
11.	HP lub pump	El.1510.0
12.	Brake and Jack Control panel	El.1510.0
13.	LT Panels (UABs)	El.1510.0

B) **Control Block Floors**

1.	General Purpose Compressor	El.1510.0m
2.	Station Service Transformers	
3.	Station Service Board	
4.	Mechanical Workshop	El.1515.0m
5.	Canteen/Stores	
6.	Model Room	
7.	Electrical Test Lab	El.1519.0m
8.	Visitor's room	
9.	Offices	
10.	Battery	El.1522.5m
11.	Battery charger	
12.	Air Conditioning	
13.	Cable Spreader room	
14.	Control Room	El.1526.5
15.	PLCC and Other Miscellaneous Equipment	
16.	Computer room	
17.	Unit Auxiliary Transformers	Bus duct gallery
18.	Drainage and Dewatering pumps	El.1505.5
19.	Ventilation Blowers	El.1530.5

C) **Transformer Hall**

1.	Generator Transformers	El.1515.0
2.	400 kV GIS (5 bays)	El.1526.0

8.4 TRANSFORMER HALL ARRANGEMENT

The transformer hall is aligned parallel to machine hall at El.1515m, located 22m away from it. The dimensions of this hall have been fixed as 143x15.5x25m. Single phase generator-transformers are adopted considering the limitation of transportation prevailing at site. 13 nos. single phase 93 MVA, 13.8/400$\sqrt{3}$ kV generator transformers would be located in this hall. A rail track of 1676mm gauge shall be embedded in the floor logitudinally for movement of transformers during installation/repair. The rail is extended upto erection bay for bringing transformers there for repair, if required. The 13.8 kV transformer bushings shall be connected to generator terminals through isolated phase busducts. Its 400 kV side will be connected directly to 400 kV gas insulated switchgear located on the floor slab at El.1526m just above the transformer. 5 nos. of 400 kV GIS bays with double bus bar arrangement shall be located here. Proposed general arrangement of GIS and transformer hall are shown in the enclosed drawings.

8.5 OUTDOOR SWITCHYARD ARRANGEMENT

The 6 feeder bays, including provision of 2 bays for future shall also be gas-insulated and installed outdoors at El.1845. The double bus bars of Indoor GIS shall be extended outdoors through 2 nos, 3 phase circuits of 400 kV SF_6 insulated busducts. installed in tunnel/shaft. The general arrangement of routing of the GI busduct is shown in enclosed drawing no.1200-2131-013. The outdoor switchyard shall comprise :

- 6 gas-insulated bays for feeders terminated in SF_6/Air bushings
- Open type ZnO lightning arresters
- Capacitive voltage transformers
- Wave trap

The general arrangement of outdoor switchyard is shown in drawing number 1200-2133-001.

8.6 E.O.T. CRANES

Two nos. E.O.T. cranes of 275/40/10t capacity shall be provided in the

Underground Power House for handling of turbine, valve, generator and other components. A lifting beam shall also be provided for tandem operation of two cranes for lifting of generator rotor. The span of the E.O.T. crane will be 20.2m with top elevation of thr crane rail, being at El.1525m.

The BFV Chamber and the underground GIS Chamber will have separate E.O.T. cranes of 65/5t and 10t capacity respectively for handling the valve and switchgear components.

8.7 VENTILATION, HEATING, AND AIR CONDITIONING ARRANGEMENT

.1 The ventilation system of main power house cavity shall comprise adequate capacity blowers at the top of the control block (El.1530.5m). The air shall be distributed to the various floors in Power House, control block and bus duct galleries through a network of air supply G.I. ducts having adjustable dampers etc.

For transformer/GIS cavity, the blower room shall be provided at El.1526m on the GIS floor for ventilation purpose. Blower rooms shall also be provided near the adits of BFV chamber and collection gallery tunnels for its ventilation.

Principal points of exhaust air shall be through access tunnel, 400kV GI bus duct shaft for which suitable rated exhaust blowers shall be provided Smoke exhaust system shall be provided to prevent recirculation of smoke in case of fire.

.2 For heating of power stations

Bleeding of hot air from generator for station heating has been considered.

.3 Suitable package type air conditioning units shall be provided for control room and offices.

Chapter - 9

CONSTRUCTION POWER ARRANGEMENT

9.1 POWER REQUIREMENT

Assessed power requirement for various work sites is as under :

• Power House	2 MVA	
• BFV Surge shaft	1 MVA	
• Adit 1 to 5	5 MVA	(1MVA each)
• Dam site	2 MVA	
• Colony	2 MVA	
Total	**12 MVA**	

Keeping diversity in view, peak power requirement of 10 MVA is foreseen.

The location and distances of various sites are indicated in layout drawing no. 1200-2159-001.

9.2 PROVISIONS

.1 Two 22kV feeders from 66/22kV Nathpa S/S of S.E.B. are proposed to be taken along the route touching the intermediate adits for tunnels and on the Dam site taking into consideration geographical limitations. Following table gives details of power requirement, shortest distance and approximate line length involved.

.2 Standby diesel sets of 3 MVA capacity each have been provided at dam site and Power House to meet any eventuality i.e. non-availability of power from

S.E.B., line problems, voltage problems. In total 6 MVA stand-by power is proposed. Two nos. 2 x 1000 kVA Diesel sets at P.H. and 1 no. 250 kVA Diesel set at Dam site will be retained for meeting P.H. operation needs. On completion of the project, credit has been provided for resale value of balance DG sets under "Recovery and Receipts".

TABLE - 1

Power Requirement Karcham Wangtoo Project

Sl.No.	Location	Distance from Nathpa S/S along route, km	Line Length, km	Power Requirement (MW)
1.	Power House	5	Double circuit 30 km	2
2.	Adit No.5	8.4		1
3.	Adit No.4	10.9		1
4.	Adit No.3	14.2		1
5.	Adit No.2	16.6		1
6.	Adit No.1	19.4		1
7.	Dam Site	22.3		1
8.	P.H. to Surge Shaft and BFV	1	Single circuit 8 km	1
9.	Tap off for dam site from Baspa 22 kV line	1.5		1
10.	Tap off to colony	4		2

.3 The transformer capacity at Nathpa will be required to be augmented and necessary provision to provide 2 x 12.5 MVA transformer against existing 2 x 6.3 MVA has been made. Credit has been provided for resale value of old transformer. This work will be executed by SEB at Company's cost.

.4 Provision for staff quarter facility and Jeep for erection/maintenance has been provided at Nathpa S/S.

.5 Provision has been made for communication system based on VHF or PLCC for proper liasion between SEB and Company.

.6 As per single line diagram for construction power, drawing no.1200-2159-002, 22 kV S/S shall be installed near P.H. site which will help control changeover and monitor power flow. The 22 kV S/S shall have 2 incoming, 1 bus-coupler 3 nos., DG set feeders, and 6 out going feeders (2 for surge shaft, 1 spare, 2 for adit 5).

.7 8-pole structure will be provided at each adit along with necessary isolators, lightning arrestor and other devices as per requirement at each of the Five adits. 2 nos 500 kVA transformers shall be provided at each adit.

.8 At dam site, 22 kV indoor type switchgear as per schemetic diagram having nine (9) VCBs shall be provided. It shall have provision for interconnection to Baspa II line for emergency use.

.9 Provision for 4 nos. 300 kVA S/S power supply to colony batching plant etc. along with step down transformer has also been made.

Chapter - 10

PROJECT IMPLEMENTATION AND ERECTION METHODOLOGY FOR ELECTRO-MECHANICAL EQUIPMENT

10.1 PROJECT MANAGEMENT

A Project Management Group would be created for overview and steering the project from inception to commissioning and would control all the following basic activities :

i) Basic Engineering;
ii) Preparation of specification, tender evaluation, ordering, vendor drawing review etc.;
iii) Material Management;
iv) Construction and erection;
v) Commissioning.

The Project Management Group would have a cell to monitor and control the following basic activities :

i) Scheduling, monitoring and reporting on all the activities;
ii) Financial control and payment to vendor/contractors.
iii) Coordination with various agencies.
iv) Quality Surveillance.
v) Certification for completion and performance.

10.2 QUALITY ASSURANCE AND INSPECTION

A quality assurance and inspection group will ensure the quality during project engineering, procurement, manufacturing stages of the Contract. As a part of the requirement vendors/sub-vendors from whom equipments are proposed to be procured and the quality plans will be approved by quality assurance group for

implementation. On the quality plans the Customer Hold Points will also be identified.

Owner will appoint one of the reputed Quality Control and Inspection agency for third party inspection which shall monitor quality of raw material, in process manufacture quality control, tests on assembly upto despatch on a continuous basis at manufacturer's works. Besides this the scope will also include review of quality standards as per International quality practices, monitor and control implementation of the same.

10.3 ERECTION, TESTING AND COMMISSIONING SCHEDULE

The erection, testing and commissioning is proposed to be done under direct supervision of Supervising Engineer/Technicians from respective suppliers. It is planned to complete the erection, testing and commissioning of major electro-mechanical equipment in 25 months starting from 47th month.

The proposed erection schedule for Electro-mechanical equipment and auxiliaries is given in the enclosed Bar-graphs and pert chart with important mile stones marked on it.

10.4 ERECTION SEQUENCE

Erection sequence of different electro-mechanical equipment is proposed as under:

(a) E.O.T. Crane (2x275/40/10t)

The erection of first E.O.T. crane in the Power House shall be taken up immediately after completion of benching down and wall supports in the Power House cavity upto Erection Bay level. Both the cranes are proposed to be installed before commencement of erection of main generating plant equipment by 48th month.

(b) **Main Generating Plant Equipment**

(i) Under Water Parts

Erection of draft tube liners is proposed as per erection sequence indicated, i.e. for unit I, starting w.e.f. 38th month and completed by 39th month end including concreting thereof. Each unit erection will be staggered by about 30 days.

Erection of scroll casing shall start in 40th month and will be completed by end of 43rd month for first unit. Concreting of scroll carsing, floors and barrel etc. shall be completed by 46th month. Activity for other unit shall be staggered by one month.

(ii) Erection of turbine and generator

Assembly of turbine and generator shall commence during 47th month and erection of first unit shall be completed by period ending 68th month. Erection of second, third and fourth unit shall be started at an interval of one month each and completed by 69th, 70th and 71st month. The complete erection, testing and commissioning shall be supervised by experts, supervisors, technicians of the manufacturers of plant equipment. Testing and commissioning test of the first unit shall commence in 69th month and it is proposed to commission all the four units by 72nd month and commercial operation commenced. Various stages of erection for generating plant equipment are indicated in the enclosed bar chart and pert chart.

(iii) Main Step up Transformers

Transformer hall cavity and civil works to house transformers shall be ready by 45th month end.

The erection of main step up transformer (13 Nos. single phase transformers) is planned to be started at the beginning of 52nd month

and completed in 13 months time at the rate of 1 transformer per month. Thus, all the transformers are proposed to be installed by end of 63rd month. The testing and commissioning of first 3 phase bank of transformers shall match with the commissioning schedule of first unit. The other banks shall follow at an interval of 1 month.

(iv) Gas Insulated Switchgear

The Switchgear floor (inside cavity) and the outdoor switchyard area for installation of gas insulated switchgear will be ready by 45th month of the start of the project. The 400 kV gas-insulated switchgear, being shipped in modular assemblies, shall take less time for its installation. It is planned to be completed in six months time. The erection shall be taken up at the beginning of 58th month which will ensure its availability to match the schedule of commissioning of first unit with a slack of 4 months.

(v) 400 kV SF_6 Insulated Busducts

The erection of 400 kV SF_6 insulated busducts in the tunnel/shaft, terminations in outdoor switchyard shall also take about 9 months. The erection of busducts will commence at beginning of 54th month and completed by 63rd month.

(vi) 400 kV Outdoor Switchyard Equipment

The erection of outdoor switchyard comprising 400 kV Surge Arresters, CVT, Wavetrap etc. shall take about 3 months. The erection work of switchyard is proposed to be started at the beginning of 61st month and completed by 63rd month.

(c) **Other Electrical and Mechanical Auxiliaries**

Time schedule for start and completion of various auxiliaries has been shown in the bar chart. Various auxiliary equipment, piping, cabling, control

and protection equipment, LT Boards etc. shall be installed well in time to match the commissioning schedule of the power station. Commissioning of these auxiliaries shall be done to match the commissioning activities of the plant equipment.

To ensure timely erection, testing and commissioning, following shall be ensured.

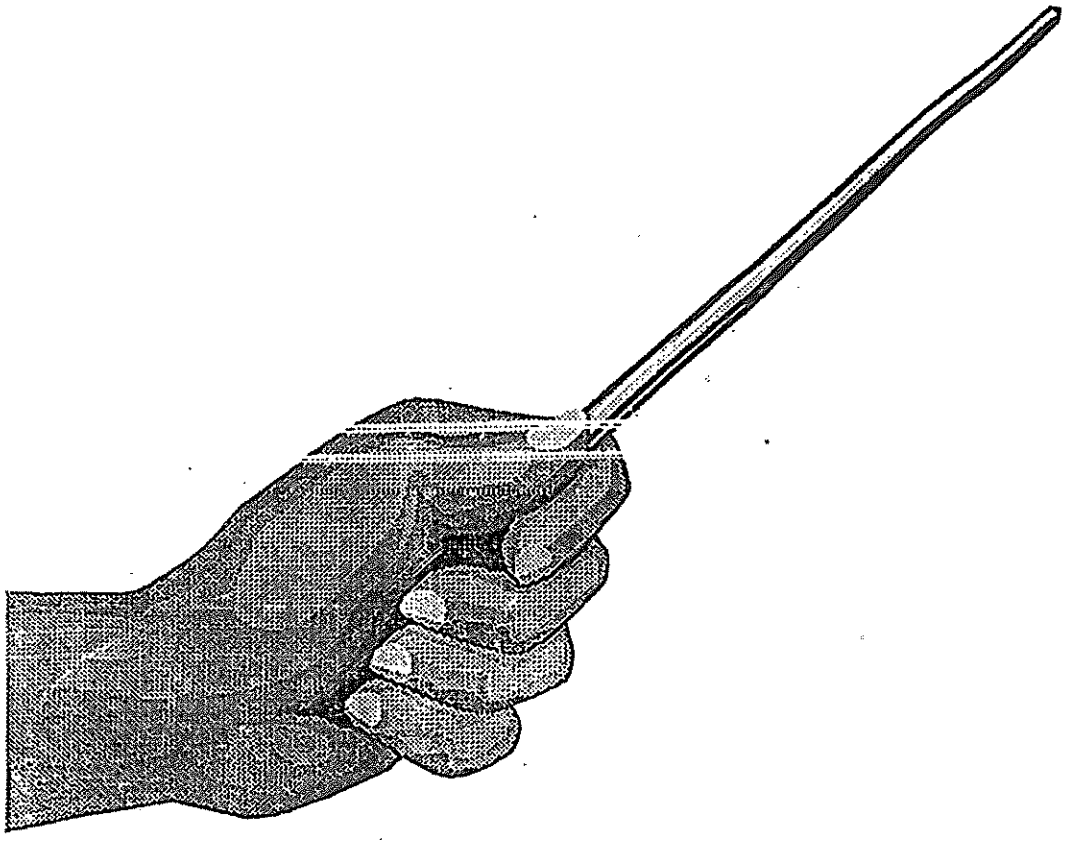
(i) Regular monitoring and control of various components of the works.

(ii) Deployment of adequate number of erection personnel of manufacturers of plant equipment.

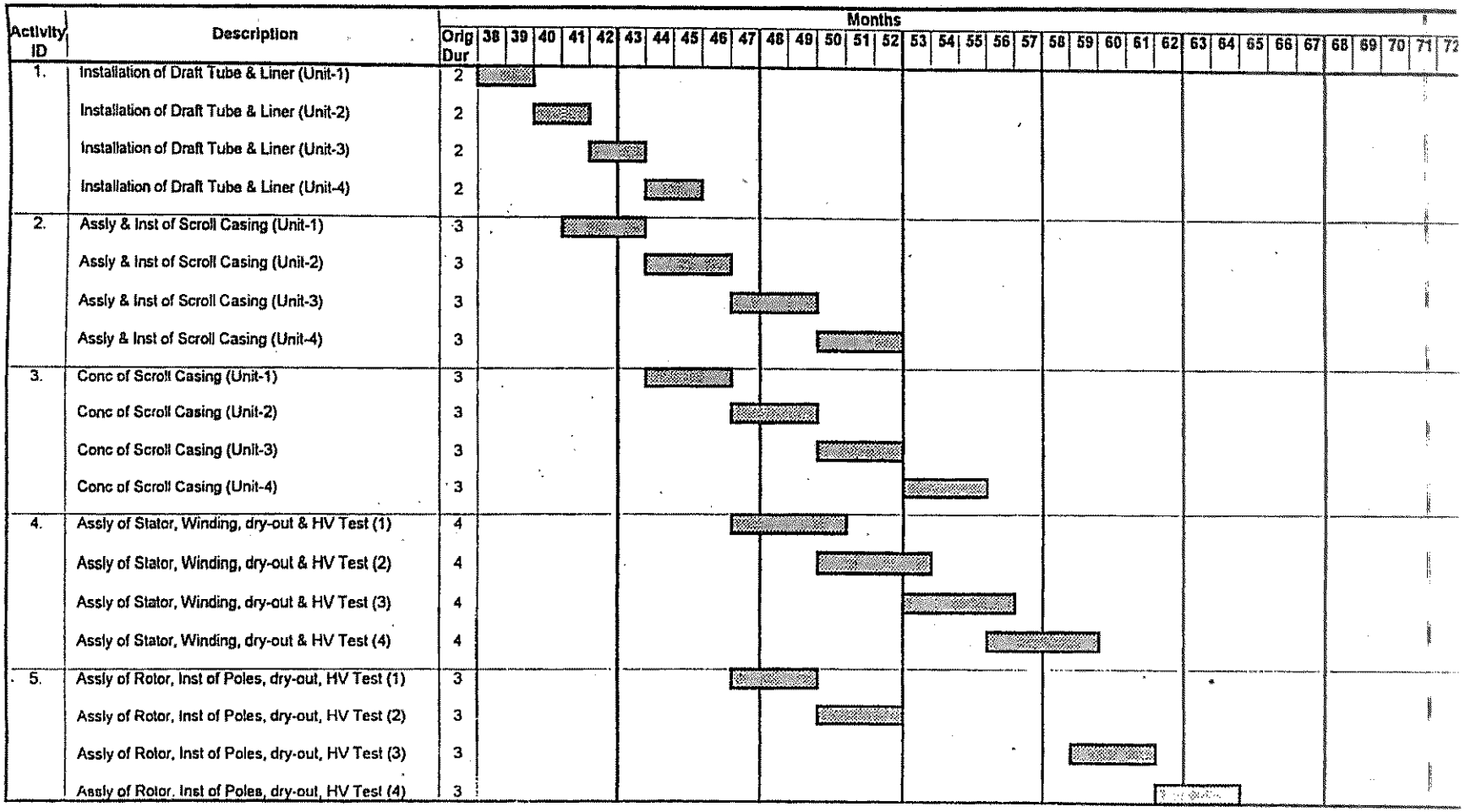
(iii) Ensuring availability of necessary tools and consumables.

(iv) Deployment of adequate experience manpower well versed in erection, testing and commissioning.

Bar Charts



BAR CHART OF SCHEDULE OF ELECTRO-MECHANICAL WORKS - FOR KARCHAM-WANGTOO HYDRO ELECTRIC PROJECT

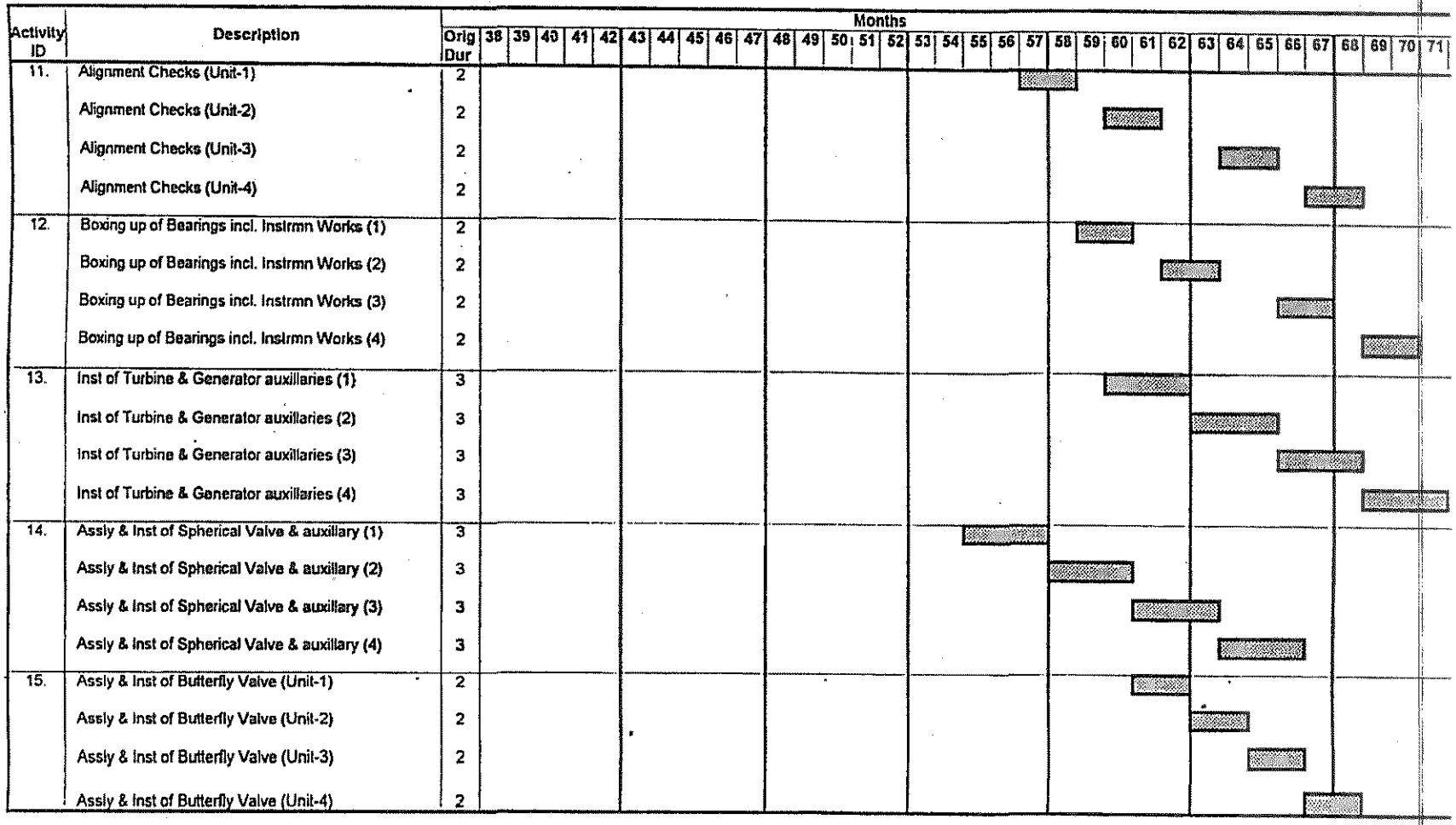


BAR CHART OF SCHEDULE OF ELECTRO-MECHANICAL WORKS - FOR KARCHAM-WANGTOO HYDRO ELECTRIC PROJECT

Activity ID	Description	Orig Dur	Months 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71
6.	Assly of Guide Vanes, Lowering of Turbn Shaft(1)	2	
	Assly of Guide Vanes, Lowering of Turbn Shaft(2)	2	
	Assly of Guide Vanes, Lowering of Turbn Shaft(3)	2	
	Assly of Guide Vanes, Lowering of Turbn Shaft(4)	2	
7.	Inst of Governor & Servo (Unit-1)	1	
	Inst of Governor & Servo (Unit-2)	1	
	Inst of Governor & Servo (Unit-3)	1	
	Inst of Governor & Servo (Unit-4)	1	
8.	Assly & Inst of Lwr, Bracket of Foundation (1)	1	
	Assly & Inst of Lwr, Bracket of Foundation (2)	1	
	Assly & Inst of Lwr, Bracket of Foundation (3)	1	
	Assly & Inst of Lwr, Bracket of Foundation (4)	1	
9.	Lowering of Rotor, Assly on Upper Bracket (1)	1	
	Lowering of Rotor, Assly on Upper Bracket (2)	1	
	Lowering of Rotor, Assly on Upper Bracket (3)	1	
	Lowering of Rotor, Assly on Upper Bracket (4)	1	
10.	Coupling of Turbine/Generator Shaft (1)	1	
	Coupling of Turbine/Generator Shaft (2)	1	
	Coupling of Turbine/Generator Shaft (3)	1	
	Coupling of Turbine/Generator Shaft (4)	1	

