

The control system logics designed for unit operating sequence shall have the following stable states.

- ◆ Unit in standstill
- ◆ Unit in SNL (speed no load without excitation)
- ◆ Unit in SNLE (speed no load with excitation)
- ◆ Unit in generating mode
- ◆ Unit in Synchronous condenser mode
- ◆ Unit in line charging mode

The system shall be designed for trouble free transfer from one state to the other. Protections and other requirements during different states and transitions shall be automatically controlled.

According to the sequence of starting, all unit auxiliaries shall be automatically started prior to unit start-up; the generating units shall come up to speed and be automatically synchronized to the grid. On normal stop operation, the unit shall automatically be brought to no-load condition, the generator circuit breaker shall be tripped, excitation switched off and the mechanical brake applied.

The control system shall be furnished with necessary devices for local manual, local automatic and remote automatic control of the units. The design shall permit transfer from one mode of control to another without disturbing the operation of the units. All Local Control Boards including Unit Control Boards shall be provided with HMI panels for process visualization and control. Each Human Machine Interface shall:

- 1) Have station with colour tactile screen or equivalent,
- 2) Have screen size of at least 20" industrial TFT panels of high resolution, with IP 65 class protection for front enclosure.
- 3) Have graphics supervision software,
- 4) Withstand to machine hall environment,
- 5) Connect directly to redundant CPU mechanism,
- 6) Display Mimic diagram views with control functions,
- 7) Maintain measurements and indications including running hours,
- 8) Maintain alarm and status indications,
- 9) Perform archival of events,
- 10) Display visualization of subsystem status,
- 11) Execute commands.

From the Local Control Board, the operator shall be able to access important information about the system, and initiate automatic, step-by-step or manual sequences to control the process. The main redundant controllers with redundant power supply cards shall be mounted on the Local Control Boards together with all the electrical protections.

measurements and indications of all analog parameters, and Alarm / Annunciation system. The communication between electrical protection system and their respective LCB/UCB shall be based on IEC 60870-5-103.

The system shall perform the following functions:

- i) Data acquisition and control of reservoir level and other related dam control parameters through optical fibre. The system in addition to the above shall also continuously monitor Tail water levels and downstream discharges.
- ii) Continuous monitoring for trash rack plugging conditions so as to raise necessary alarms.
- iii) Speed control and load control through governor.
- iv) Generation control based on reservoir level restrictions, Availability based tariff based restrictions, downstream release considerations and time based schedules.
- v) Flow control: The flow control shall control the power output of the plant according to the water quantity available over a period.
- vi) Parallel operation with integrated generating system.
- vii) Joint control of all the four units.
- viii) Monitoring from a remote control centre.
- ix) Isolated operation on a selected grid.
- x) Black-start, i.e. no external power source available, but only on the emergency diesel generators.
- xi) Line charging Operation
- xii) Synchronous condenser operation
- xiii) Automatic voltage regulation.
- xiv) Machine loading with active and reactive power.
- xv) Metering and recording of all characteristics of the turbine and generator operation.
- xvi) Automatic backup of on-line process data using Network Attached Storage Devices.
- xvii) Perform periodic permanent backups of process data on archival storage media.
- xviii) Indication of normal operation of the auxiliaries that are essential for secure and reliable operation of the unit
- xix) Audible and visual warning of dangerous / faulty operating conditions of the unit and / or essential auxiliaries.
- xx) Audible and visual alarm and display of dangerous operation of the unit and the essential auxiliaries, or faults that may initiate tripping of the circuit breaker without stopping the unit.



- xxi) Power supply and control of essential auxiliaries of each unit.
- xxii) Video Mimic and indication labels on VDU.
- xxiii) Automatic synchronization.
- xxiv) Manual synchronization.
- xxv) Manually operated covered push buttons for automatic safe shut down of units.
- xxvi) Fault location: this function shall have a high accuracy. The fault location assessment shall be independent of fault resistance, load current or the supply of a data from different sources.
- xxvii) Automatic station supply changeover.
- xxviii) Interlocking of various equipment for safe operation.
- xxix) Configuration tools: Easy to use interactive configuration tools shall customize the various functionalities. The configuration tools shall provide visual presentation of the object, adaptations needed in process database, and adaptations of the communication configuration data. These tools shall provide:
 - a) system configuration,
 - b) system testing,
 - c) help functions,
 - d) program documentation,
 - e) down and up loading of programs,
 - f) system commissioning,
 - g) real time distributed data base management,
 - h) changing parameters.