BAR CHART OF SCHEDULE OF ELECTRO-MECHANICAL WORKS - FOR KARCHAM-WANGTOO HYDRO ELECTRIC PROJECT

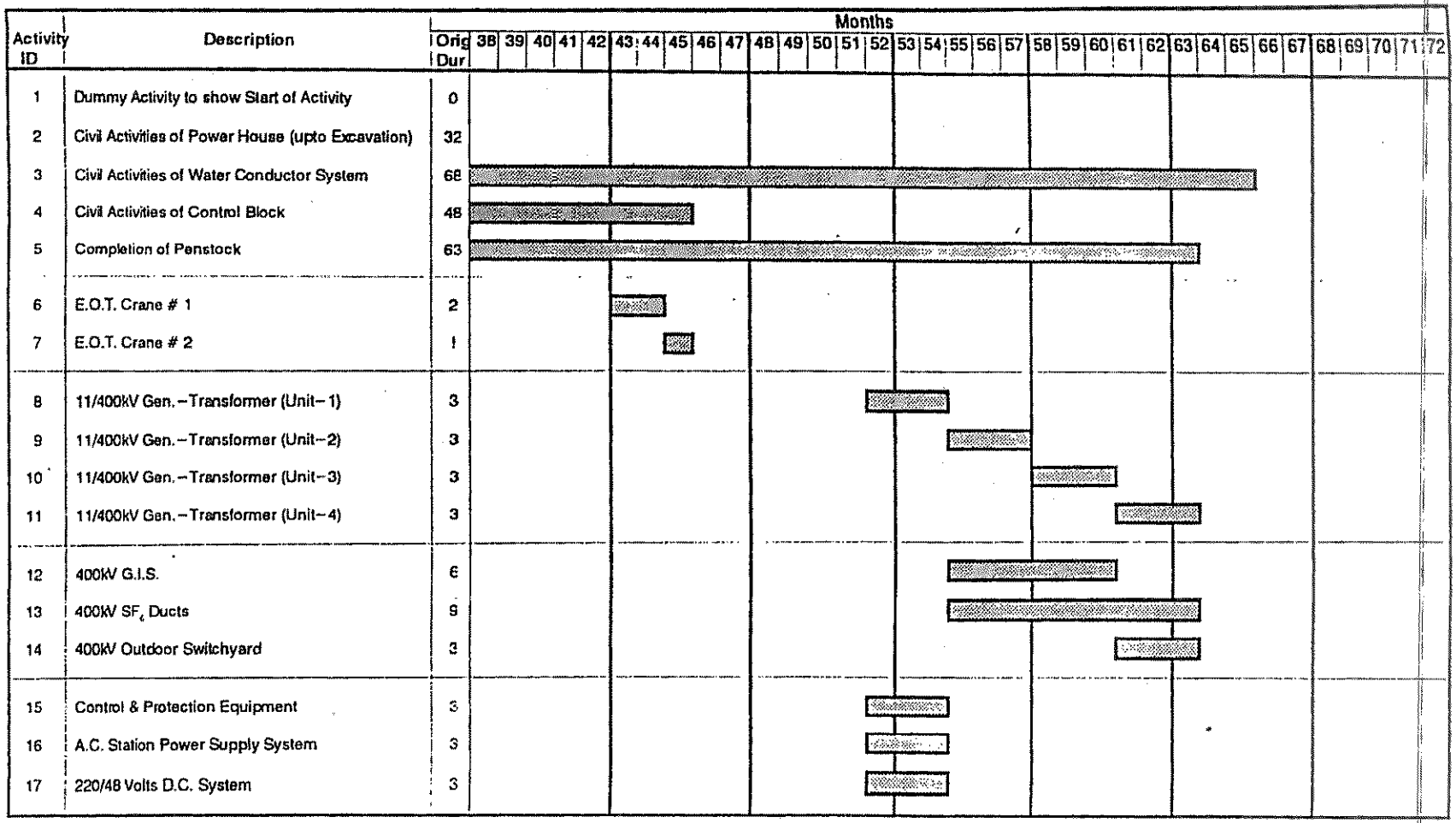
Activity ID	Description	Orig Dur
11.	Alignment Checks (Unit-1)	2
	Alignment Checks (Unit-2)	2
	Alignment Checks (Unit-3)	2
	Alignment Checks (Unit-4)	2
12.	Boxing up of Bearings incl. Instrmn Works (1)	2
	Boxing up of Bearings incl. Instrmn Works (2)	2
	Boxing up of Bearings incl. Instrmn Works (3)	2
	Boxing up of Bearings incl. Instrmn Works (4)	2
13.	Inst of Turbine & Generator auxillaries (1)	3
	Inst of Turbine & Generator auxillaries (2)	3
	Inst of Turbine & Generator auxillaries (3)	3
	Inst of Turbine & Generator auxillaries (4)	3
14.	Assly & Inst of Spherical Valve & auxillary (1)	3
	Assly & Inst of Spherical Valve & auxillary (2)	3
	Assly & Inst of Spherical Valve & auxillary (3)	3
	Assly & Inst of Spherical Valve & auxillary (4)	3
15.	Assly & Inst of Butterfly Valve (Unit-1)	2
	Assly & Inst of Butterfly Valve (Unit-2)	2
	Assly & Inst of Butterfly Valve (Unit-3)	2
	Assly & Inst of Butterfly Valve (Unit-4)	2



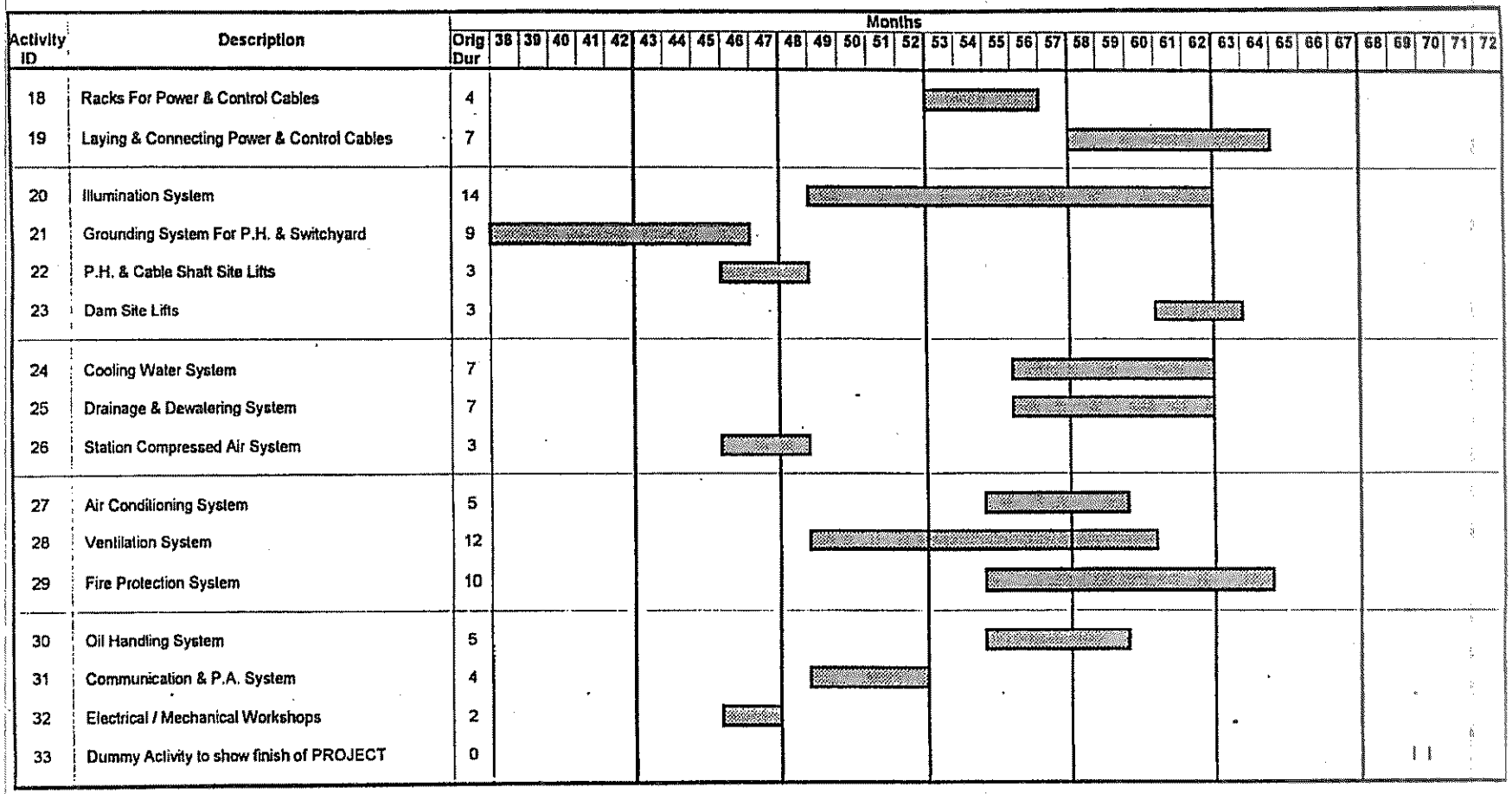
BAR CHART OF SCHEDULE OF ELECTRO-MECHANICAL WORKS - FOR KARCHAM-WANGTOO HYDRO ELECTRIC PROJECT

Activity ID	Description	Orig Dur	Months 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72
16.	Inst of Unit Control & Excit Panels (Unit-1)	2	
	Inst of Unit Control & Excit Panels (Unit-2)	2	
	Inst of Unit Control & Excit Panels (Unit-3)	2	
	Inst of Unit Control & Excit Panels (Unit-4)	2	
17.	Assly & Inst of IP Bus Duct NG & LAVT Cub (1)	3	
	Assly & Inst of IP Bus Duct NG & LAVT Cub (2)	3	
	Assly & Inst of IP Bus Duct NG & LAVT Cub (3)	3	
	Assly & Inst of IP Bus Duct NG & LAVT Cub (4)	3	
18.	Boxing up of Generator (Unit-1)	3	
	Boxing up of Generator (Unit-2)	3	
	Boxing up of Generator (Unit-3)	3	
	Boxing up of Generator (Unit-4)	3	
19.	Spinning, testing & commissioning (Unit-1)	2	
	Spinning, testing & commissioning (Unit-2)	2	
	Spinning, testing & commissioning (Unit-3)	2	
	Spinning, testing & commissioning (Unit-4)	2	

BAR CHART OF SCHEDULE OF OTHER WORKS – FOR KARCHAM–WANGTOO HYDRO ELECTRIC PROJECT

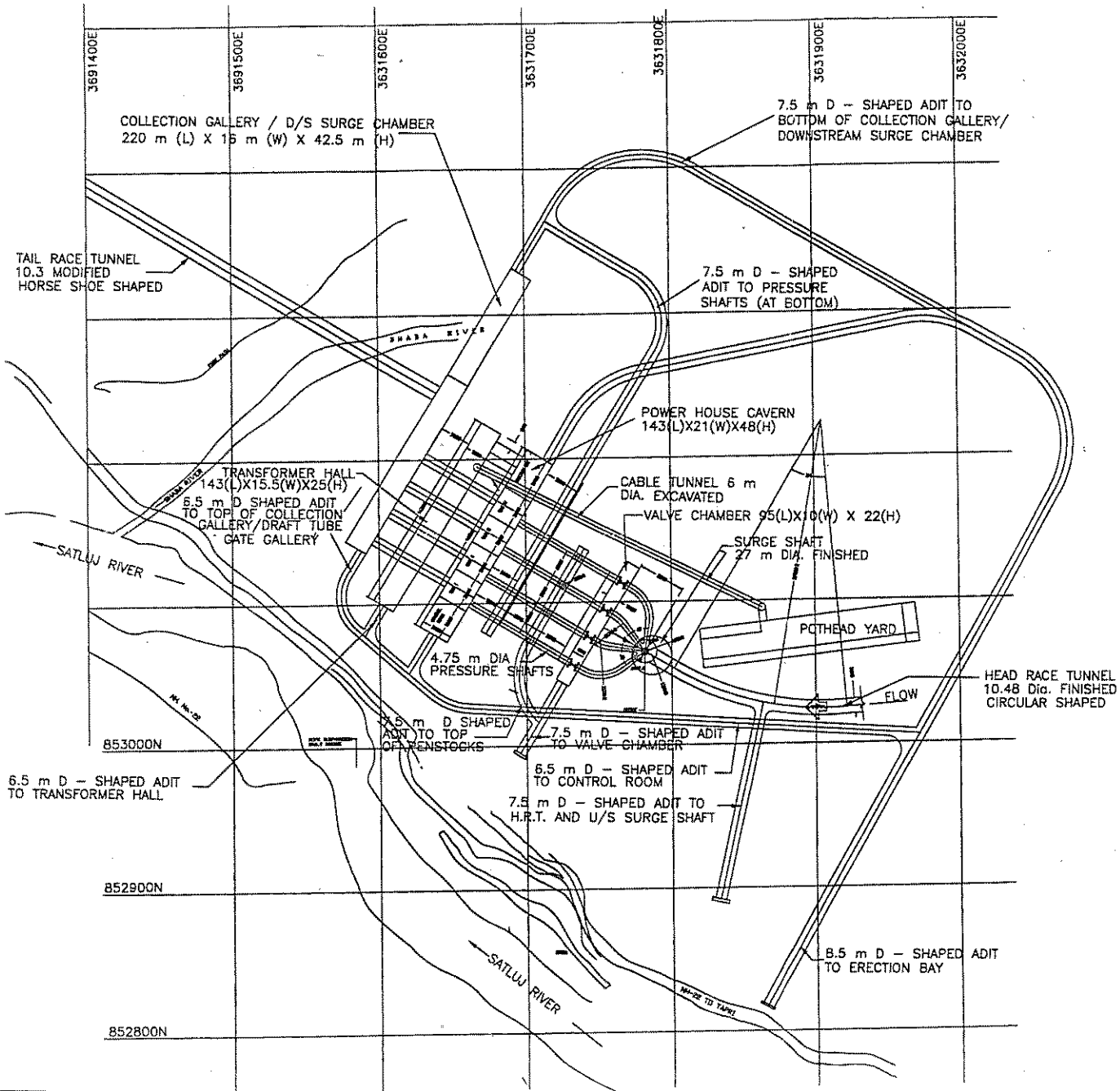


BAR CHART OF SCHEDULE OF OTHER WORKS - FOR KARCHAM-WANGTOO HYDRO ELECTRI



Activity ID	Description	Orig Dur
18	Racks For Power & Control Cables	4
19	Laying & Connecting Power & Control Cables	7
20	Illumination System	14
21	Grounding System For P.H. & Switchyard	9
22	P.H. & Cable Shaft Site Lifts	3
23	Dam Site Lifts	3
24	Cooling Water System	7
25	Drainage & Dewatering System	7
26	Station Compressed Air System	3
27	Air Conditioning System	5
28	Ventilation System	12
29	Fire Protection System	10
30	Oil Handling System	5
31	Communication & P.A. System	4
32	Electrical / Mechanical Workshops	2
33	Dummy Activity to show finish of PROJECT	0

Months: 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72



REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	LAYOUT OF P.H. & TRANSFORMER HALLS	1200-2131-002
2	PLAN & SECTION OF B.F.V. CHAMBER	1200-2137-001

0 20 40 60 80 m
SCALE

D.P.R. DRAWING

NOTE:
1) ALL DIMENSIONS ARE IN mm.; AND ALL ELEVATIONS IN m.

Rev.	DESCRIPTION	By	App (Proj. Man.)	Dat
R1	CIVIL CORRECTIONS COMPLETE	par	S. CHANDRA	8/3/
Print Issue Date	9/3/2000	Dwg-5> C:\PSF\Acad-2\JK-Wangtoo\KW-PH		
		Drawn	P. Gupta Asst Sr.D.E	
		Drawing Checked	A.K. Sinha ADM(P	
Designed	S. Chandra Director	Approved	S. Chandra Direct	

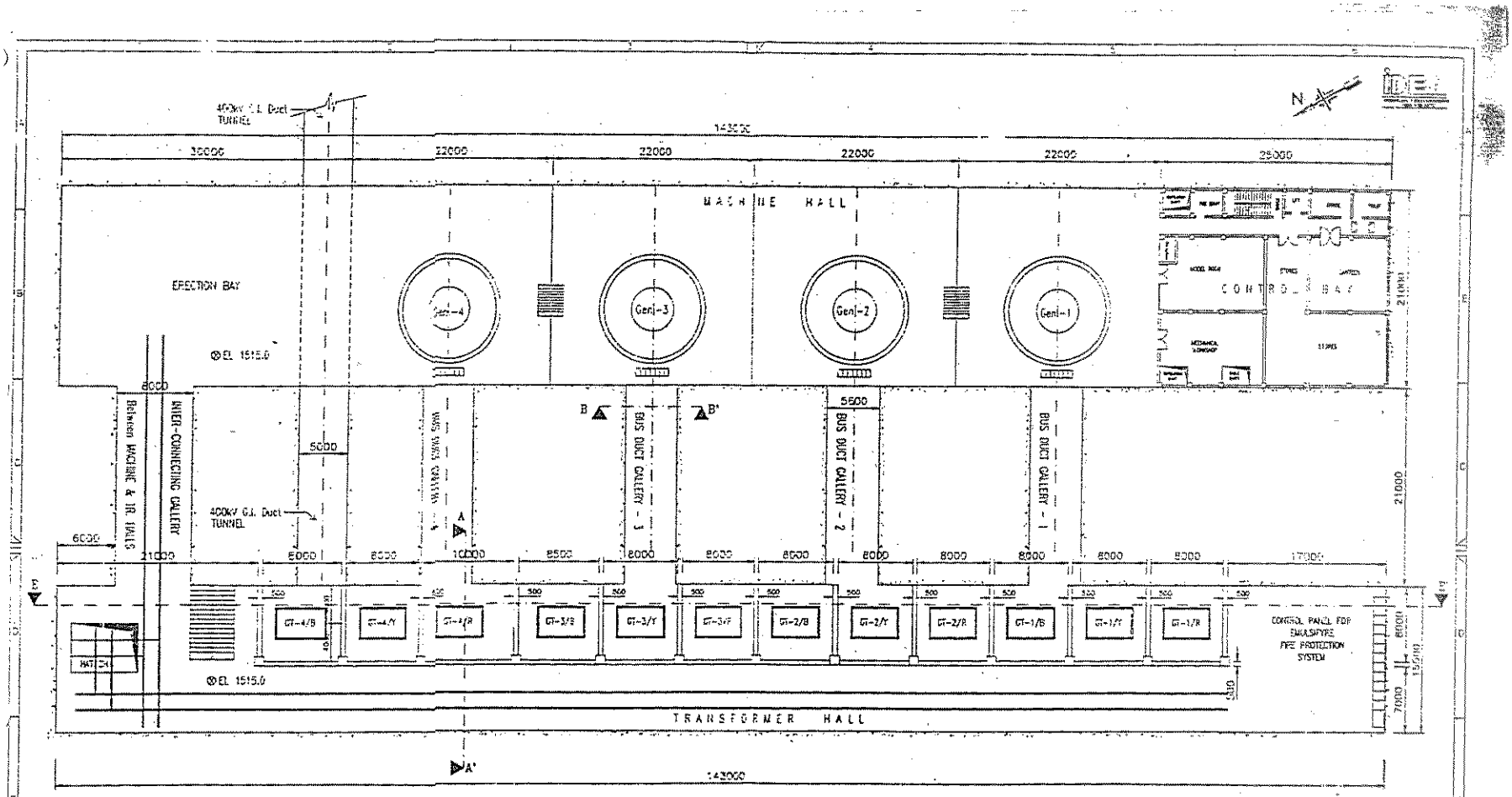
JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division

PROJECT: KARCHAM-WANGTOO H. E. POWER STATION (4 x 250 M

TITLE: LAYOUT OF POWER HOUSE WORKS & 400kV SWITCHYARD

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE As Shown | DRAWING NO. 1200-213?-201 | REV. 1



NOTE:

1) ALL DIMENSIONS ARE IN mm.; AND ALL ELEVATIONS IN m.
2) FOR SECTIONS A-A' & B-B' REFER TO DRG: 1200-2131-012.
3) FOR SECTIONS E-E' REFER TO DRG: 1200-123 -014.

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	CROSS SECTION OF TRANSFORMER HALL	1200-2131-012
2	C/S OF P.H./TR. HALLS & DUCT (TUNNEL) SHAFT	1200-2131-013
3	PLAN & L. SECTION OF U/G 400kV G.I.S. HALL	1200-2131-014

D.P.R. DRAWING

First Issue Date	17/1/1996		
Designed	S. Chandra Director		

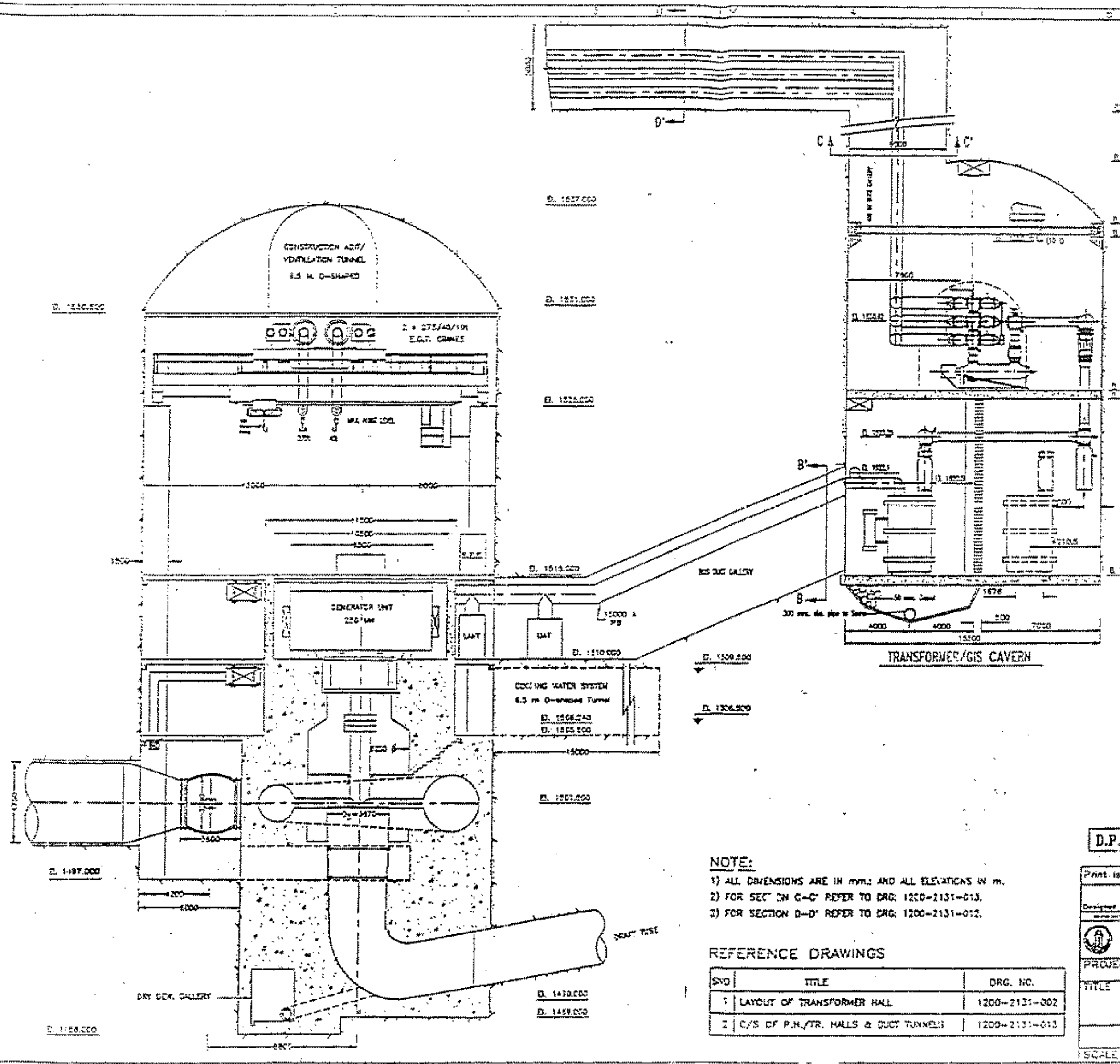
JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division)

PROJECT: KARCHAM-WANGTOO H. E. POWER STATION (4 x 250 MW)

TITLE: LAYOUT OF POWER HOUSE & TRANSFORMER HALLS

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE: 1:400 DRAWING NO. 1200-2131-002



NOTE:

1) ALL DIMENSIONS ARE IN mm; AND ALL ELEVATIONS IN m.
2) FOR SECTION C–C' REFER TO DRG: 1200–2131–013.
3) FOR SECTION D–D' REFER TO DRG: 1200–2131–012.

REFERENCE DRAWINGS

S.NO	TITLE	DRG. NO.
1	LAYOUT OF TRANSFORMER HALL	1200–2131–002
2	C/S OF P.H./TR. HALLS & DUCT TUNNELS	1200–2131–013

D.P.R. DRAWING

Print Issue Date 17/1/1996

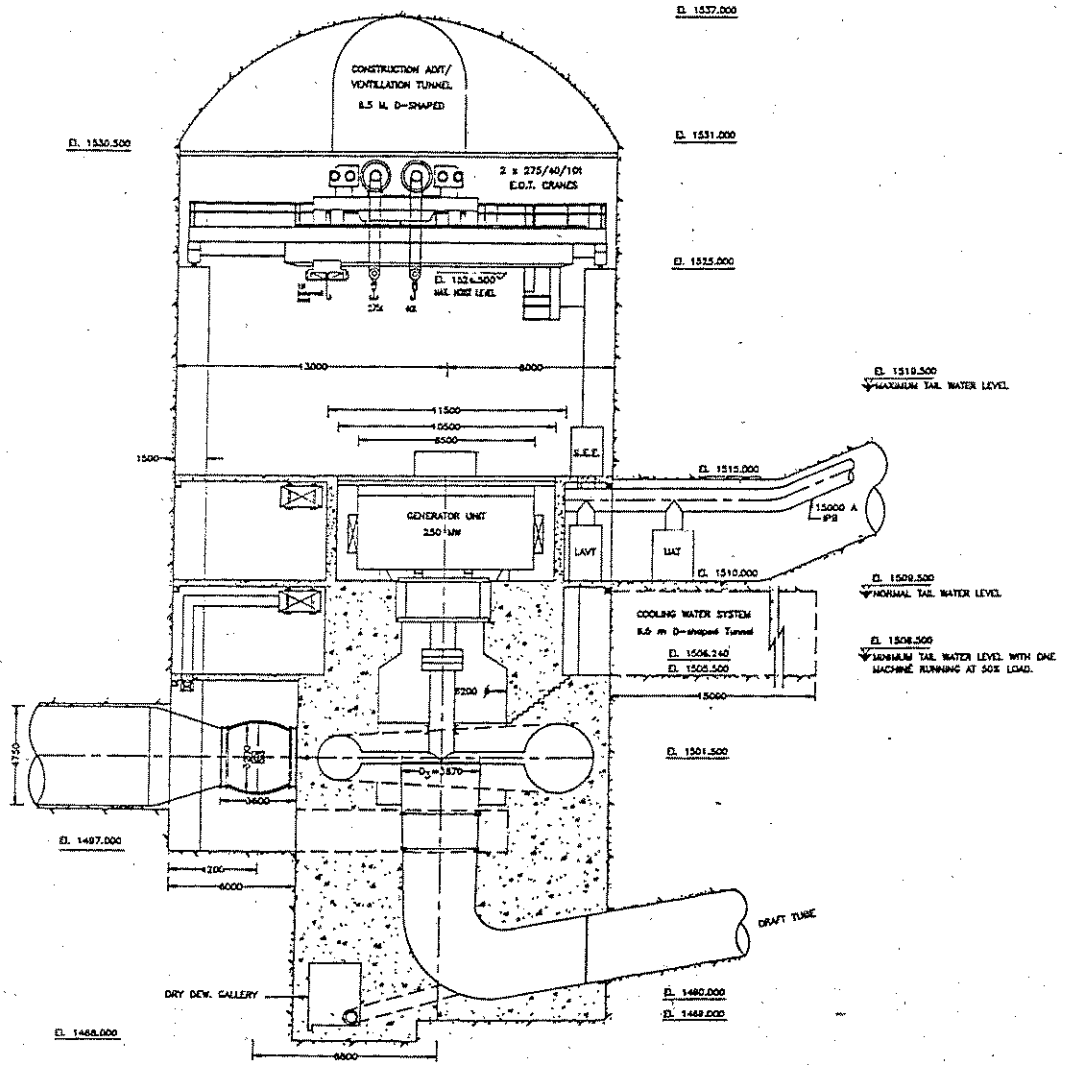
JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division)

PROJECT: KARCHAM–WANGTOO H. E. POWER STATION (4 x 250 MW)

TITLE: DETAILED CROSS SECTION OF P.H. & TRANSFORMER HALLS

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE N.T.S. DRAWING NO. 1200–2131–001



Rating

Output	250 MW
N	214.30 RPM
N_s	113.51
Q	104.25 Cumecs
Design Head	273.50 m
Rotor Wt.	429 t
ROTATION	ANTI-CLOCKWISE
VALVE DIA	3200 mm

NOTES

1. ALL DIMENSIONS ARE IN mm AND LEVELS ARE IN METRES.

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	LONGITUDINAL SECTION OF POWER HOUSE THROUGH TURBINE	1200-2131-005
2	FLOOR PLAN OF POWER HOUSE – EL. 1488.0 & 1487.0	1200-2131-006
3	FLOOR PLAN OF POWER HOUSE – EL. 1500.500	1200-2131-007
4	FLOOR PLAN OF POWER HOUSE – EL. 1516.000	1200-2131-008
5	FLOOR PLAN OF POWER HOUSE – EL. 1515.000	1200-2131-009

DPR DRAWING

Print Issue Date 18/01/1998

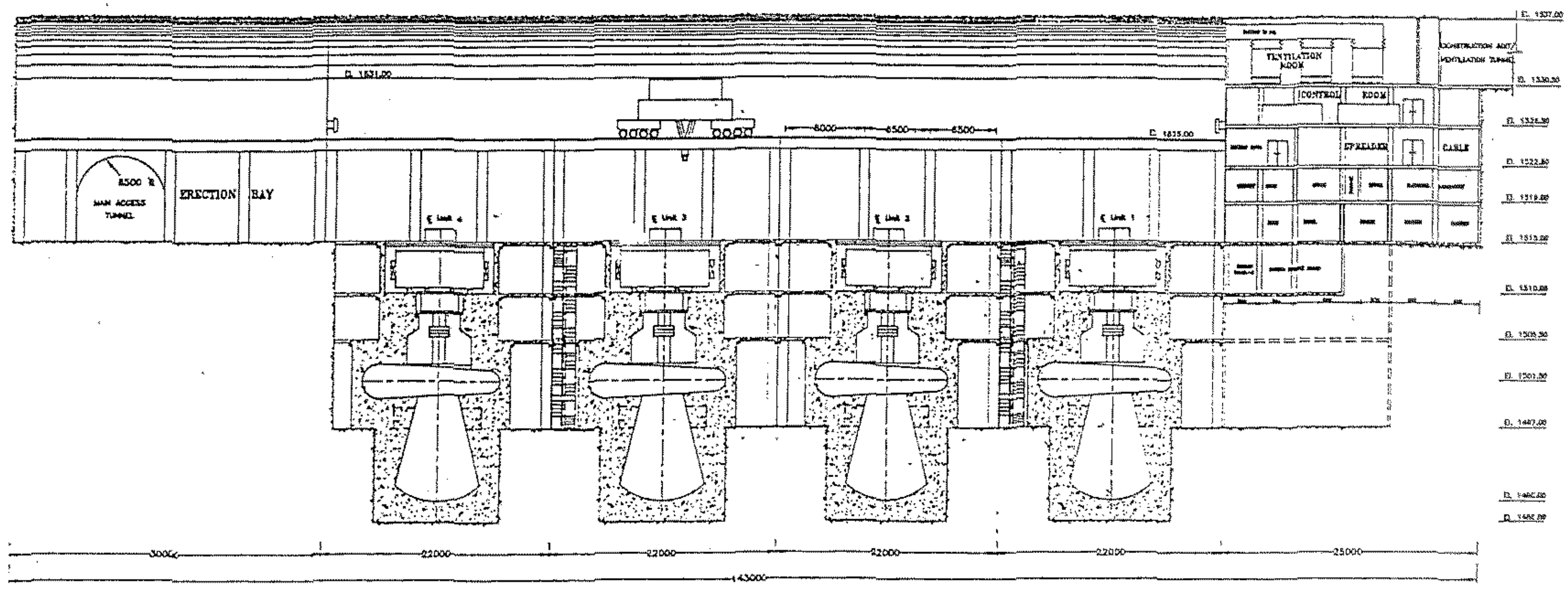
JAIPRAKASH INDUSTRIES LIMITED (Hydro Power Division)

PROJECT KARCHAM WANGTOO HYDRO ELECTRIC PROJECT (4x250 MW)

TITLE CROSS SECTION OF POWER HOUSE THROUGH TURBINE

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE 1:150 DRAWING NO. 1200-2131-004 REV.



NOTES

1 ALL DIMENSIONS ARE IN mm AND LEVELS ARE IN METRES.

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	CROSS SECTION OF POWER-HOUSE THROUGH TURBINE	1200-2131-004
2	FLOOR-PLAN OF POWER HOUSE EL. 1480.0 & 1497.0	1200-2131-006
3	FLOOR-PLAN OF POWER-HOUSE EL. 1505.50	1200-2131-007
4	FLOOR-PLAN OF POWER HOUSE EL. 1510.00	1200-2131-008
5	FLOOR PLAN OF POWER HOUSE EL. 1515.00	1200-2131-009

DPR DRAWING

Print Issue Date 15/01/1996

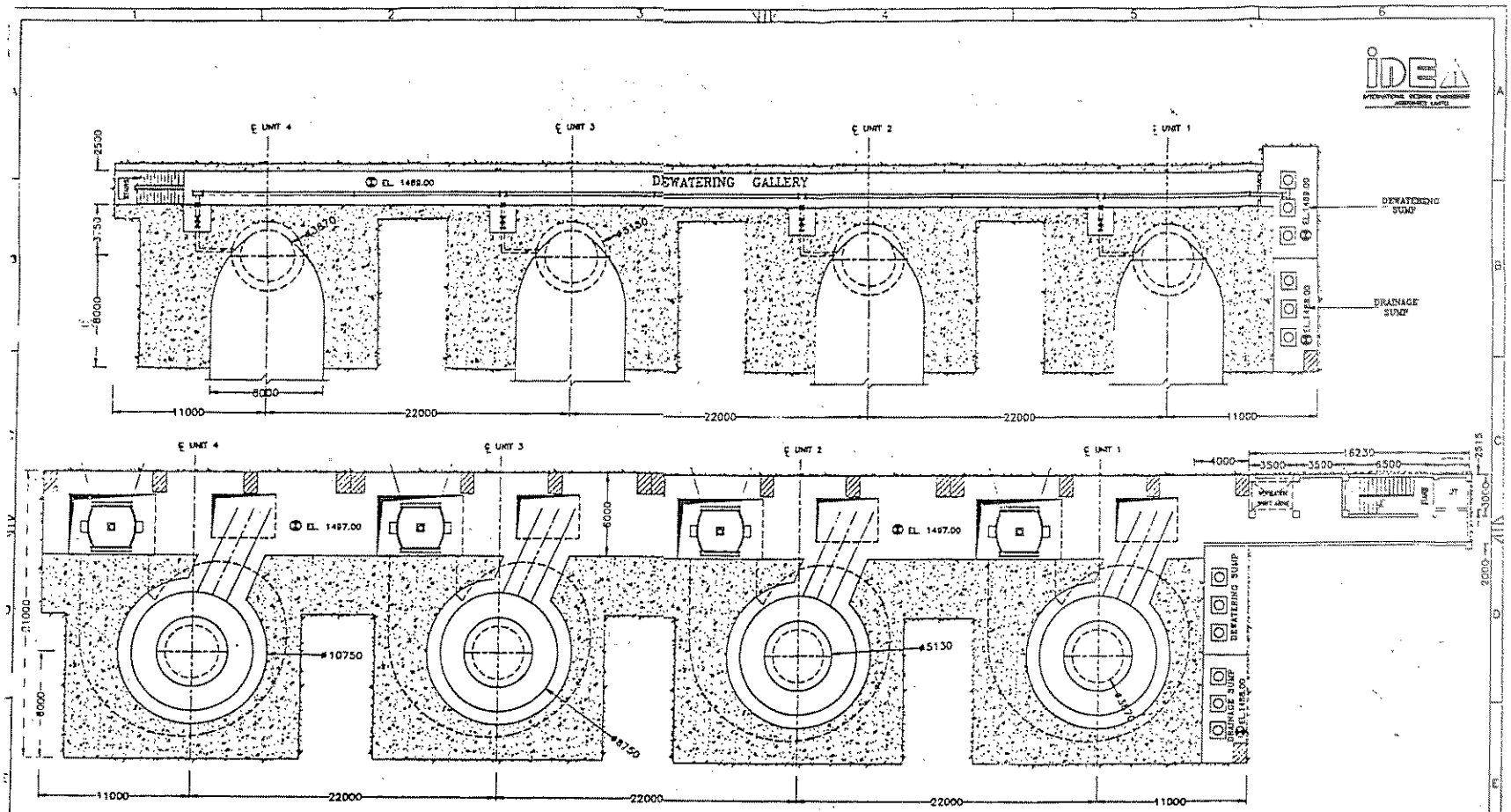
JAIPRAKASH INDUSTRIES LIMITED (Hydro Power Division)

PROJECT KARCHAM WANGTOO HYDRO ELECTRIC PROJECT (4x250 MW)

TITLE LONGITUDINAL SECTION OF POWER HOUSE THROUGH TURBINE

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE 1:300 DRAWING NO. 1200-2131-005 REV.



NOTES

1 ALL DIMENSIONS ARE IN mm AND LEVELS ARE IN METRES.

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	CROSS SECTION OF POWER HOUSE THROUGH TURBINE	1200-2131-004
2	LONGITUDINAL SECTION OF POWER HOUSE THROUGH TURBINE	1200-2131-005
3	FLOOR PLAN OF POWER HOUSE EL 1505.50	1200-2131-007
4	FLOOR PLAN OF POWER HOUSE EL 1510.00	1200-2131-008
5	FLOOR PLAN OF POWER HOUSE EL 1515.00	1200-2131-009

DPR DRAWING

Print issue Date 11/01/1996

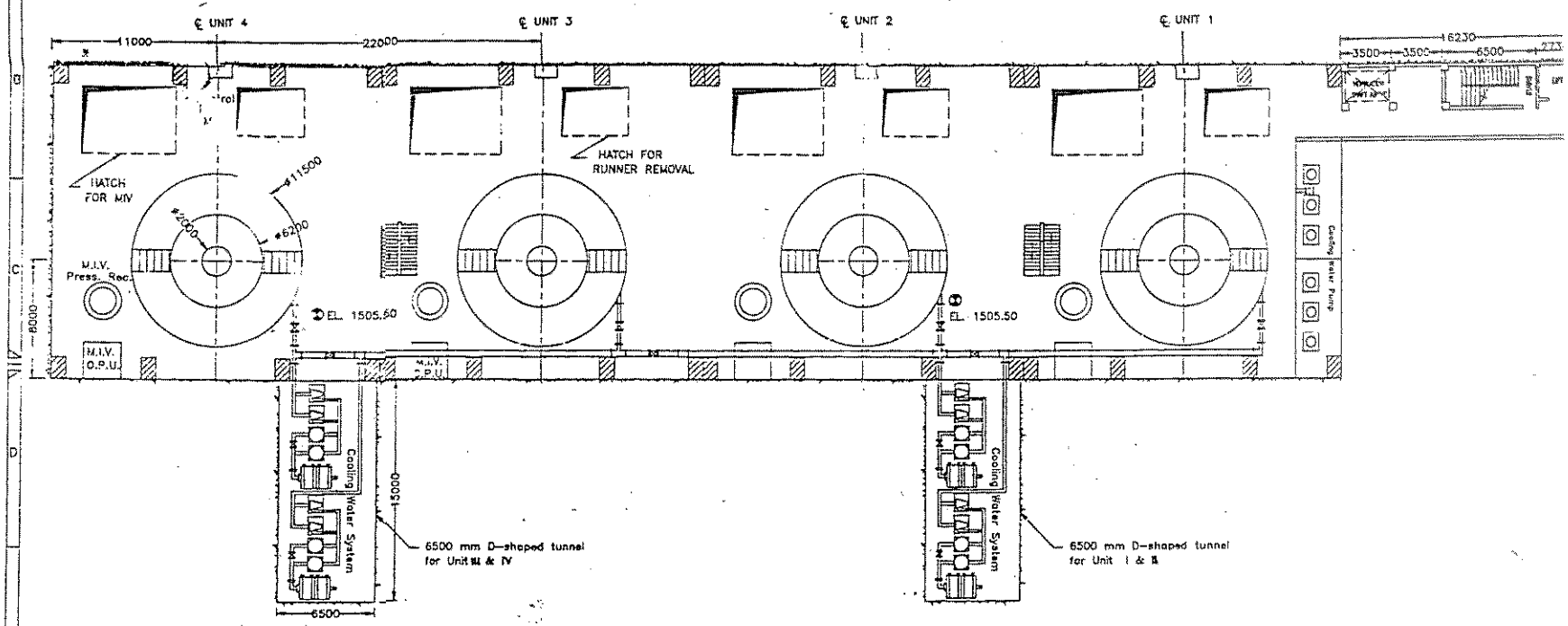
JAIPRAKASH INDUSTRIES LIMITED (Hydro Power Division)

PROJECT KARCHAM WANGTOO HYDRO ELECTRIC PROJECT (4x250 MW)

TITLE FLOOR PLAN OF POWER HOUSE - EL. 1469.0 & 1497.0 (ICT FLOOR)

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE 1:200 DRAWING NO. 1200-2131-006 REV.



NOTES

1. ALL DIMENSIONS ARE IN mm AND LEVELS ARE IN METRES.

DPR DRAWING

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	CROSS SECTION OF POWER HOUSE THROUGH TURBINE	1200-2131-004
2	LONGITUDINAL SECTION OF POWER HOUSE THROUGH TURBINE	1200-2131-005
3	FLOOR PLAN OF POWER HOUSE - EL. 1489.00 & 1497.00	1200-2131-006
4	FLOOR PLAN OF POWER HOUSE - EL. 1510.00	1200-2131-008
5	FLOOR PLAN OF POWER HOUSE - EL. 1513.00	1200-2131-009

Print Issue Date 11/01/1996

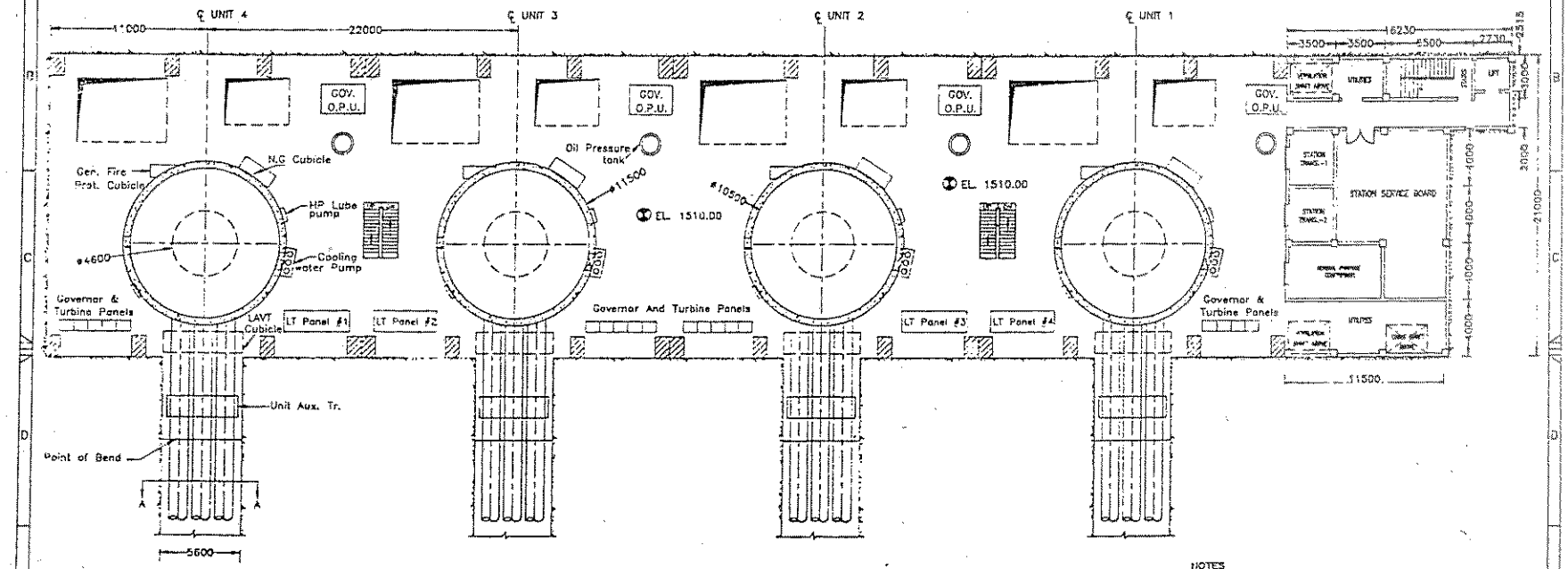
JAIPRAKASH INDUSTRIES LIMITED (Hydro Power Division)

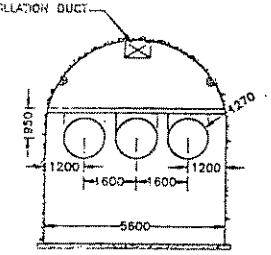
PROJECT KARCHAM WANGTOO HYDRO ELECTRIC PROJECT (4x250 MW)

TITLE FLOOR PLAN OF POWER HOUSE - EL. 1505.50

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE 1:200 DRAWING NO. 1200-2131-007 REV.