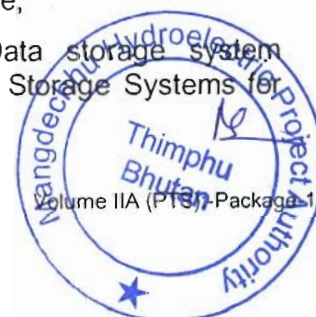
11.5.4 Central Control Centre

The architectural finishing work, i.e., suspended ceiling, suspended floor, furniture, wall finishing required for the Central Control Room etc., shall be in accordance to clause "Control Room Layout Design" of this section.

11.5.4.1 Layout

In Central Control Room the following equipment shall be provided:

- i) Operator workstations with video display units keyboards and pointing devices,
- ii) Routers/gateways for communication between Power House & Remote distant end and Load Dispatch Centre,
- iii) Data logger and a high performance Data storage system implemented by a pair of Network Attached Storage Systems for



online automatic data storage, Devices and drives and necessary media for permanent backup of data on optical medium,

- iv) Colour laser report printer
- v) Colour laser high quality printer
- vi) High quality plotter along with accessories .
- vii) Alarm printer and Event & data logging printer,
- viii) Engineering station,
- ix) Training Simulator station,
- x) Necessary interfaces such as LAN switch for extending the Central Control Room Network to connect to Power House LAN and plant subsystems (e.g Communication system etc),
- xi) Portable engineering and operator stations,

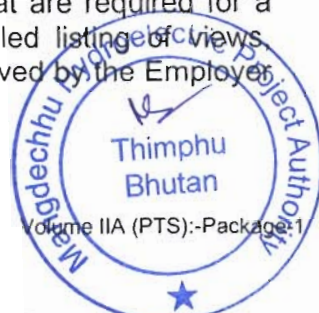
The Central Control Room shall use latest high end, SCSI workstations based on latest version of Windows Networking operating system. Operator Workstations shall be configured so that in case of failure of one operator workstation, the other stations shall automatically takeover the control of the failed one without requiring any operator intervention. Such changeover shall be smooth and rapid without affecting the system that is being controlled. Necessary arrangements for maintaining mirror copies of process data on all operator workstations shall be provided.

All functions shall be accessible through the VDU and keyboards and also through a pointing device such as trackball, so that the operator never needs to take his eyes off the screen.

Basic functions of control and supervision of power plants shall be included in a standard software package. The functions shall be upgradeable by reprogramming through a standard programming language implemented in an Integrated Development Environment (IDE). The supply of IDE along with the programming language shall be included in the scope of supply. A library of functions related to hydro power plant control and operation shall be provided

The Central Control Room shall:

- a) Provide acquisition of data inputs coming from the local controllers,
- b) Process the data inputs in order to update its real time data base,
- c) Process the data outputs to control the power plant,
- d) Implement screen based video mimics made available on-operator workstations, and engineering stations, The above shall be provided with all the necessary views that are required for a fully functional and complete system. Detailed listing of views, their design, look and feel etc, shall be approved by the Employer during detailed engineering.



- e) Printing reports (events and sequence of events logs, periodic log) upon operator's request,
- f) Perform computational functions,
- g) Perform data archiving functions,
- h) Provide facilities for training and simulation of the control system,
- i) Automatic management of unit starting, stopping, running in different stable states and transitions,
- j) Execute joint control for automatic operation of the plant,
- k) Monitoring of reservoir level, gates and flow regulations and process hydraulic data calculations and also monitor for trash rack plugging conditions,
- l) Provide an interface/module complete in every aspect for remote control of the entire plant from Load Despatch Centre. The system should comply with IEC protocol standards to communicate with remote despatch centre.

11.5.4.2 Large Screen LED Display

LED based display wall of at least 140-inch overall diagonal Screen, with aspect ratio of 16:9 or better and high resolutions of at least 1920 x 1080 pixels with necessary display controller/accessories along with application softwares shall be provided. The display wall shall be formed by tiling four identical display blocks and shall be connected to the central control room network through display controller so as to display any combination of the control system views. Display blocks used for formation of display wall shall be of seamless Mullion of less than 0.7 mm. The concerned operator shall select the views from any of the available plant control views from any of the operator workstations. The display screen shall have a high viewing angle of at least 150° and shall have adequate level of brightness for display in ambient light conditions of the control room. The system shall have automatic colour and brightness control feature. The Screen shall display four mimics at a time, when required. A digital clock with date and time indication shall be provided on top of the display.

11.5.4.3 Operator workstations

The operator consoles shall assist the operator for an easy operation and control of power station and shall allow to print out and to show on the displays, all relevant signals, events, alarms, status, status changes, abnormalities, history data and plant conditions on request or immediately in case of alarm.

In the control room two operator workstations with desks shall be provided. Each operator desk shall be equipped with two VDUs, sealed membrane covered keyboard and pointing device such as mouse / trackball, sealed membrane covered function keyboard, integrated telephone set, microphone, writing pad and workplace integrated. Each of

the two monitors, attached to the workstations, shall be interfaced to be capable of displaying any of the selected plant control mimic views.

All the Operator workstations shall be implemented in such a way so that each workstation shall be capable of individually controlling the entire control system even in the case of failure of all other workstations.

The configuration of each workstation shall be:

- i) Two VDUs each of at least 22", LED backlit flat screen and flicker-free,
- ii) Dual Processor CPU with highest CPU clock speeds and Mother Board Front Side Bus speeds available at the time of supply,
- iii) Minimum of 4 GB RDRAM,
- iv) Two (2) or more – Hard Disk Drives with latest technology each of at least 500 GB capacity,
- v) HD-DVD writer,
- vi) USB (2.0 or higher, if available at the time of procurement) hub and ports,
- vii) Functional key board with all functions and provision of shortcuts for alarms,
- viii) Pointing device such as mouse.

The workstations shall be high performance systems with SCSI drives and controllers and latest configuration available at the time of supply. They shall be loaded with latest 'Professional version' of Microsoft Office Suite. The operator desks, to be supplied by the Contractor, shall be provided with all accessories, telephone desk-type, power socket outlets, provision for public address system installation etc.

11.5.4.4 Mobile Operator Stations

One number of Mobile Operator Station with attached portable laser printer shall be provided with all the databases and software, all necessary interfaces and connectors so that they can be connected to any of the Local Control Boards directly, to control the board as and when necessary in cases of failure of Plant Control Network. In addition to the above software shall be loaded with latest 'Professional version' of Microsoft Office Suite. This Mobile Operator Station shall be used for complete control of the specific connected Local Control Board or Unit Control Board and all the associated auxiliary equipment. They shall also have event log functions. These workstations shall have Wi-Fi wireless LAN connectivity and should be designed to withstand high humid conditions and machine hall environment. The printer shall be used to take report, event and hard copy or alarm printouts as and when desired by the operator. The operator station shall be having the following but not limited to features apart from others mentioned above:

- i) At least 500 GB Hard disk with latest technology



- ii) At least 4 GB of RDRAM
- iii) HD-DVD writer

This station shall be installed on separate desk in the control room and connected to the control room network through docking arrangements with Advanced Port Replicators (APR). The desk shall have separate monitor, keyboard, mouse and other necessary accessories connected with APR interface.

11.5.4.5 Engineering stations (fixed)

One Engineering Workstation with separate desks shall be provided. The Engineering Station shall be equipped with single 22", full HD resolution, flicker free LED backlit flat screen monitor and other hardware configuration same as that of Operator Workstations mentioned above. These stations shall have the following features including software for:

- i) Reprogramming,
- ii) Process simulation,
- iii) Engineering calculation,
- iv) Program testing,
- v) Documentation,
- vi) Low level expert system tester,
- vii) Training functions.

Software and programming tools provided shall be responsible for the definition and creation of all mimic views to be displayed. From this desk, it shall be possible to follow the control and operation and to execute trouble shooting, reprogramming, parameter and set point changes and all necessary work to support and maintain the system. Each Engineering station shall be provided with latest 'Developer version' of Microsoft Office Suite. The engineering station shall be having the following (but not limited to) features apart from others mentioned above:

- a) At least 500 GB Hard disk with latest technology
- b) At least 4 GB of RDRAM
- c) HD-DVD writer

11.5.4.6 Portable engineering station (movable)

One portable engineering workstation with all features and accessories to maintain, reprogram, check the status and test the LCB programmable controllers, loaded with all software & system configuration settings similar to fixed engineering station necessary for the purpose, shall be included in the scope of the supply. In addition to this, this station will be equipped with necessary software & ports to programme test, data downloading & analysis for Protection relays, Governor and Digital voltage regulator described in other chapters of this document. This station shall be

installed on separate desk in the control room and connected to the control room network through docking arrangements with Advanced Port Replicators (APR). The desk shall have separate monitor, keyboard, mouse and other necessary accessories connected with APR interface.