Section AA
(Scale 1:100)

NOTES

1. ALL DIMENSIONS ARE IN mm AND LEVELS ARE IN METRES.

REFERENCE DRAWINGS

SNO	TITLE	DWG. NO.
1	CROSS SECTION OF POWER HOUSE THROUGH TURBINE	1200-2131-004
2	LONGITUDINAL SECTION OF POWER HOUSE THROUGH TURBINE	1200-2131-005
3	FLOOR PLAN OF POWER HOUSE – EL. 1499.00 & 1497.20	1200-2131-006
4	FLOOR PLAN OF POWER HOUSE – EL. 1503.300	1200-2131-007
5	FLOOR PLAN OF POWER HOUSE – EL. 1513.00	1200-2131-008

DPR DRAWING

Print Issue Date 09/01/1998

Designed	S. Chandra Director	Drawing Checked	A.K. Gupta Manager	Approved	S. Chandra Director

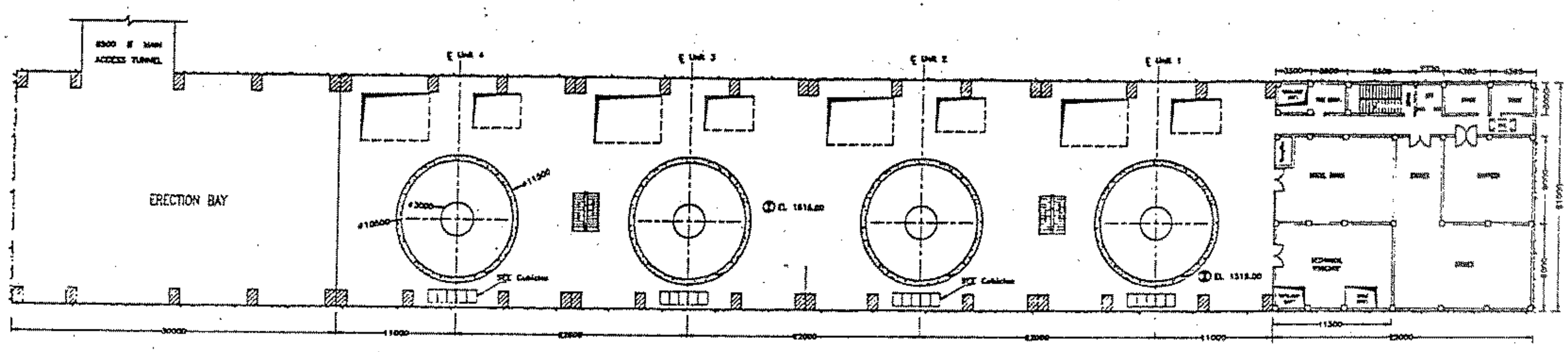
JAIPRAKASH INDUSTRIES LIMITED (Hydro Power Division)

PROJECT KARCHAM WANGTOO HYDRO ELECTRIC PROJECT (4x250 MW)

TITLE FLOOR PLAN OF POWER HOUSE – EL. 1510.000

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE 1:200 DRAWING NO. 1200-2131-008 REV.



NOTES

1. [illegible]

REFERENCE DRAWINGS

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1	[illegible]	1200-2131-[illegible]
2	LONGITUDINAL SECTION OF POWER HOUSE THROUGH [illegible]	1200-2131-[illegible]
3	[illegible] PLAN OF POWER HOUSE – EL. [illegible]	1200-2131-[illegible]
4	FLOOR PLAN OF POWER HOUSE – EL. [illegible]	1200-2131-007
5	FLOOR PLAN OF POWER HOUSE – EL. [illegible]	1200-2131-[illegible]

DPR DRAWING

Print Issue Date	11/01/1998

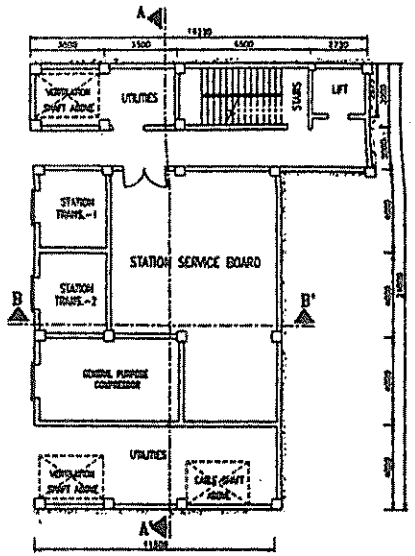
JAIPRAKASH INDUSTRIES LIMITED (Hydro Power Division)

PROJECT: KARCHAM WANGTOO HYDRO ELECTRIC PROJECT (4x250 MW)

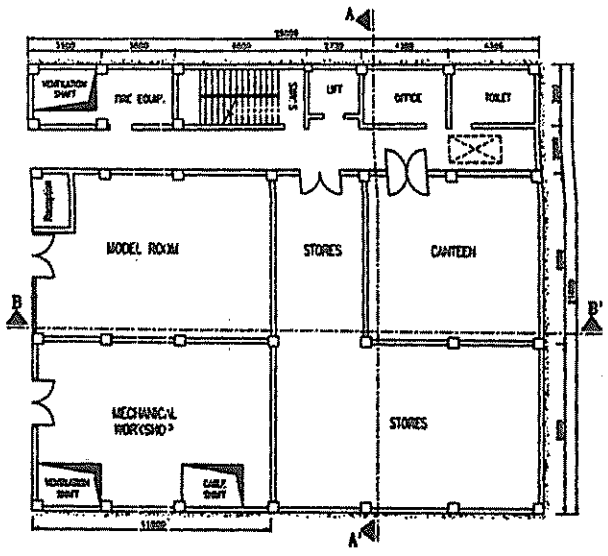
TITLE: FLOOR PLAN OF POWER HOUSE – EL. 1515.000

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

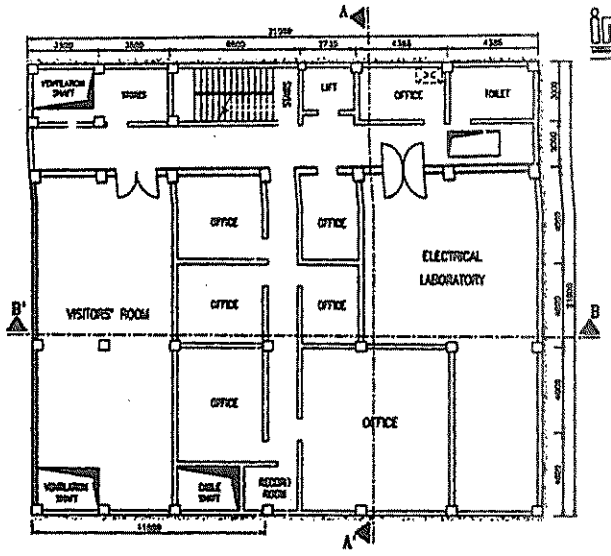
SCALE	DRAWING NO.	REV.
1:300	1200-2131-009	



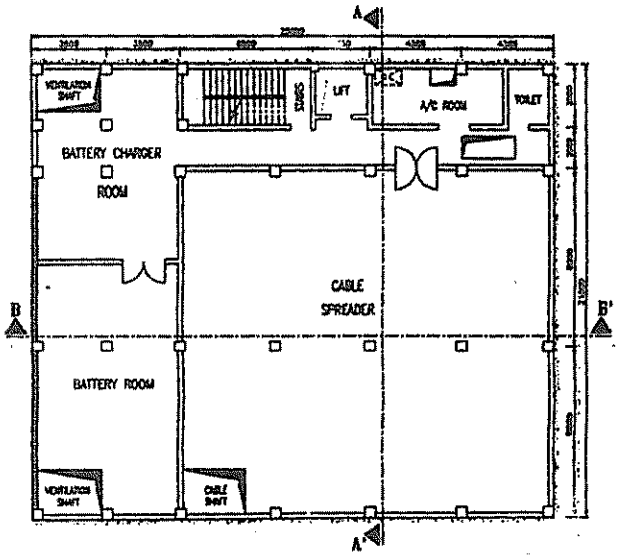
PLAN at EL. 1510.0 m



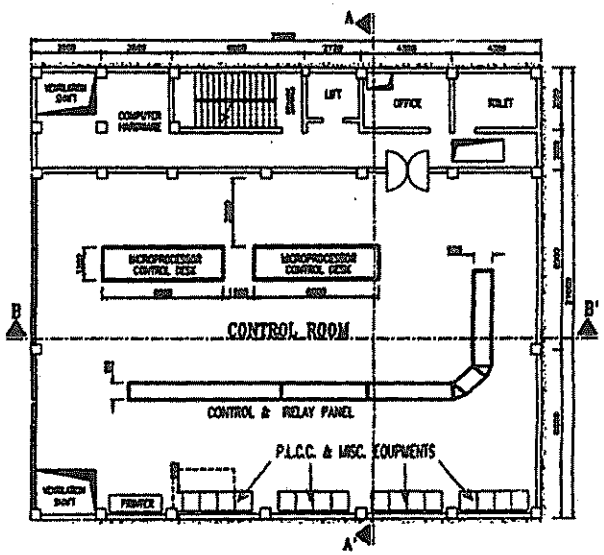
PLAN at EL. 1515.0 m



PLAN at EL. 1510.0 m



PLAN at EL. 1522.5 m



PLAN at EL. 1526.5 m

NOTE:

1) ALL DIMENSIONS ARE IN mm.; AND ALL ELEVATIONS IN m.

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	PLANS & SECTION OF CONTROL BLOCK	1200-2131-011
2		

D.P.R. DRAWING

Print Issue Date	13/1/1998		
Designed		Drawn	
Checked	S. Chandra Shekar	Drawing Checked	
Approved		Approved	S. Chandra Shekar

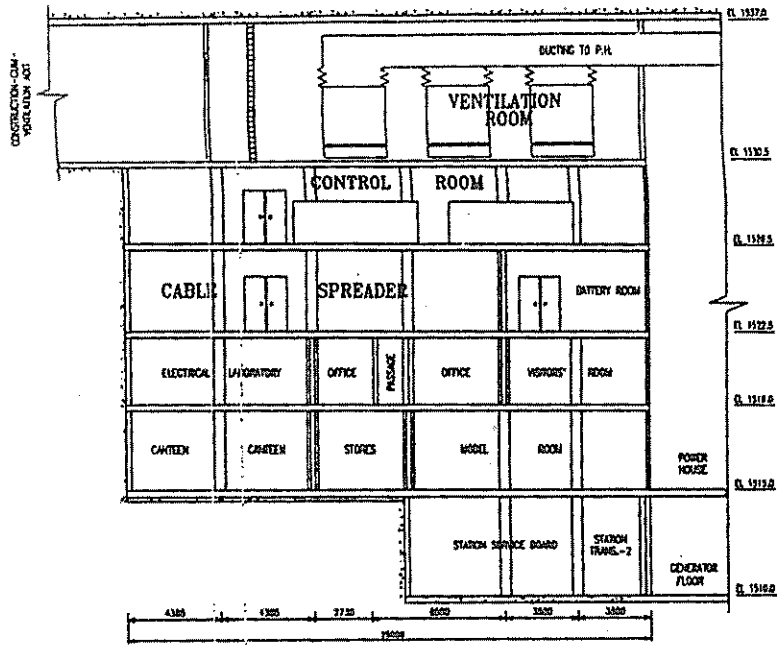
JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division)

PROJECT: KARCHAM-WANGTOO H. E. POWER STATION (4 x 250 MW)

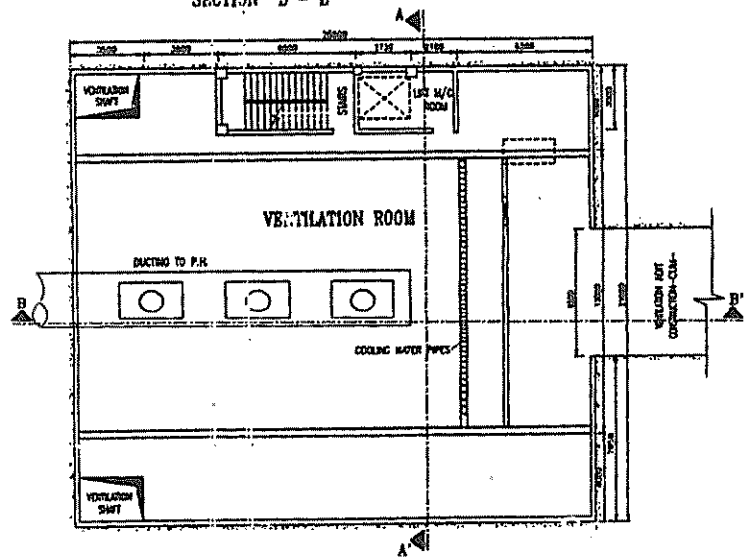
TITLE: LAYOUT PLANS OF CONTROL BLOCK

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

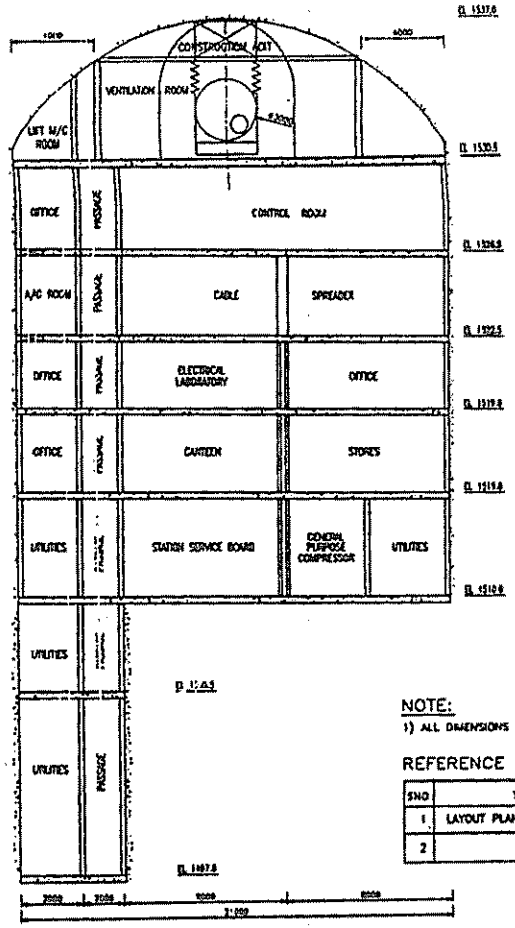
SCALE	DRAWING NO.	REV.
1:150	1200-2131-010	



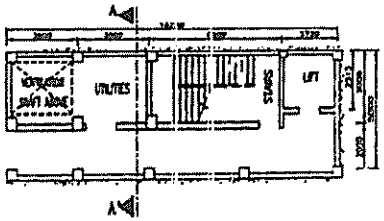
SECTION B – B'



PLAN at EL. 1530.5 m



SECTION A – A'



PLAN at EL. 1497.0 m
(SIMILAR TO PLAN AT EL. 1505.5)

NOTE:
1) ALL DIMENSIONS ARE IN mm.; AND ALL ELEVATIONS IN m.

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	LAYOUT PLANS OF CONTROL BLOCK	1200-2131-010
2		

D.P.R. DRAWING

Print Issue Date 13/1/1998

Designed S. Chandra Director

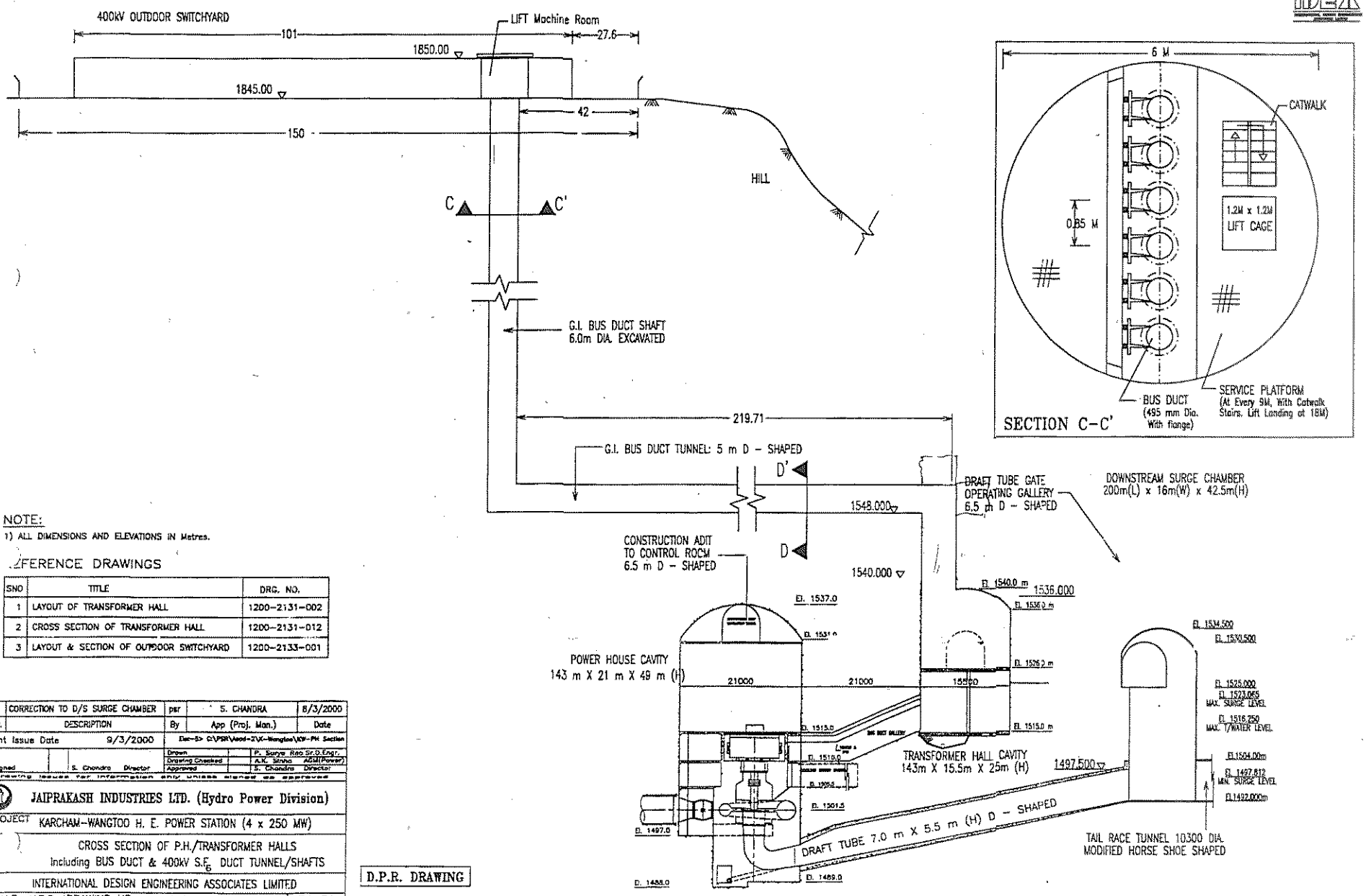
JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division)

PROJECT KARCHAM-WANGTOO H. E. POWER STATION (4 x 250 MW)

TITLE PLANS & SECTION OF CONTROL BLOCK

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE 1:150 DRAWING NO. 1200-2131-011 REV.



NOTE:

1) ALL DIMENSIONS AND ELEVATIONS IN Metres.

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	LAYOUT OF TRANSFORMER HALL	1200-2131-002
2	CROSS SECTION OF TRANSFORMER HALL	1200-2131-012
3	LAYOUT & SECTION OF OUTDOOR SWITCHYARD	1200-2133-001

Rev.	DESCRIPTION	By	App (Proj. Man.)	Date
R1	CORRECTION TO D/S SURGE CHAMBER	per	S. CHANDRA	8/3/2000
Print Issue Date	9/3/2000	Elec-S> C:\PSR\Wood-2\K-Wangtoo\KW-PH Section		
Designed	S. Chandra Director	Drawn	P. Surya Rao Sr.D.Engr.	
		Drawing Checked	A.K. Sinha ADM(Power)	
		Approved	S. Chandra Director	

Drawing issued for information only unless signed as approved

JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division)

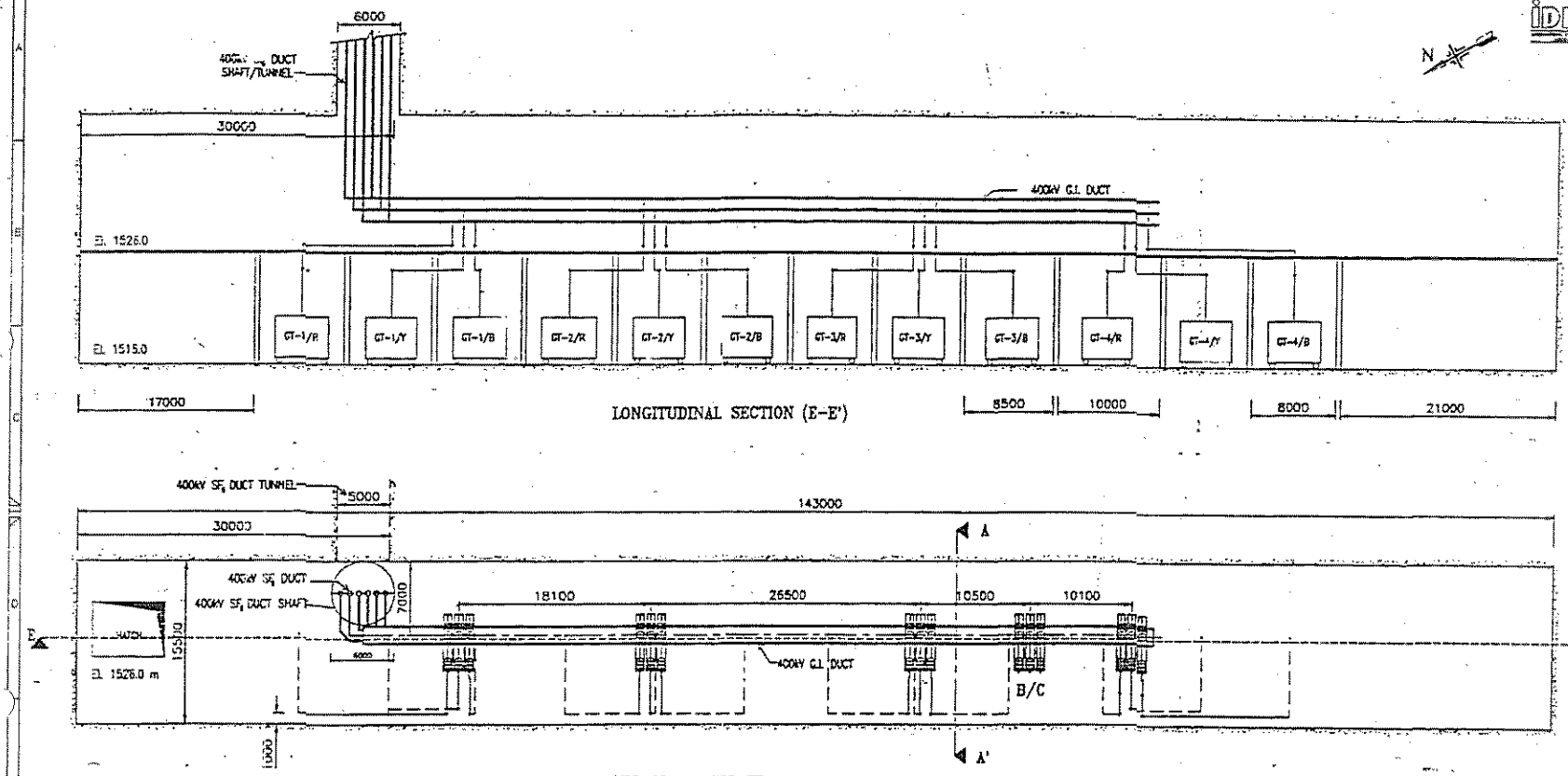
PROJECT KARCHAM-WANGTOO H. E. POWER STATION (4 x 250 MW)

CROSS SECTION OF P.H./TRANSFORMER HALLS
Including BUS DUCT & 400kV $S.F_6$ DUCT TUNNEL/SHAFTS

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE N.T.S. DRAWING NO. 1200-2131-013 REV. R1

D.P.R. DRAWING



NOTE:

1) ALL DIMENSIONS ARE IN mm. AND ALL ELEVATIONS IN m.
2) FOR DETAILED SECTIONS, REFER DRG. 1200-2131-012 & -013.

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	LAYOUT OF TRANSFORMER HALL	1200-2131-002
2	CROSS SECTION OF TRANSFORMER HALL	1200-2131-012
3	C/S OF P.H./TR. HALLS & DUCT TUNNEL/SHAFT	1200-2131-013
4	SINGLE LINE DIAG. FOR G.I.S. INTERCONNECTIONS	1200-2132-003

D.P.R. DRAWING

Print Issue Date 17/1/1996

Designed | S. Chandra Director | Drawn | Checked | Approved

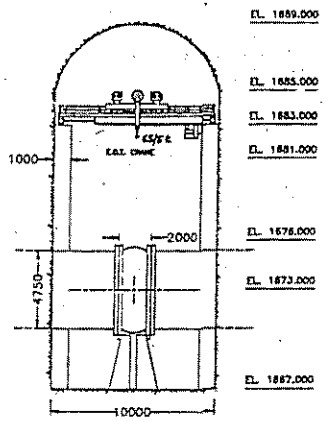
JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division)

PROJECT: KARCHAM-WANGTOO H. E. POWER STATION (4 x 250 MW)

TITLE: PLAN AND LONGITUDINAL SECTION OF UNDERGROUND 400kV G.I.S. HALL

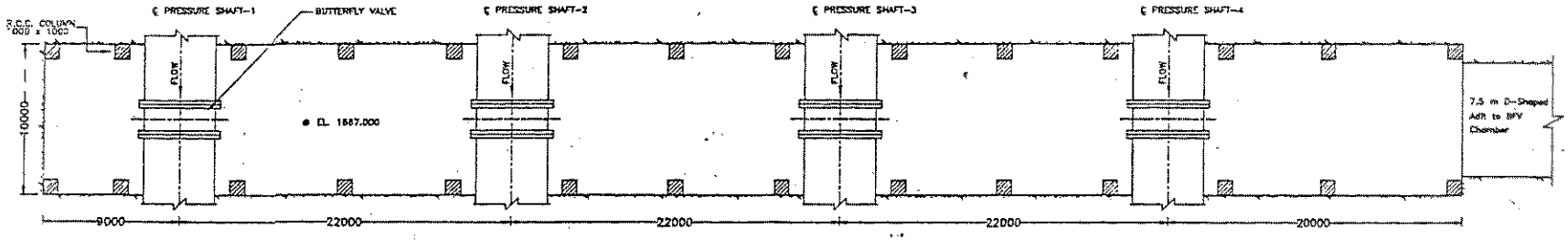
INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE 1:400 | DRAWING NO. 1200-2131-014 | REV. 0



SECTION – AA

FLOW



PLAN AT EL. 1667.000

NOTES

1. ALL DIMENSIONS ARE IN mm AND LEVELS ARE IN METRES.

DPR DRAWING

Print Issue Date	10/01/1999

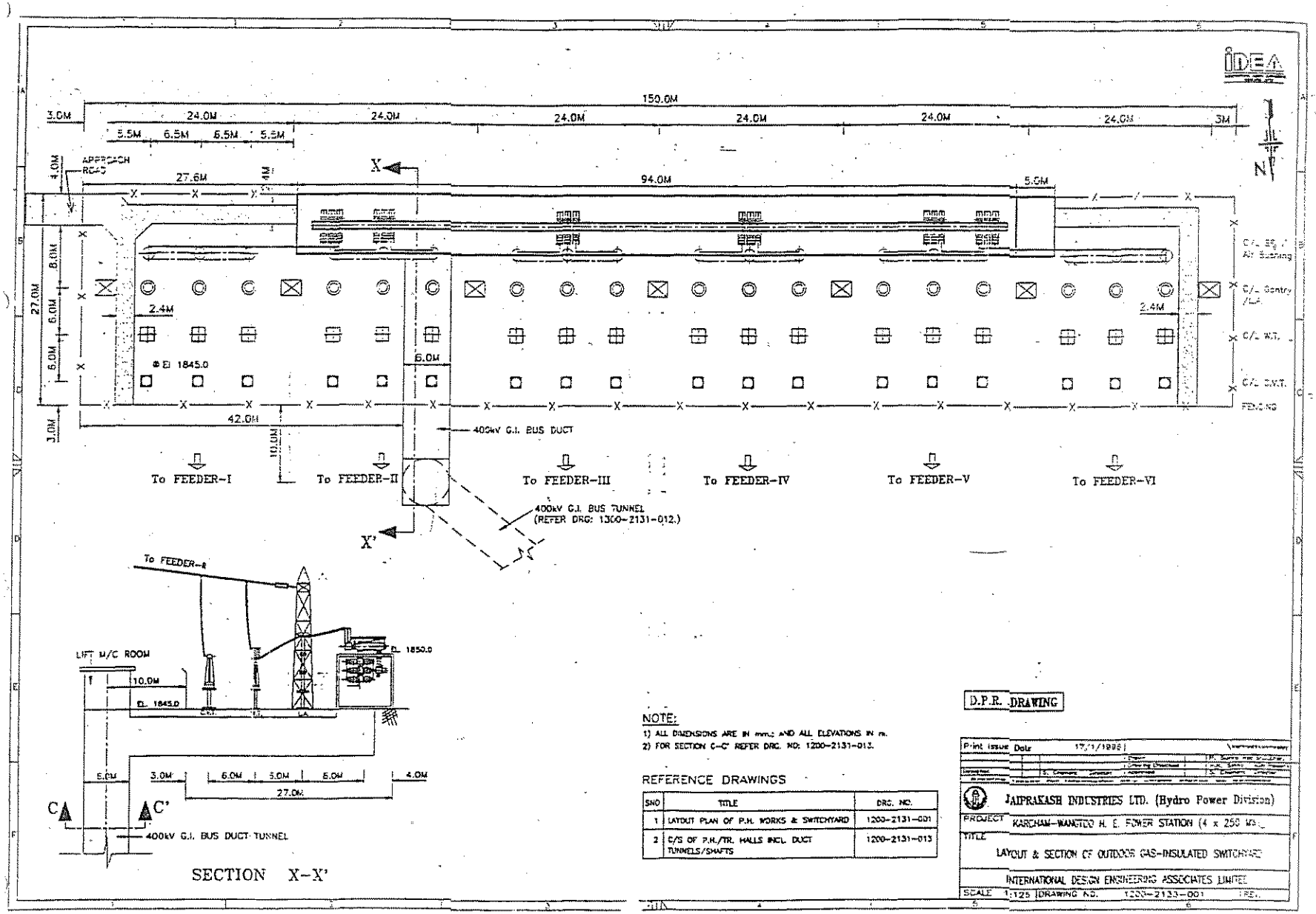
JAIPRAKASH INDUSTRIES LIMITED (Hydro Power Division)

PROJECT: KARCHAM WANGTOO HYDRO ELECTRIC PROJECT (4x250 MW)

TITLE: PLAN AND SECTION OF THE BUTTERFLY VALVE CHAMBER

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE 1:200 | DRAWING NO. 1200--2137--001 | REV.



NOTE:

1) ALL DIMENSIONS ARE IN mm; AND ALL ELEVATIONS IN m.
2) FOR SECTION C–C' REFER DRG. NO: 1200-2131-013.

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	LAYOUT PLAN OF P.H. WORKS & SWITCHYARD	1200-2131-001
2	C/S OF P.H./TR. HALLS INCL. DUCT TUNNELS/SHAFTS	1200-2131-013

D.P.R. DRAWING

Print Issue Date 17/1/1998

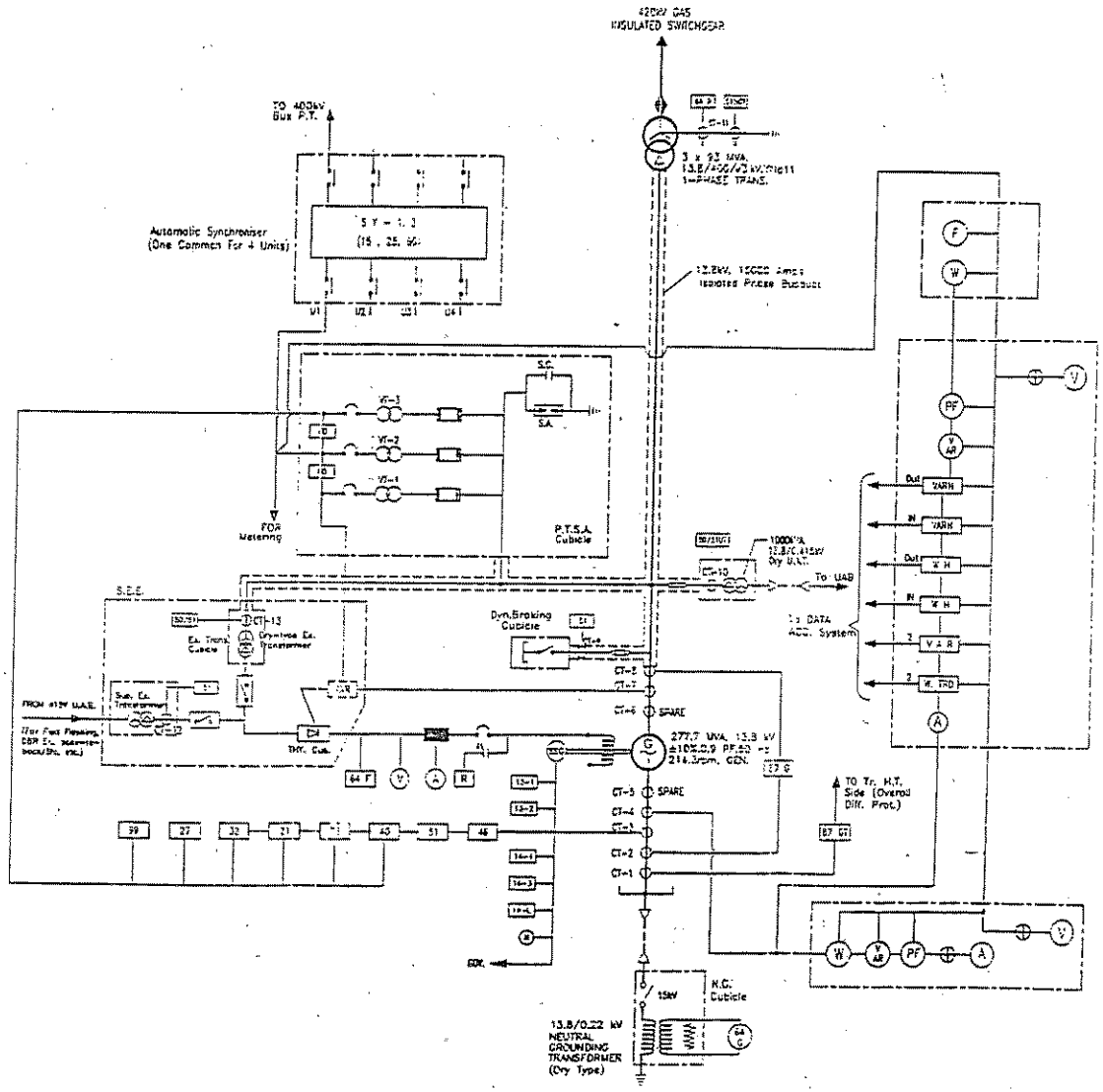
JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division)

PROJECT KARCHAM-WANGTOO H. E. POWER STATION (4 x 250 MW)

TITLE LAYOUT & SECTION OF OUTDOOR GAS-INSULATED SWITCHYARD

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE 1:125 DRAWING NO. 1200-2133-001 REV.



LEGEND

	GENERATOR
	GENERATOR TRANSFORMER
	SURGE ARRESTOR (S.A.)
	SURGE CAPACITOR (S.C.)
	VOLTAGE TRANSFORMER
	CURRENT TRANSFORMER
	DISCONNECT SWITCH
	SF6/OIL BUSHING
	CABLE CONNECTION
	ISOLATED PHASE BUS DUCT
	SELECTOR SWITCH

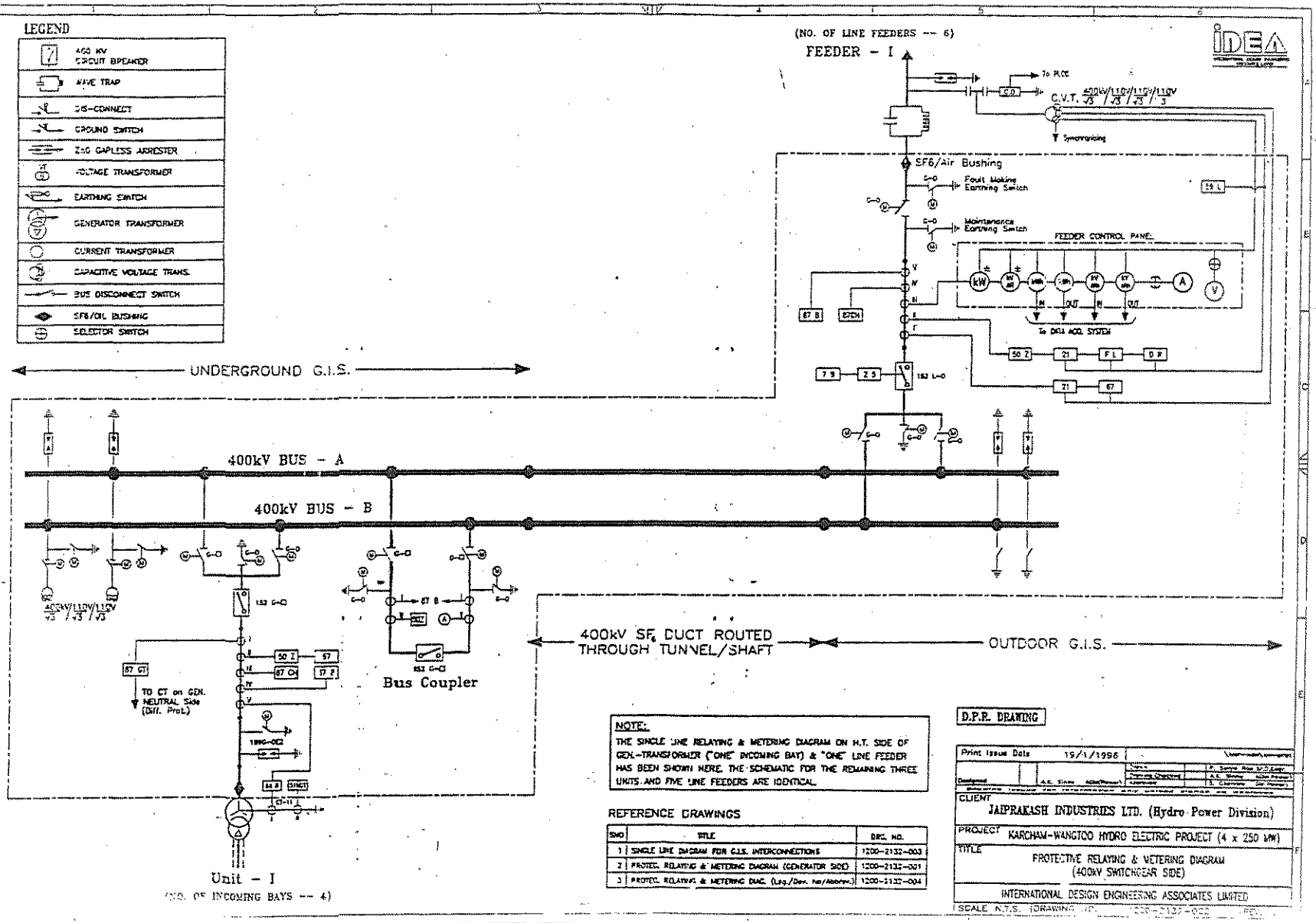
NOTE:
THIS SINGLE LINE RELAYING & METERING DIAGRAM, UPTO L.T. SIDE OF GEN.-TRANSFORMER, IS SHOWN FOR "ONE" INCOMING BAY ONLY. THE SCHEMATIC FOR THE REMAINING 3 UNITS ARE IDENTICAL.

REFERENCE DRAWINGS

S.NO	TITLE	DRG. NO.
1	SINGLE LINE DIAGRAM FOR G.I.S. INTERCONNECTIONS	1200-2132-003
2	PROTEC. RELAYING & METERING DWG. (400kV S/GEAR SIDE)	1200-2132-002
3	PROTEC. RELAYING & METERING DWG. (Leg./Det. No/Annexure)	1200-2132-004

D.P.R. DRAWING

Print Issue Date	18/1/1996
CLIENT	JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division)
PROJECT	KARCHAM-WANGTOO HYDRO ELECTRIC PROJECT (4 x 250 MW)
TITLE	PROTECTIVE RELAYING & METERING DIAGRAM (GENERATOR S.IDE)
	INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED
SCALE N.T.S.	DRAWING NO. 1200-2132-001 REV. 0



NOTE:
THE SINGLE LINE RELAYING & METERING DIAGRAM ON H.T. SIDE OF GEN.-TRANSFORMER ("ONE" INCOMING BAY) & "ONE" LINE FEEDER HAS BEEN SHOWN HERE. THE SCHEMATIC FOR THE REMAINING THREE UNITS AND FIVE LINE FEEDERS ARE IDENTICAL.

D.P.R. DRAWING

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	SINGLE LINE DIAGRAM FOR G.I.S. INTERCONNECTIONS	1200-2132-003
2	PROTEC. RELAYING & METERING DIAGRAM (GENERATOR SIDE)	1200-2132-001
3	PROTEC. RELAYING & METERING DIAG. (Lkg./Dev. for/Aborny.)	1200-2132-004

Print Issue Date 15/1/1996

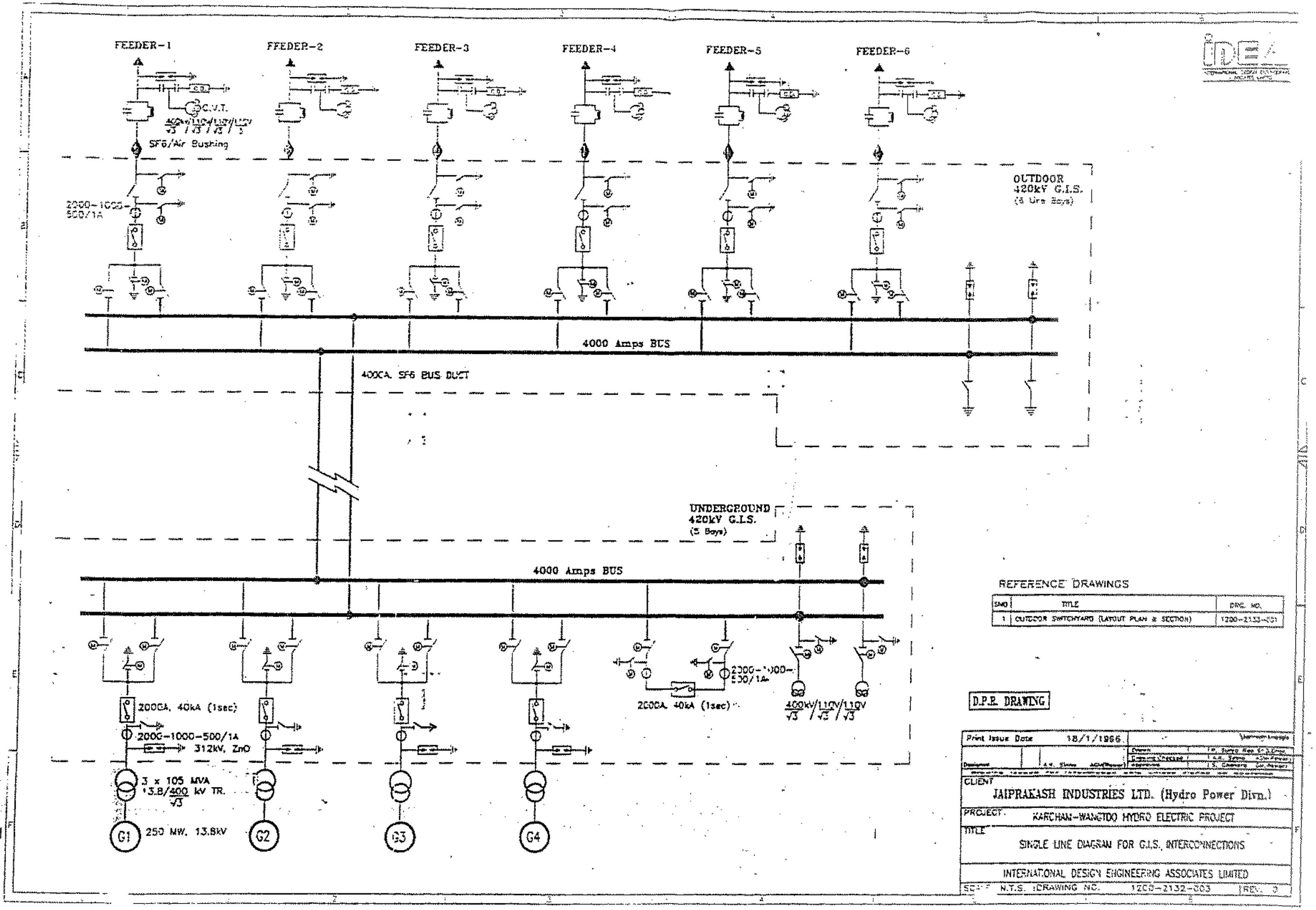
CLIENT
JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division)

PROJECT
KARCHAM-WANGTOO HYDRO ELECTRIC PROJECT (4 x 250 MW)

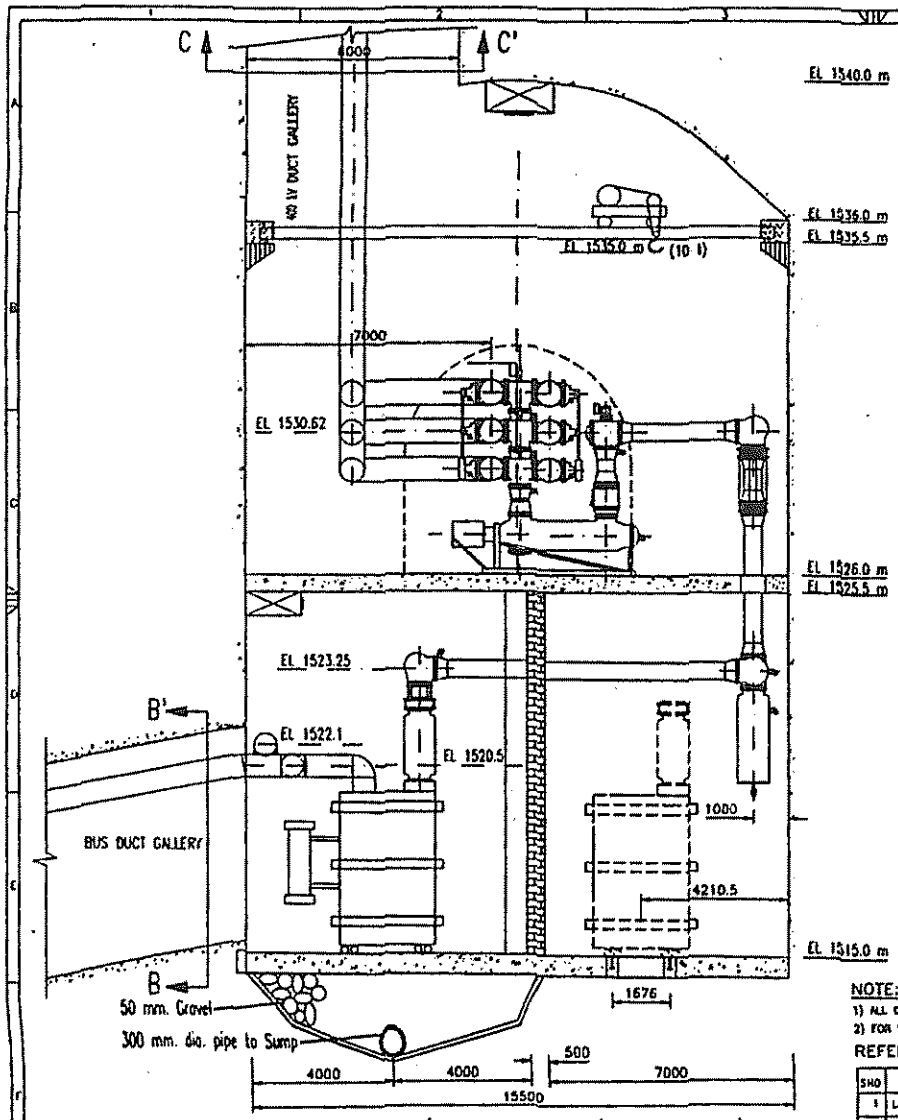
TITLE
PROTECTIVE RELAYING & METERING DIAGRAM
(400kV SWITCHGEAR SIDE)

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

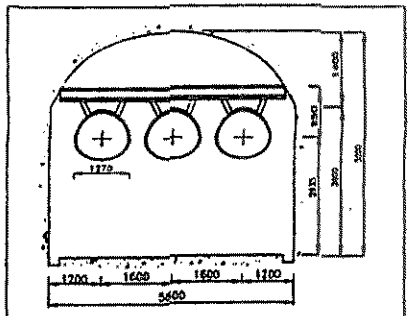
SCALE N.T.S. DRAWING NO. 1200-2132-002 REV.