The portable engineering station shall be having the following, but not limited to features apart from others mentioned above:

- i) At least 500 GB Hard disk with latest technology
- ii) At least 4 GB of RAM
- iii) HD-DVD writer

11.5.4.7 Simulator and training

One separate simulator station with all accessories for operational staff shall be integrated into the system and included in the scope of supply. The software shall consist of standard and easy to use simulation of the hydro power plant and complete on line documentation to allow the operator to train himself at using the control system. Adequate training of the operator personnel for acquaintance of the system is included in the contract.

11.5.5 Unit Control Boards (UCB)

Dedicated Unit Control Boards with HMI shall be installed for each turbine-generator unit. The governor, excitation system and protection panels shall be integrated with Unit Control Board. These boards shall communicate with the central control system through the Plant Control Network. The main and redundant unit controllers shall be mounted on Unit Control Boards together with all the electrical and mechanical protections of the generating unit, its auxiliaries, generator step-up transformers and measurement of all parameters of the unit. All facilities, equipment and interfaces shall be provided for complete local control of the unit from Unit control board in "Local Manual mode".

Each Unit Control Board shall comprise of the all the required control and monitoring devices and components required for operation of the unit including:

- 1) Redundant controllers with redundant power supply distribution,
- 2) Necessary I/O module racks,
- 3) Redundant bus and sub-local network as per requirement
- 4) All necessary I/O interfacing,
- 5) One colour Human-machine interface terminal to perform local supervision and control of the unit and its auxiliaries,
- 6) Monitoring of generator fire fighting system,



- 7) All condition monitoring of Unit such as Vibration, bearing temperatures, stator and rotor temperatures, transformer monitoring etc,
- 8) Necessary energy meters for metering,
- 9) Automatic and manual synchronizing devices and one synchroscope,
- 10) Brake dust collection system,
- 11) Cooling water system,
- 12) High pressure automatic lubrication system,
- 13) Governor oil pressure unit,
- 14) All analog indications/ meters as mentioned under clause 3.5.4.5, including MVAR and Power factor.
- 15) Stator heating system,
- 16) Main inlet valve,
- 17) Integration with unit protection devices and their monitoring as described in "Section 12- Protection System",
- 18) Covered push button and necessary controller for unit emergency shutdown, Emergency shutdown shall be implemented with hardwired logic using Safety Relays (SIL-3, IEC61508), in addition to the emergency shutdown controller for redundancy,
- 19) Other systems not mentioned but are essential for working of the unit.

Each Unit Control Board shall perform at least the following functions:

- i) Monitoring of tail race gate indications,
- ii) Control and monitoring of inlet valve,
- iii) Local acquisition of the logic and analog information from generator, excitation, turbine, governor, unit auxiliaries, unit protection and generator transformer, sensors and actuators,
- iv) Local dating of events through the programmable controllers with high resolutions of 1milli second,
- v) Management of unit starting, stopping, running in different stable states and transitions,
- vi) Management of emergency shutdown of the unit,
- vii) Control of the process actuators with necessary interlocking and protections,
- viii) Alarm supervision,
- ix) Monitoring of protection system,
- x) Automatic and manual synchronization control,
- xi) Management of the local operator terminal (HMI),
- xii) Communication with measuring devices,

- xiii) Communication with all condition monitoring systems of the unit such as temperature-monitoring device, vibration sensors, etc,
- xiv) Communication with the other controllers and Local Control Boards and computer system through the Plant Control Network.

In manual mode, the operator shall be responsible for the good progress of the operating sequence from the Unit Control Board and Local Control Cubicles. Only basic interlocking shall be provided in order to prevent damages to the unit. Orders are initiated through Local Control Cubicles. Otherwise, when the "Local Automatic" mode is selected, all the control and monitoring is made through the HMI of the Unit Control Board. Control from the Local Control Boards shall be possible even when upper levels are out of order.

Sequence controllers shall be provided with all indications on the Central Processor Unit that are required for trouble shooting in case of failures such as:

- a) Missing start conditions,
- b) Missing conditions for the next control step in case of sequence fault,
- c) Actual step and sequence.

All status information from the logic controllers shall be also transmitted to the Central Control Room (CCR).

All necessary controls and devices shall be provided to allow manual control and synchronization of the generators from their UCBs while the basic safety interlocking and the protection remain operative.

11.5.5.2 Modes of operation

The following operating modes shall be selected via a key or code operated selector switch installed in the UCB:

- | | | |
|------|--------|---|
| i) | OFF | No operation possible |
| ii) | MANUAL | Manual control from UCB |
| iii) | AUTO | Automatic control from UCB |
| iv) | CR | Automatic control from Central Control room |
| v) | TEST | Self testing diagnostics |

11.5.5.3 Sequential control

The automatic starting and stopping of the unit shall be initiated by covered start and stop push buttons. All the component elements of the hydraulic system shall be operated according to a logic and sequential manner, which shall bring the unit to the synchronized condition and automatically synchronized or stop it completely when the stop push-button is pressed.

Video mimics on VDUs of the Central Control Room shall indicate all step indications. All indication signals shall be disabled/switched-off, when status "stand still" or "general overhaul" is achieved.

The controllers used for sequential control shall be provided for the following operating modes:

- i) Automatic control.
- ii) Step by step control.
- iii) Test simulation of the input signals by setting, while input cards shall be blocked
- iv) Complete program tests, while output cards shall be blocked

11.5.5.4 Manual control of unit

Unit Control Boards shall be provided with all features, accessories, wiring, indications, and meters that are necessary for manual control of the unit locally through the unit programmable controllers. It shall be possible to operate generator circuit breaker from UCB even when upper control levels are out of order.

11.5.5.5 Alarms

Each Unit Control Board shall be provided with an Alarm and Annunciation System with all equipment to achieve the required functions, such as alarm units, Annunciation panels, horns, transmission facilities.

11.5.5.6 Generator Step-up Transformers

All Generator step-up transformers shall be monitored, controlled and supervised with the electrical system delivered with "Generator Transformers" for temperature, cooling water system and fire fighting system.

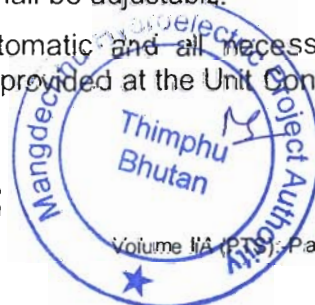
11.5.5.7 Synchronizing equipment

Synchronizing facilities shall be provided from control room to allow automatic synchronizing of the units. Local Control Boards shall have the features to synchronize units both manually and automatically.

The fully automatic synchronizing devices shall be of the electronic type, complete with all auxiliaries for automatic connection of the generators to the grid.

The circuit-breaker closing time, maximum admissible frequency & voltage difference as well as the control time shall be adjustable.

Selector switches off / test / manual / automatic and all necessary instruments for manual synchronizing shall be provided at the Unit Control Boards.



The automatic synchronizing shall also be possible when the generating units are controlled locally from their respective Unit Control Boards and plant control network is non-functional.

11.5.6 Local control Boards (LCB)

11.5.6.1 LCB for Electrical Power Supply Service

One LCB shall cater to the electrical power supply needs of all the power house equipment and auxiliaries. The board shall perform control, metering and monitoring of the following general functions:

- i) Electrical power supply distribution including DG sets, Unit Tap-off Transformers, Station Auxiliary Transformer, Auxiliary Transformers, Pothead yard transformer, Distribution transformers, all 0.415 kV boards including UABs/SABs and 11kV switchgear, 33kV Switchgear
- ii) 220 V DC supply,
- iii) Protection interfaces for all the above systems.

All MV and LV switchgear including DG sets and spare panels, if any, shall be remotely controllable. All start-up sequences, interlocking and switching operations of MV and LV switchgear shall be controlled from this LCB.