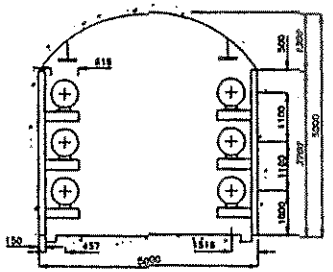
FEEDER-1
FEEDER-2
FEEDER-3
FEEDER-4
FEEDER-5
FEEDER-6
C.V.T.
SF6/Air Bushing
2000-1000-500/1A
OUTDOOR 420kV G.I.S.
4000 Amps BUS
400CA. SF6 BUS DUCT
UNDERGROUND 420kV G.I.S. (5 Bays)
4000 Amps BUS
2000A, 40kA (1sec)
2000-1000-500/1A
312kV, ZnO
3 x 105 MVA
13.8/400 kV TR.
250 MW, 13.8kV
G1
G2
G3
G4
2000A, 40kA (1sec)
REFERENCE DRAWINGS
SNO | TITLE | DRG. NO.
1 | OUTDOOR SWITCHYARD (LAYOUT PLAN & SECTION)
D.P.R. DRAWING
Print Issue Date 18/1/1996
CLIENT
JAIPRAKASH INDUSTRIES LTD. (Hydro Power Divn.)
PROJECT
KARCHAM-WANGTOO HYDRO ELECTRIC PROJECT
TITLE
SINGLE LINE DIAGRAM FOR G.I.S. INTERCONNECTIONS
INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED
N.T.S.
DRAWING NO.
1200-2132-003
REV.



SECTION A-A' (TRANSFORMER/GIS CAVERN)



Section of G.I. BUS DUCT GALLERY (B-B') (Scale = 1:100)



Section of 400kV G.I. Duct Tunnel (D-D') (Scale = 1:100)

D.F.R. DRAWING

NOTE:
1) ALL DIMENSIONS ARE IN mm.; AND ALL ELEVATIONS IN m.
2) FOR SECTION C-C' REFER TO DRG: 1200-2131-013.

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	LAYOUT OF TRANSFORMER HALL	1200-2131-002
2	C/S OF P.H./TR. HALLS & DUCT TUNNELS	1200-2131-013
3	PLAN & L. SECTION OF U/G 400kV GIS HALL	1200-2131-014

Print Issue Date 13/1/1998

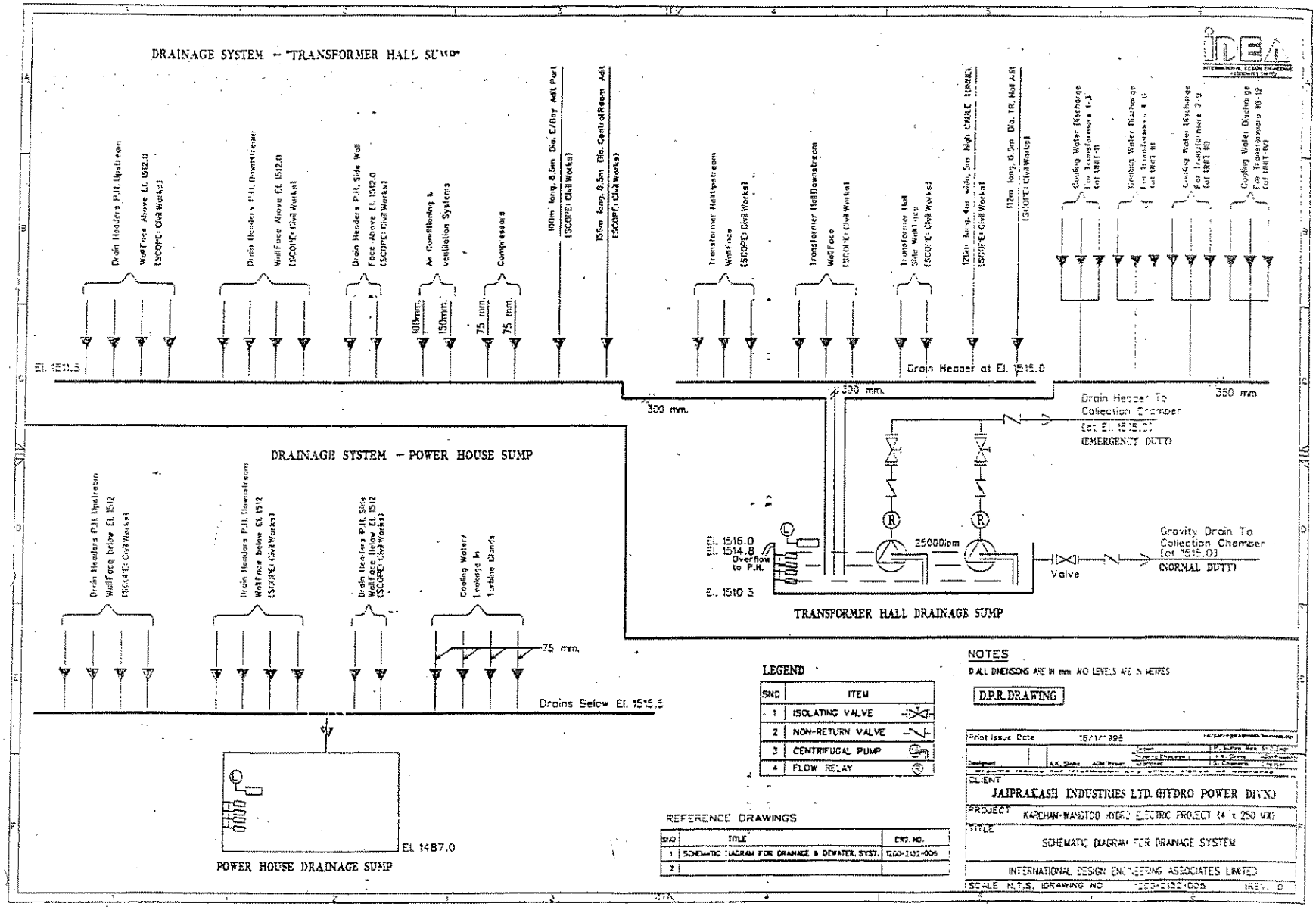
JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division)

PROJECT KARCHAM-WANGTOO H. E. POWER STATION (4 x 250 MW)

TITLE CROSS SECTION OF TRANSFORMER HALL

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE 1:125 DRAWING NO 1200-2131-012 REV.



LEGEND

SNO	ITEM
1	ISOLATING VALVE
2	NON-RETURN VALVE
3	CENTRIFUGAL PUMP
4	FLOW RELAY

REFERENCE DRAWINGS

SNO	TITLE	DWG. NO.
1	SCHEMATIC DIAGRAM FOR DRAINAGE & DEWATER. SYST.	1200-2102-006
2		

NOTES

1) ALL DIMENSIONS ARE IN mm AND LEVELS ARE IN METRES

D.P.R. DRAWING

Print Issue Date 15/11/1995

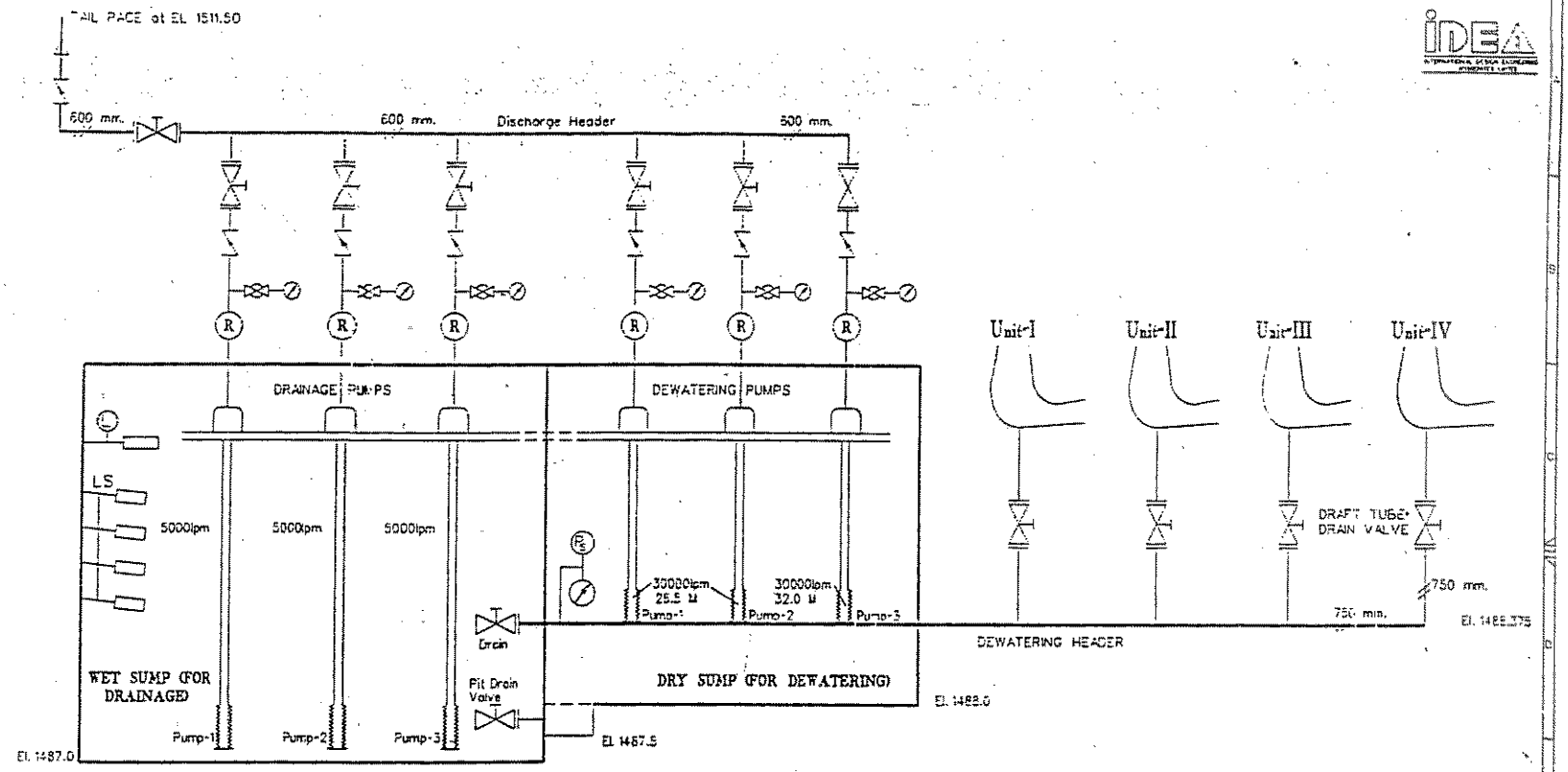
CLIENT: JAIPRAKASH INDUSTRIES LTD. (HYDRO POWER DIVN.)

PROJECT: KARCHAM-WANGTOO (HYDRO) ELECTRIC PROJECT (4 x 250 MW)

TITLE: SCHEMATIC DIAGRAM FOR DRAINAGE SYSTEM

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE: N.T.S. DRAWING NO: 1200-2102-005 REV.: 0



LEGEND

SNO	ITEM
1	ISOLATING VALVE
2	NON-RETURN VALVE
3	FLOW RELAY
4	PRESSURE GAUGE
5	PRESSURE SWITCH
6	VALVE FOR MANOMETER
7	TURBINE PUMP
8	LEVEL SWITCH
9	FLOW ACTIVATED LEVEL TRANSDUCER

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	SCHEMATIC DIAGRAM FOR DRAINAGE SYSTEM	1200-2132-005
2		

NOTES

1) ALL DIMENSIONS ARE IN mm AND LEVELS ARE IN METRES

D.P.R. DRAWING

Print Issue Date	18/1/1996

CLIENT: JAIPRAKASH INDUSTRIES LTD. (HYDRO POWER DIVN.)

PROJECT: KARCHAM-WANGTOO HYDRO ELECTRIC PROJECT (4 x 250 MW)

TITLE: SCHEMATIC DIAGRAM FOR DRAINAGE & DEWATERING SYSTEM

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE: N.T.S. DRAWING NO. 1200-2132-006 REV. 2

LEGEND

	400 KV CIRCUIT BREAKER
	WAVE TRAP
	DIS-CONNECT
	GROUND SWITCH
	ZnO GAPLESS ARRESTER
VT	VOLTAGE TRANSFORMER
	EARTHING SWITCH
	GENERATOR TRANSFORMER
	CURRENT TRANSFORMER
	CAPACITIVE VOLTAGE TRANS.
	BUS DISCONNECT SWITCH
	SF6/OIL BUSHING
	SELECTOR SWITCH
	GENERATOR
	SURGE ARRESTOR (S.A.)
	SURGE CAPACITOR (S.C.)
VT	VOLTAGE TRANSFORMER
	DISCONNECT SWITCH
	CABLE CONNECTION
	ISOLATED PHASE BUS DUCT

DEVICE FUNCTION NUMBERS :

12-1	SPEED OVER 90%
12-2	SPEED OVER 80%
14-1	SPEED BELOW 50%
14-2	SPEED BELOW 15%
14-L	UNIT STOP (0.5%)
15	SPEED BALANCING DEVICE
21	GENERATOR BACKUP IMPEDANCE RELAY
25	SYNCHRONISING RELAY
27	UNDER VOLTAGE RELAY
32	REVERSE POWER RELAY
40	LOSS OF EXCITATION RELAY
46	NEGATIVE PHASE SEQUENCE RELAY
50	LOCAL BREAKER BACKUP PROTECTION RELAY
50Z	BREAKER FAILURE RELAY
51	O/C RELAY WITH TIME DELAY
50/51UT	INSTANTANEOUS/TIME DELAY O/C RELAY
51NGT	TRANSFORMER NEUTRAL O/C RELAY
59L	OVER VOLTAGE RELAY
60	VOLTAGE BALANCE RELAY
64F	GENERATOR FIELD E/F RELAY
64G	100% STATOR E/F PROTECTION RELAY
64R	RESTRICTED EARTH FAULT (E/F) RELAY
67	DIRECTIONAL E/F RELAY
78	OUT OF STEP PROTECTION RELAY
79	AUTO RECLOSING RELAY
87B	BUSBAR DIFF. PROTECTION ZONE 'A' & 'B'
87CH	BUSBAR CHECK DIFFERENTIAL RELAY
87G	PHASE REVERSING ISOLATORS
87GT	DIFF. PROTECTION FOR GEN.-TRANSFORMER
99	OVER FLUXING PROTECTION RELAY

ABBREVIATIONS :

A	AMMETER
AVR	AUTOMATIC VOLTAGE REGULATOR
CD	COUPLING DEVICE
CT	CURRENT TRANSFORMER
DR	DISTURBANCE RECORDER
E/F	EARTH FAULT
F	FREQUENCY METER
FL	DISTANCE TO FAULT RECORDER
kW	KILO-WATT METER
N.G.	NEUTRAL GROUNDING
O/L	OVER LOAD
PF	POWER FACTOR METER
PLCC	POWER LINE CARRIER COMMUNICATION
P.T.	POTENTIAL TRANSFORMER
R	RECORDER
SEE	STATIC EXCITATION EQUIPMENT
SSG	SPEED SIGNAL GENERATOR
TGB	TURBINE GAUGE BOARD
UCB	UNIT CONTROL BOARD
UCD	UNIT CONTROL DESK
V	VOLTMETER
VAR	REACTIVE VOLT AMPERE METER
VARH	REACTIVE VOLT AMPERE HOUR METER
W	WATT METER
WH	WATT HOUR METER
W.TRD	WATT TRANSDUCER

IDEA

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	SINGLE LINE DIAGRAM FOR G.I.S. INTERCONNECTIONS	1200-2132-003
2	PROTEC. RELAYING & METERING DIAGRAM (GENERATOR SIDE)	1200-2132-001
3	PROTEC. RELAYING & METERING DIAG. (400kV S/GEAR SIDE)	1200-2132-002

D.P.R. DRAWING

Print Issue Date	13/1/1998		
		Drawn	P. Surya Prakash
		Checked	A.K. Sinha
Designed	A.K. Sinha	Approved	T. Chetan

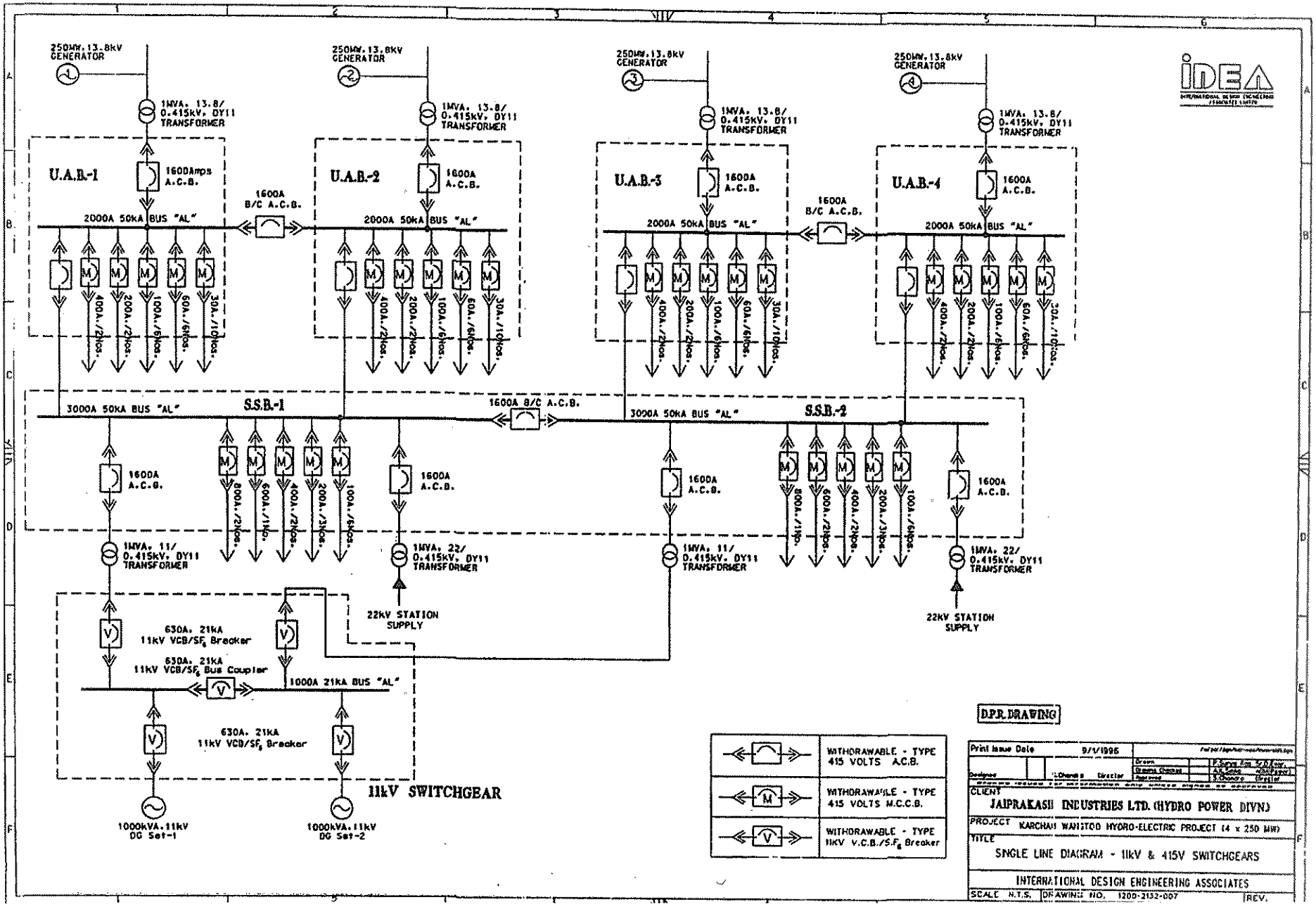
CLIENT: JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division)

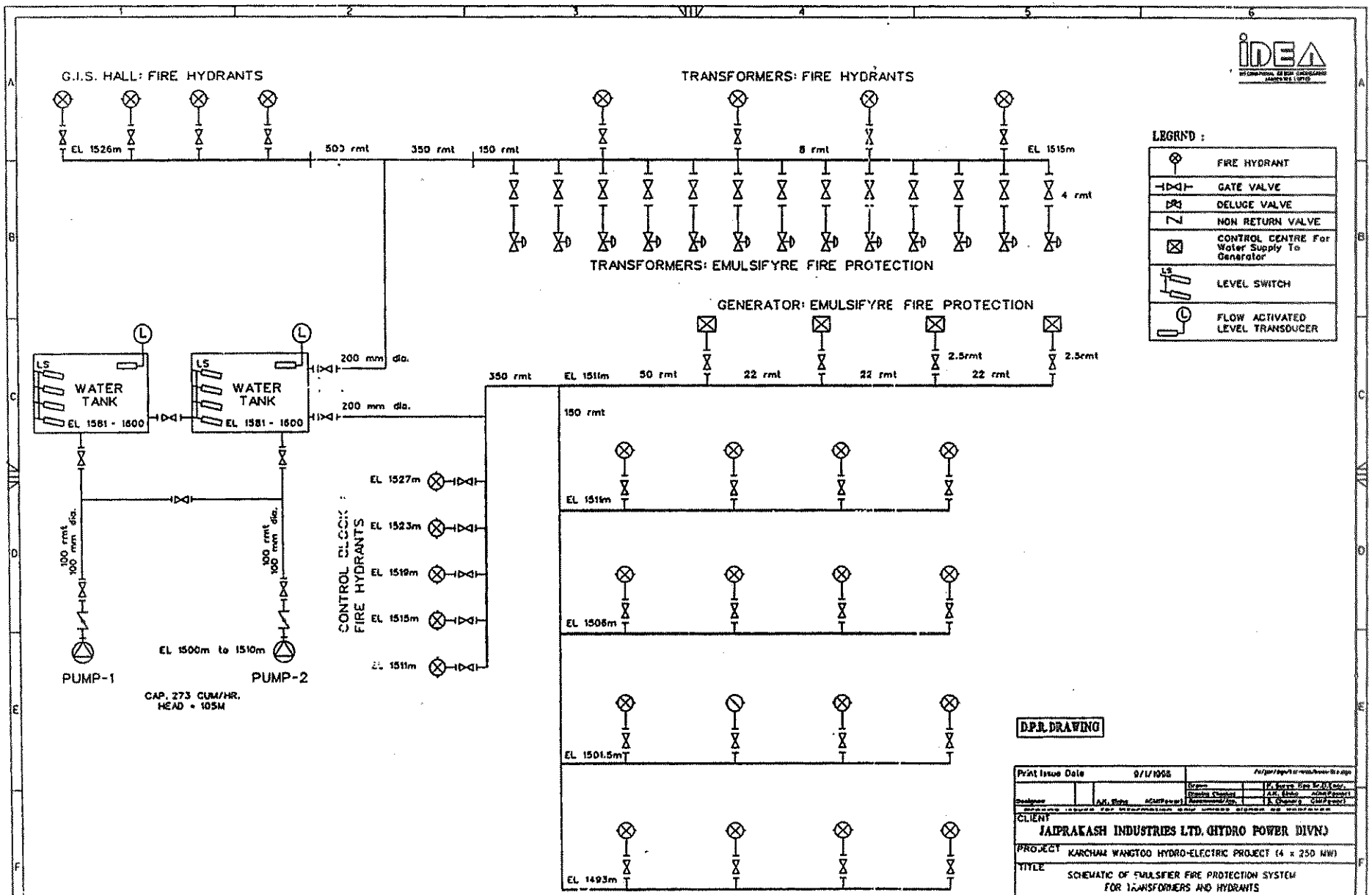
PROJECT: KARCHAM-WANGTOO HYDRO ELECTRIC PROJECT (4 x 250 MW)

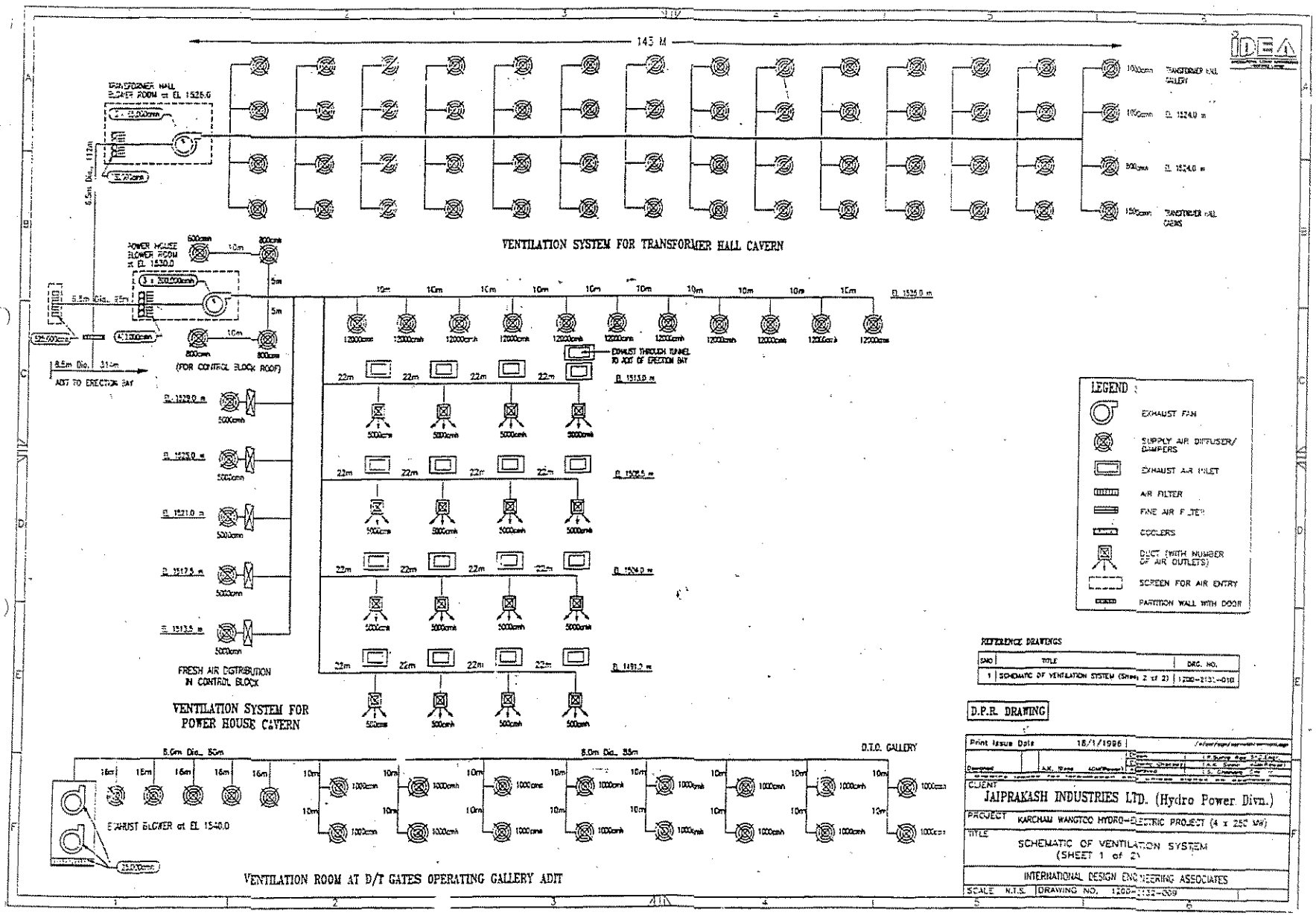
TITLE: PROTECTIVE RELAYING & METERING DIAGRAM (LEGEND, DEVICE NUMBERS & ABBREVIATIONS)

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE N.T.S. | DRAWING NO. 1200-2132-004 | REV 0


250MW, 13.8kV GENERATOR
1MVA, 13.8/0.415kV, DY11 TRANSFORMER
U.A.B.-1
U.A.B.-2
U.A.B.-3
U.A.B.-4
1600Amps A.C.B.
1600A A.C.B.
1600A B/C A.C.B.
2000A 50kA BUS "AL"
400A./12kos.
200A./12kos.
100A./6kos.
60A./6kos.
30A./10kos.
3000A 50kA BUS "AL"
S.S.B.-1
S.S.B.-2
800A./12kos.
600A./12kos.
400A./12kos.
200A./3kos.
100A./6kos.
1MVA, 11/0.415kV, DY11 TRANSFORMER
1MVA, 22/0.415kV, DY11 TRANSFORMER
22kV STATION SUPPLY
630A, 21kA 11kV VCB/SF6 Breaker
630A, 21kA 11kV VCB/SF6 Bus Coupler
1000A 21kA BUS "AL"
11kV SWITCHGEAR
1000kVA, 11kV DG Set-1
1000kVA, 11kV DG Set-2
WITHDRAWABLE - TYPE 415 VOLTS A.C.B.
WITHDRAWABLE - TYPE 415 VOLTS M.C.C.B.
WITHDRAWABLE - TYPE 11kV V.C.B./S.F6 Breaker
D.P.R. DRAWING
Print Issue Date 9/1/1996
CLIENT
JAIPRAKASH INDUSTRIES LTD. (HYDRO POWER DIVN.)
PROJECT KARCHAM WANGTOO HYDRO-ELECTRIC PROJECT (4 x 250 MW)
TITLE
SINGLE LINE DIAGRAM - 11kV & 415V SWITCHGEARS
INTERNATIONAL DESIGN ENGINEERING ASSOCIATES
SCALE N.T.S.
DRAWING NO. 1200-2132-007
REV.


G.I.S. HALL: FIRE HYDRANTS
TRANSFORMERS: FIRE HYDRANTS
EL 1526m
500 rmt
350 rmt
150 rmt
8 rmt
EL 1515m
4 rmt
TRANSFORMERS: EMULSIFYRE FIRE PROTECTION
GENERATOR: EMULSIFYRE FIRE PROTECTION
2.5rmt
2.5rmt
22 rmt
22 rmt
22 rmt
50 rmt
350 rmt
EL 1511m
150 rmt
LEGEND :
FIRE HYDRANT
GATE VALVE
DELUGE VALVE
NON RETURN VALVE
CONTROL CENTRE For Water Supply To Generator
LEVEL SWITCH
FLOW ACTIVATED LEVEL TRANSDUCER
WATER TANK
EL 1581 - 1600
200 mm dia.
200 mm dia.
100 rmt 100 mm dia.
100 rmt 100 mm dia.
EL 1500m to 1510m
PUMP-1
PUMP-2
CAP. 273 CUM/HR. HEAD = 105M
CONTROL BLOCK : FIRE HYDRANTS
EL 1527m
EL 1523m
EL 1519m
EL 1515m
EL 1511m
EL 1511m
EL 1508m
EL 1501.5m
EL 1493m
D.P.R. DRAWING
Print Issue Date 9/1/1998
CLIENT
JAIPRAKASH INDUSTRIES LTD. (HYDRO POWER DIVN.)
PROJECT KARCHAM WANGTOO HYDRO-ELECTRIC PROJECT (4 x 250 MW)
TITLE
SCHEMATIC OF EMULSIFIER FIRE PROTECTION SYSTEM FOR TRANSFORMERS AND HYDRANTS
INTERNATIONAL DESIGN ENGINEERING ASSOCIATES
SCALE N.T.S.
DRAWING NO. 1200-2132-008



REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	SCHEMATIC OF VENTILATION SYSTEM (Sheet 2 of 2)	1200-2131-010

D.P.R. DRAWING

Print Issue Date	18/1/1996		
Designed	A.K. Mona	Checked	

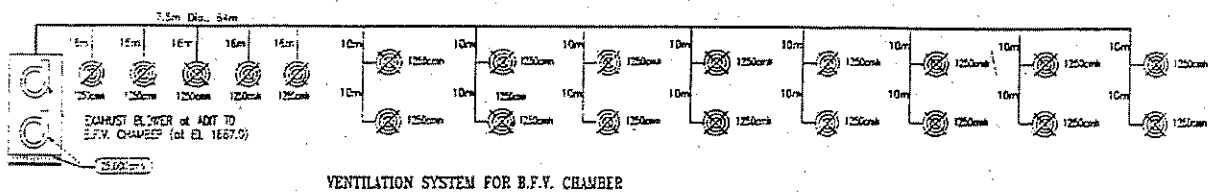
CLIENT: JAIPRAKASH INDUSTRIES LTD. (Hydro Power Divn.)

PROJECT: KARCHAM WANGTOO HYDRO-ELECTRIC PROJECT (4 x 250 MW)

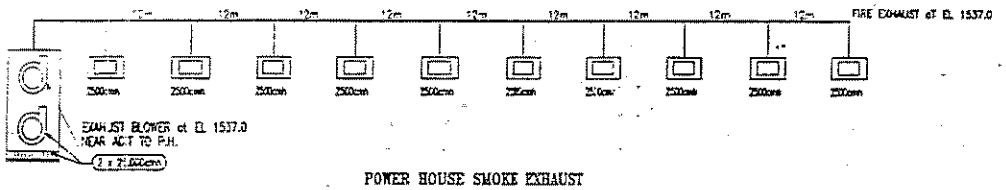
TITLE: SCHEMATIC OF VENTILATION SYSTEM (SHEET 1 of 2)

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES

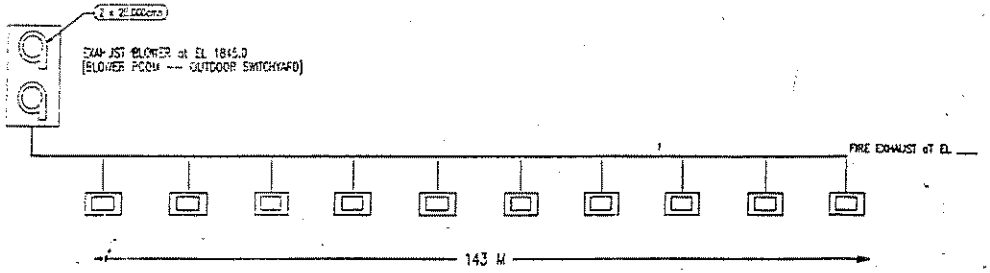
SCALE N.T.S. DRAWING NO. 1200-2132-009



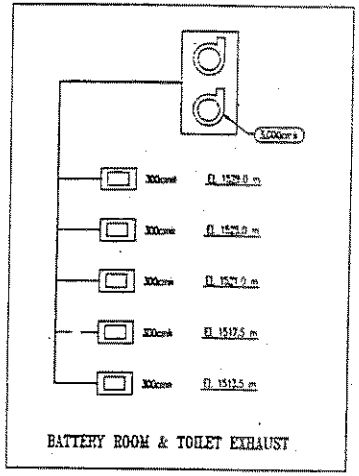
VENTILATION SYSTEM FOR E.F.V. CHAMBER



POWER HOUSE SMOKE EXHAUST



TRANSFORMER HALL SMOKE EXHAUST DUCTS



LEGEND :

- EXHAUST FAN
- SUPPLY AIR DIFFUSER/ DAMPERS
- EXHAUST AIR INLET
- COOLERS
- DUCT (WITH NUMBER OF AIR OUTLETS)

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	SCHEMATIC OF VENTILATION SYSTEM (Sheet 1 of 2)	1200-2132-003

D.P.R. DRAWING

Print Issue Date 19/1/1996

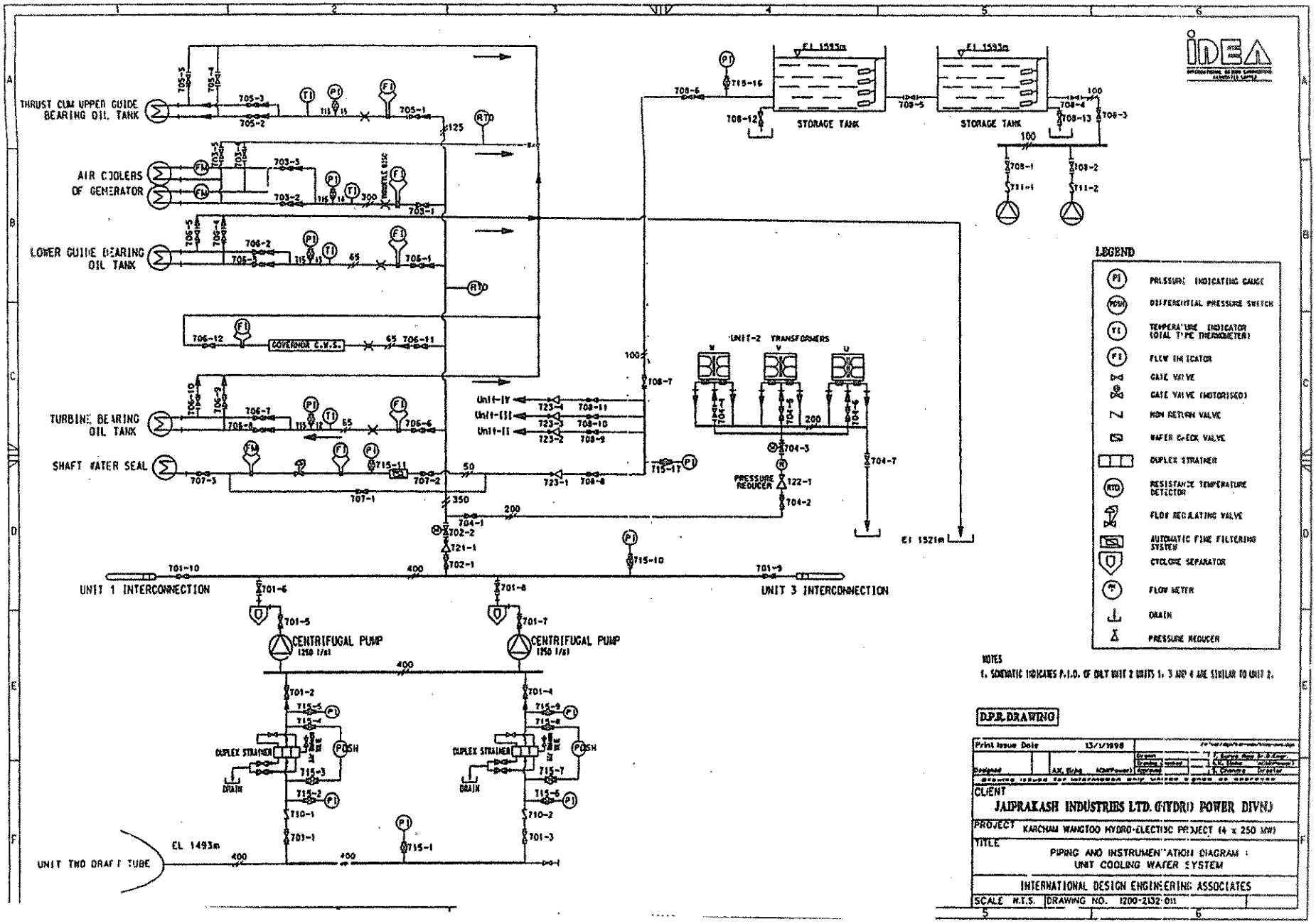
CLIENT
JAIPRAKASH INDUSTRIES LTD. (Hydro Power Divn.)

PROJECT KARCHAM WANGTOO HYDRO-ELECTRIC PROJECT (4 x 250 MW)

TITLE
SCHEMATIC OF VENTILATION SYSTEM
(SHEET 2 of 2)

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES

SCALE N.T.S. DRAWING NO. 1200-2132-010



NOTES

1. SCHEMATIC INDICATES P.I.D. OF ONLY UNIT 2 UNITS 1, 3 AND 4 ARE SIMILAR TO UNIT 2.

D.P.R. DRAWING

Print Issue Date	13/1/1998

CLIENT

JAIPRAKASH INDUSTRIES LTD. (HYDRO POWER DIVN.)

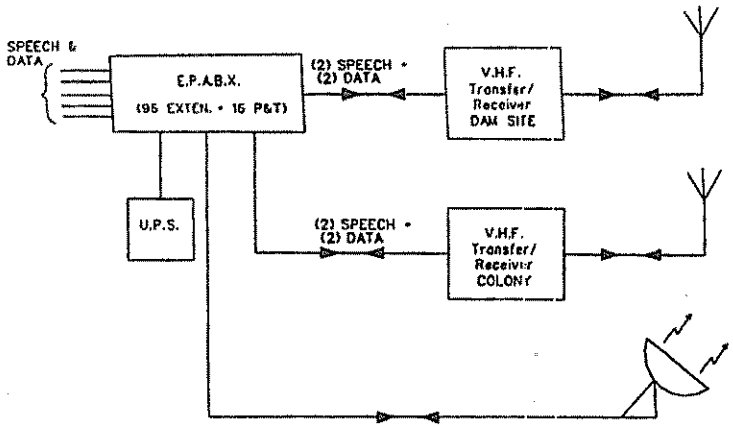
PROJECT KARCHAM WANGTOO HYDRO-ELECTRIC PROJECT (4 x 250 MW)

TITLE

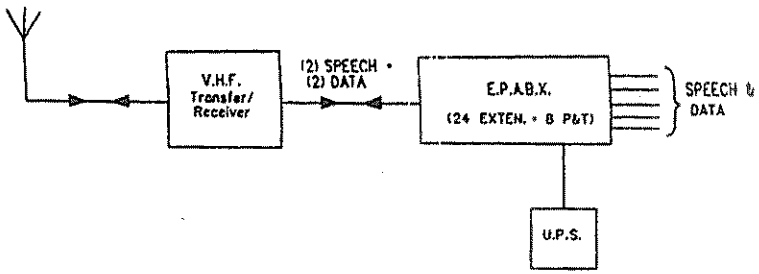
PIPING AND INSTRUMENTATION DIAGRAM : UNIT COOLING WATER SYSTEM

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES

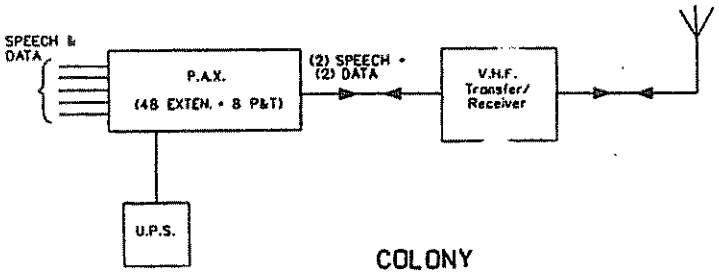
SCALE N.T.S. DRAWING NO. 1200-2132-011



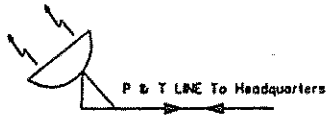
POWER HOUSE



DAM



COLONY



DELHI HEAD OFFICE

LEGEND

SAT-COM SYMBOL

V.H.F. COMM. (MARR/MART)

D.P.R. DRAWING

Print Issue Date 13/1/1995

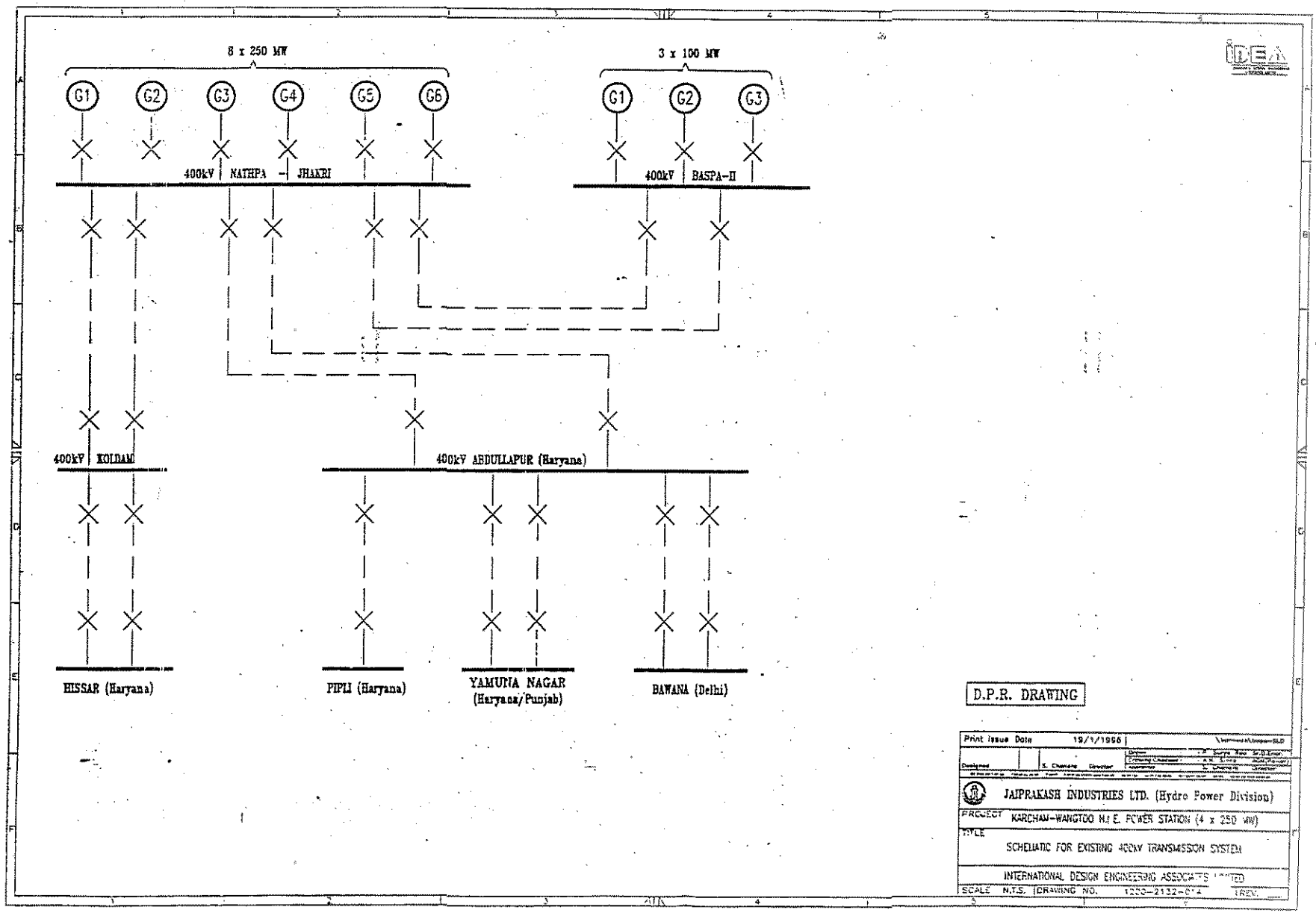
JAIPRAKASH INDUSTRIES LTD. (HYDRO POWER DIVN.)