11.5.6.2 LCB for Common & Station Services

The LCB shall cater to the common services of the power station and shall perform control and monitoring of the following general functions:

- i) Low pressure compressed air system for brake and service air etc.
- ii) Cooling water system,
- iii) Drainage and dewatering system.
- iv) Ventilation and air conditioning system (monitoring only),
- v) Fire fighting system (monitoring only),
- vi) Tail water level monitoring
- vii) Downstream discharge monitoring
- viii) Any other station services,
- ix) Dam Monitoring
- x) BFV control

11.5.6.3 RTU for DAM monitoring

For communication / data transfer from Dam site equipment, RTU at Dam site and ADSS optical fibre from dam RTU to the LCB with all necessary provisions shall be provided. RTU shall be located at the dam site and shall include power supply, transducers and cables to connect dam site

equipment for monitoring reservoir level, intake gates, spill way gates, sluice gates, inflow, spillages, Dam power supply etc. It shall continuously monitor trash rack for plugging conditions. All necessary provisions shall be provided for data acquisition and analysis of parameters from dam and water conductor system in powerhouse computers and also to display the same on request. The cabling from PLC panel of HM equipment to RTU at Dam shall be covered under the E&M scope.

11.5.6.4 RTU for Butterfly Valve control

For communication / data transfer from Butterfly valve equipment, RTU at Butterfly valve chamber and ADSS optical fibre from BFV RTU to the LCB with all necessary provisions shall be provided. RTU shall be located at the Butterfly valve chamber and shall include power supply, transducers and cables to connect butterfly valve equipment for its control & operation. All necessary provisions shall be provided for data acquisition and analysis of parameters from BFV chamber in powerhouse computers and also to display the same on request.

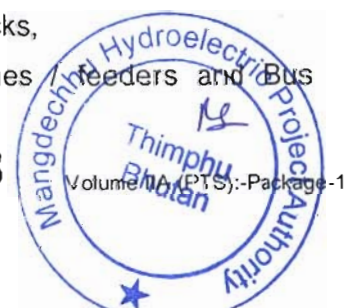
11.5.6.5 LCB for 420 kV GIS control

One (1) number of LCB shall be provided for control and monitoring of 420 kV GIS & pothead yard and shall perform the following general functions:

- i) Local controls and monitoring of complete 420 kV GIS system,
- ii) Protection interfaces of complete 420 kV GIS system,
- iii) Local controls and monitoring of complete Bus Reactor System,
- iv) Protection interfaces of complete Bus Reactor system,
- v) Integration with OLTE / FOTE to be installed at the potyard
- vi) Provision for Local controls & monitoring and Protection interfaces for ICT Bay,

420 kV GIS & Pothead yard shall be supervised, interlocked and controlled from this Local Control Boards. Necessary control and alarm functions along with data acquisition of parameters shall be provided. The protection cubicles described in Protection Package shall be integrated into the respective LCB as a protection panel. All the bays shall be controlled and operated safely, reliably and efficiently in all modes of control i.e., remote, local and manual. The Control Boards shall cover the following:

- a) Complete protection and monitoring equipment of the GIS, Bus Reactor and Pothead yard
- b) Operation of Breakers with various interlocks,
- c) Operation of Isolators with various interlocks,
- d) Interfacing of various protections of lines / feeders and Bus Coupler as applicable,



- e) Metering of all lines / feeders as applicable.

11.5.7 Router/Gateway for Remote Monitoring and Operation

It shall be the responsibility of the contractor to provide and install necessary routers/gateways, interfacing and other accessories for remote operation, control and monitoring. The communication protocol shall be based on IEC 60870-6 series TASE.2 (ICCP) standards.

11.5.8 Remote data Transmission

11.5.8.1 Provision for remote data transmission to Remote SCADA centre and Load Despatch Centre

Router / gateway with necessary firewall functionality, interfaces (including modems for OLTE linkages), terminal units and accessories shall be provided suitable for following communication/data transfer:

- i) Power house to Remote distant end
- ii) Power house Load Despatch Centre through OPGW.
- iii) It will be the responsibility of contractor to provide implementation profile during detailed engineering for examining the interfacing with Load Dispatch Centre and Remote Monitoring system profiles for compatibility of data transmission and final integration of specified plant data. The communication protocol for gateway to RLDC shall support IEC 60870-5-101 for all levels. Protocol gateway specifications shall be decided during detailed engineering.

11.5.8.2 Remote Monitoring from Administrative Building at Power House Colony and at Dam Colony

Router / gateway with necessary firewall functionality, interfaces (including modems for OLTE/FOTE/RTU linkages), terminal units and accessories shall be provided suitable for following communication/data transfer:

- i) Power house to Administrative Building at Power House Colony through ADSS Cable
- ii) Power house to Administrative Building at Dam Colony through ADSS Cable

11.5.9 Local control cubicles

Separate Local Control Cubicles (LCC) provided for unit auxiliaries, Station services and Common services shall be controlled along with complete sequence interlocks from the LCC itself, corresponding Local Control Board and also from the Central Control Room.