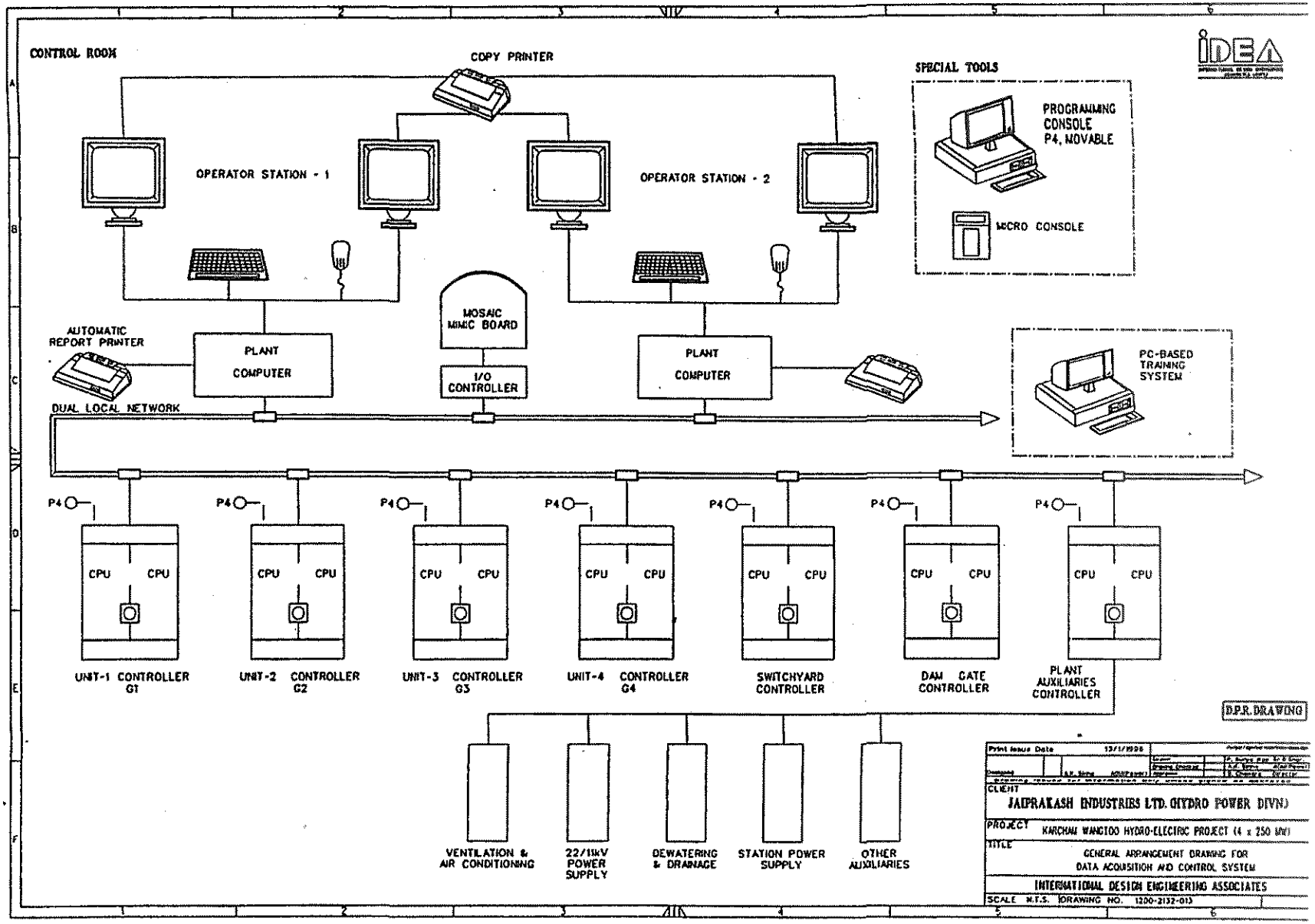
KIRTHAI WANGTOO HYDRO-ELECTRIC PROJECT (4 x 250 MW)

SCHEMATIC FOR COMMUNICATION SYSTEM

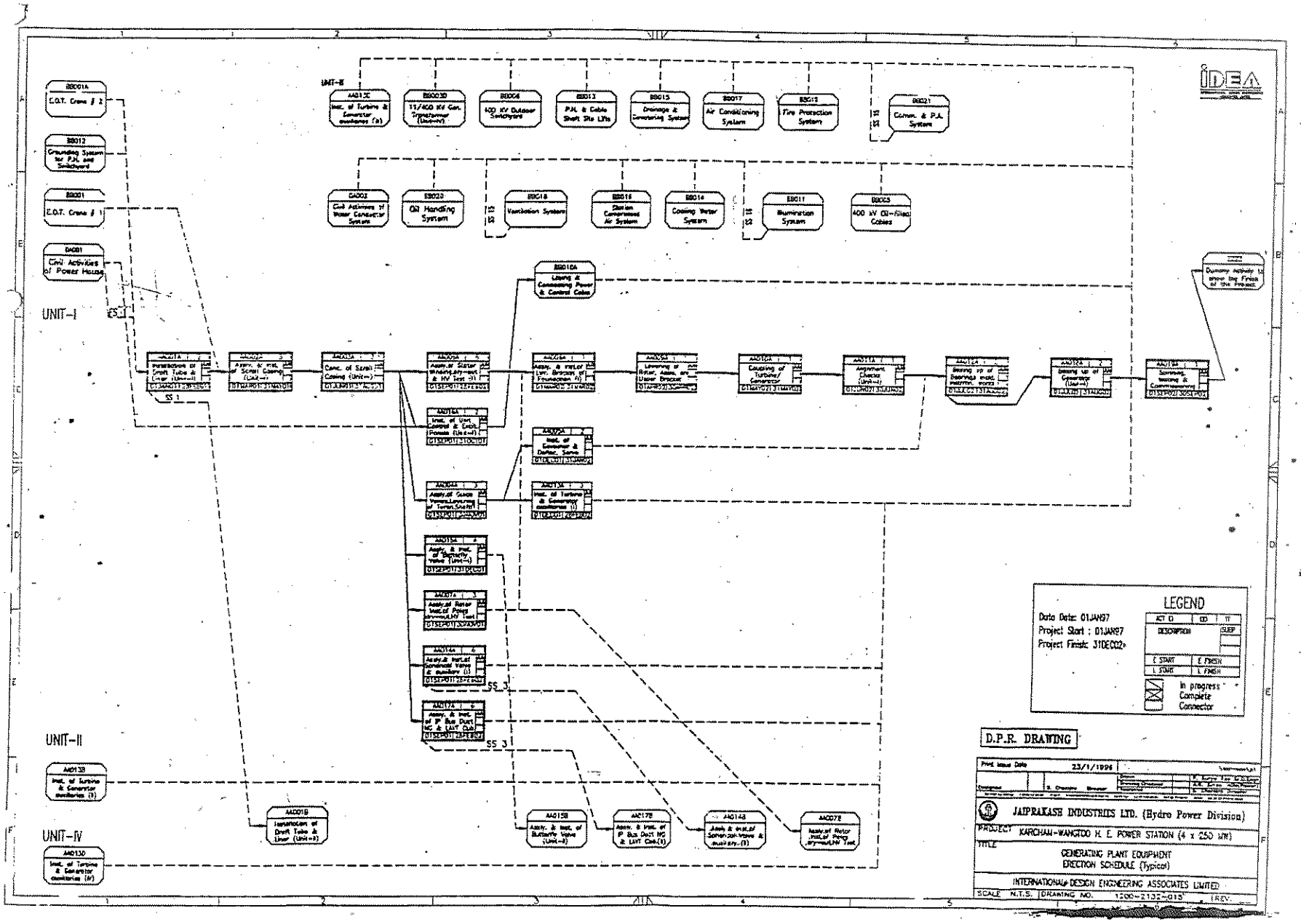
INTERNATIONAL DESIGN ENGINEERING ASSOCIATES

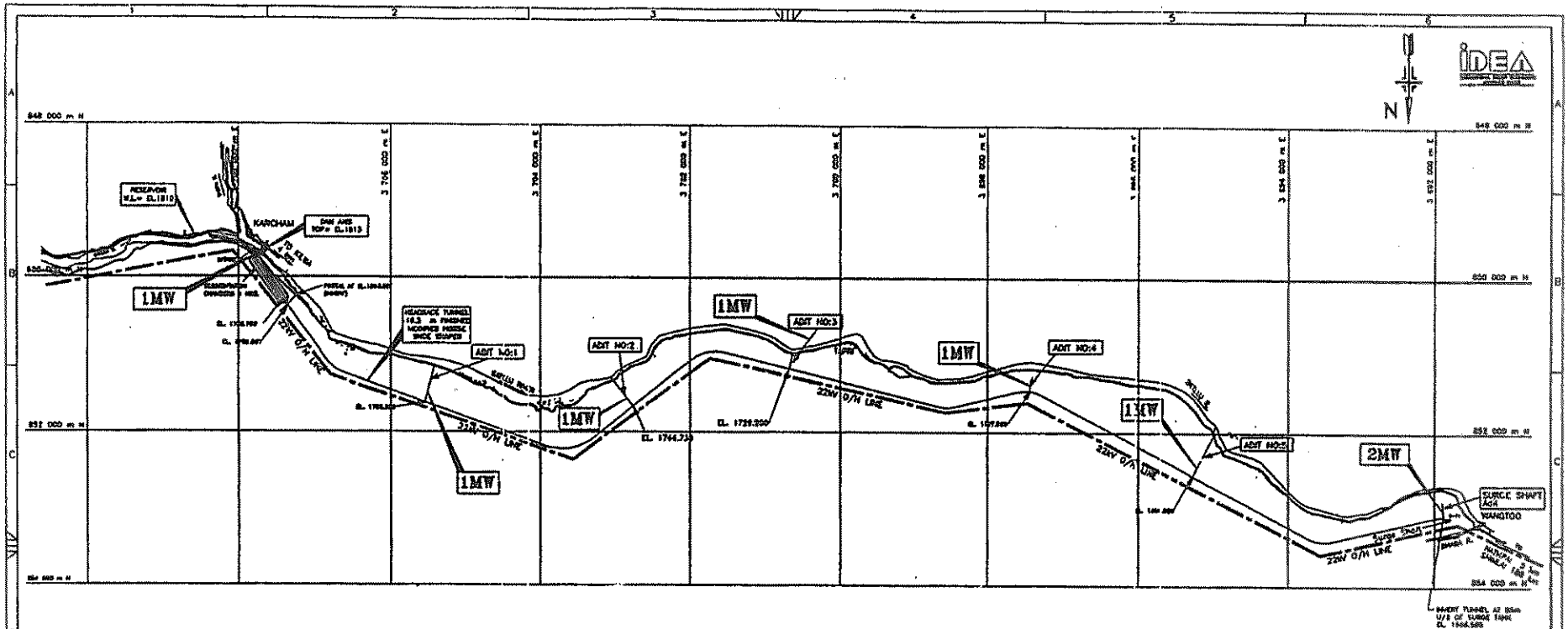
SCALE N.T.S. DRAWING NO. 1200-2132-012


8 x 250 MW
3 x 100 MW
G1
G2
G3
G4
G5
G6
400kV NATHPA – JHAKRI
400kV BASPA-II
400kV KOLDAM
400kV ABDULLAPUR (Haryana)
HISSAR (Haryana)
PIPLI (Haryana)
YAMUNA NAGAR (Haryana/Punjab)
BAWANA (Delhi)
D.P.R. DRAWING
Print Issue Date 19/1/1998
JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division)
PROJECT KARCHAM-WANGTOO H.E. POWER STATION (4 x 250 MW)
TITLE
SCHEMATIC FOR EXISTING 400kV TRANSMISSION SYSTEM
INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED
SCALE N.T.S. DRAWING NO. 1220-2132-01A REV.


CONTROL ROOM
COPY PRINTER
SPECIAL TOOLS
PROGRAMMING CONSOLE P4, MOVABLE
MICRO CONSOLE
OPERATOR STATION - 1
OPERATOR STATION - 2
MOSAIC MIMIC BOARD
I/O CONTROLLER
AUTOMATIC REPORT PRINTER
PLANT COMPUTER
PLANT COMPUTER
PC-BASED TRAINING SYSTEM
DUAL LOCAL NETWORK
P4
CPU
CPU
UNIT-1 CONTROLLER G1
UNIT-2 CONTROLLER G2
UNIT-3 CONTROLLER G3
UNIT-4 CONTROLLER G4
SWITCHYARD CONTROLLER
DAM GATE CONTROLLER
PLANT AUXILIARIES CONTROLLER
VENTILATION & AIR CONDITIONING
22/11kV POWER SUPPLY
DEWATERING & DRAINAGE
STATION POWER SUPPLY
OTHER AUXILIARIES
D.P.R. DRAWING
Print Issue Date 13/1/1998
CLIENT
JAIPRAKASH INDUSTRIES LTD. HYDRO POWER DIVN.)
PROJECT
KARCHAM WANGTOO HYDRO-ELECTRIC PROJECT (4 x 250 MW)
TITLE
GENERAL ARRANGEMENT DRAWING FOR DATA ACQUISITION AND CONTROL SYSTEM
INTERNATIONAL DESIGN ENGINEERING ASSOCIATES
SCALE N.T.S. DRAWING NO. 1200-2132-013

PERT Charts


UNIT-I
UNIT-II
UNIT-IV
SS 1
SS 3
LEGEND
Data Date: 01JAN97
Project Start : 01JAN97
Project Finish: 31DEC02
In progress
Complete
Connector
D.P.R. DRAWING
JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division)
PROJECT KARCHAM-WANGTOO H. E. POWER STATION (4 x 250 MW)
TITLE
GENERATING PLANT EQUIPMENT
ERECTION SCHEDULE (Typical)
INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED
SCALE N.T.S. DRAWING NO. 1500-2132-015 REV.



POWER REQUIREMENTS

SNO	LOCATION	Distance From NATHPA S/S	POWER Requirement
1)	POWER HOUSE	5.0 KM	2 MW
2)	ADIT NO: 5	8.4 KM	1 MW
3)	ADIT NO: 4	10.8 KM	1 MW
4)	ADIT NO: 3	14.2 KM	1 MW
5)	ADIT NO: 2	16.6 KM	1 MW
6)	ADIT NO: 1	19.4 KM	1 MW
7)	DAM SITE	22.3 KM	1 MW
	P.H. to Surge Shaft & BFV	1.0 KM	1 MW

22kV O/H LINE

NOTE:

1) ALL DIMENSIONS AND ELEVATIONS IN Metres.

REFERENCE DRAWINGS

SNO	TITLE	DRG. NO.
1	SCHEMATIC FOR CONSTRUCTION POWER ARRGT.	1200-2159-002
2		

I.P.R. DRAWING

Prin. Issue Date	9/1/1998		
Designed	S. Chandra Director	Drawn / Drawing Checked / Approved	P. Surya Rao G.M.(Engg.) A.K. Sinha Addl.(Projects) S. Chandra Director

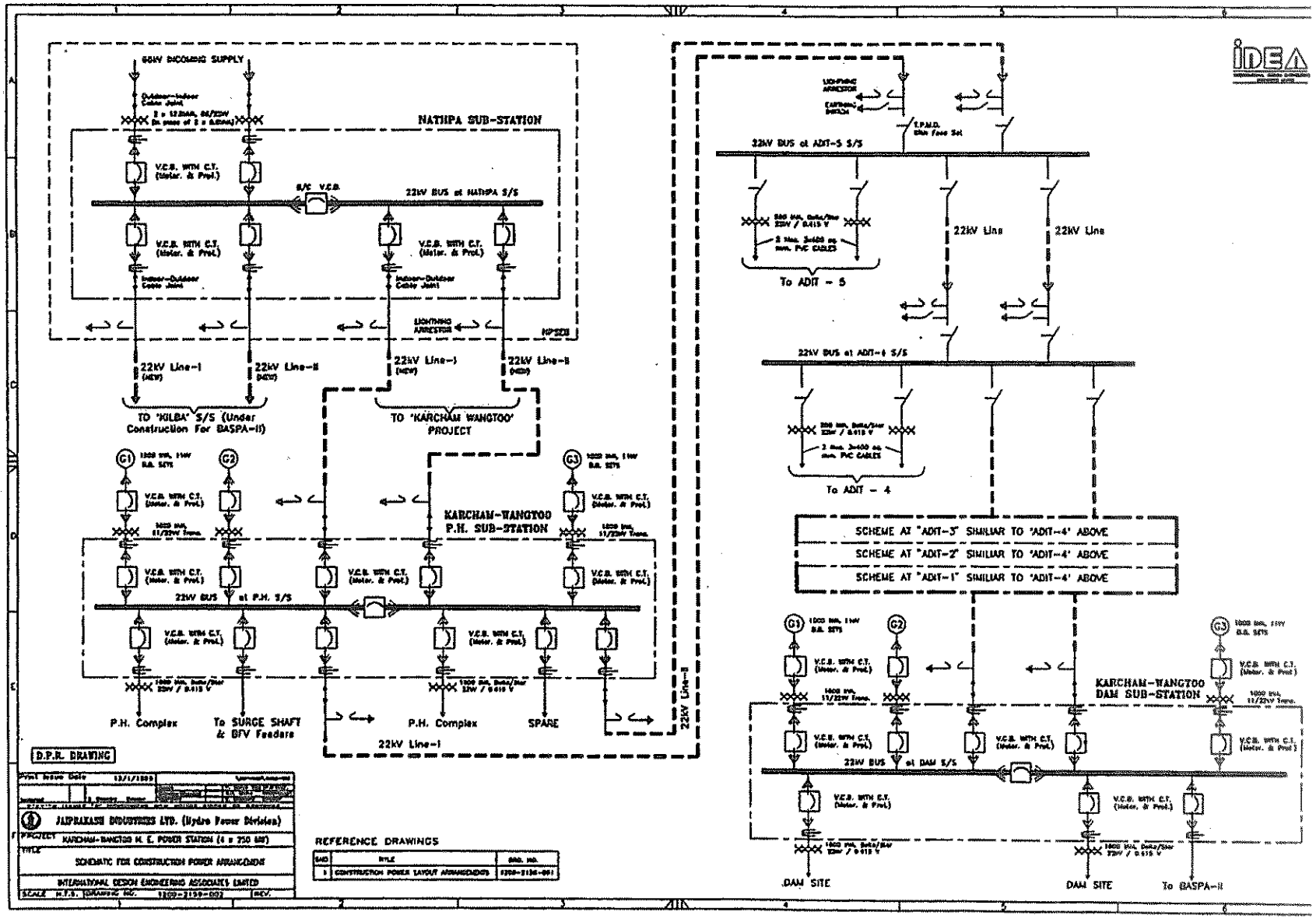
JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division)

PROJECT KARCHAM-WANGTOO H. E. POWER STATION (4 x 250 MW)

TITLE CONSTRUCTION POWER LAYOUT ARRANGEMENT

INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED

SCALE As Shown DRAWING NO. 1200-2159-001 REV.


NATHPA SUB-STATION
66kV INCOMING SUPPLY
22kV BUS at NATHPA S/S
22kV Line-I (NEW)
22kV Line-II (NEW)
22kV Line-I (NEW)
22kV Line-II (NEW)
TO 'KILBA' S/S (Under Construction For BASPA-II)
TO 'KARCHAM WANGTOO' PROJECT
KARCHAM-WANGTOO P.H. SUB-STATION
22kV BUS at P.H. S/S
P.H. Complex
To SURGE SHAFT & BFV Feadars
P.H. Complex
SPARE
22kV Line-I
22kV Line-II
22kV BUS at ADIT-5 S/S
To ADIT - 5
22kV Line
22kV Line
22kV BUS at ADIT-4 S/S
To ADIT - 4
SCHEME AT "ADIT-3" SIMILIAR TO "ADIT-4" ABOVE
SCHEME AT "ADIT-2" SIMILIAR TO "ADIT-4" ABOVE
SCHEME AT "ADIT-1" SIMILIAR TO "ADIT-4" ABOVE
KARCHAM-WANGTOO DAM SUB-STATION
22kV BUS at DAM S/S
DAM SITE
DAM SITE
To BASPA-II
D.P.R. DRAWING
JAIPRAKASH INDUSTRIES LTD. (Hydro Power Division)
KARCHAM-WANGTOO H. E. POWER STATION (4 x 250 MW)
SCHEMATIC FOR CONSTRUCTION POWER ARRANGEMENT
INTERNATIONAL DESIGN ENGINEERING ASSOCIATES LIMITED
REFERENCE DRAWINGS
1 CONSTRUCTION POWER LAYOUT ARRANGEMENTS