All logics with I/O connections for manual as well as auto operation of the auxiliary shall be built into Local Control Cubicles. Each Local control

Cubicle shall be able to perform all its functions in auto and manual modes even when corresponding Local Control Board is not functional or even when communication between LCB and LCC is not established. Each Local Control Cubicle shall be supplied with two selector switches; one switch for selecting between remote operation and local operation and another switch for selecting "Local Auto" mode and "Local Manual" mode. The local control systems shall be controlled locally, from their respective Local Control Cubicles when selector switches are used for "Local Manual" mode.

Required signals and information shall be transmitted between cubicles, local control board and central control room through redundant optical fibre field bus connections. Suitable numbers of I/O switches at respective floors shall be provided from where signal/ data is transferred to LCB/ CCR through optical fibre.

11.5.10 Software

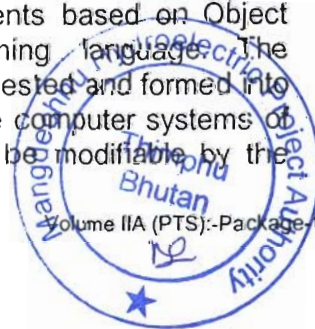
All software along with necessary licenses, required for performing intended duties in an efficient manner, shall be provided in addition to the software explicitly specified for individual equipment. The source codes of project specific application software shall be the property of the Employer. The software shall be modular in structure, facilitating changes and extensions of the system. Complete literature including program listings in source language for application and customized application software shall be provided. All documentation and computer print-outs shall be in English only. All software shall comply with open system standards, shall make optimal use of CPU, main memory, and disk space, and shall not cause any problem for the operating systems.

11.5.10.1 Operating system

The operating system shall be latest Windows based network operating system available at the time of supply with a standardized, user friendly look and feel. All Servers shall be based on latest Enterprise edition of windows based Server operating system available at the time of supply.

11.5.10.2 Application software

The purpose of the Application Software is to allow a complete control and monitoring of the plant. The Application Software shall be structured in various levels. The lowest level shall assure system performance and contain basic functions / Application programming interfaces (API), which shall not be accessible by the application and maintenance Engineer for modifications. In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard modules built as functional block elements based on Object Oriented Programming in Standard programming language. The functional blocks shall be documented, thoroughly tested and formed into a library. The software shall be implemented in the computer systems of the control room. All operating parameters shall be modifiable by the



operator and necessary interfaces /mimic views/ forms shall be provided for assigning set points with respect to voltage, load settings etc, assigning unit priorities, and giving direct orders/commands to the system.

All necessary provisions such as firewalls and other security measures shall be strictly implemented so as to insulate the Control system, networks, plant data bases etc. from unwanted intrusions.

11.5.10.3 Power house intranet

The software supplied by the Contractor shall also include a Power House Intranet Site containing complete information in web pages regarding the working of the power plant with all status reports and information, Maintenance procedures, drawings and detailed documentation of all the equipment of the powerhouse.

The Intranet and its web pages shall be designed to provide access to information of the powerhouse and other details from any computer connected to the Central Control Room Network with appropriate passwords and Access Restrictions at different levels. The Intranet site shall be complete in every aspect with necessary web server and other peripherals, containing full details of all powerhouse equipment, their maintenance procedures, drawings etc. The Contractor shall supply any other software necessary to run, maintain, update and modify the Intranet. The Intranet and its web pages shall be so implemented as to present information in a well-organized and easily understandable manner for use by persons without any technical background.

11.5.10.4 On-line help and diagnostic system

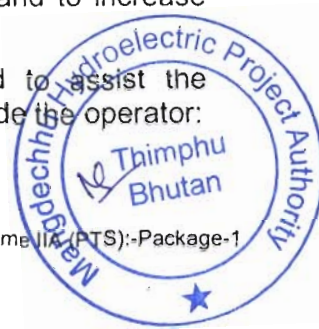
Apart from the printed documentation manuals, the Contractor shall also provide all of his documentation online including equipment drawings and other details. The basic features of online help shall include but not restricted to the following:

- i) Operator Manual detailing all aspects of the Control system.
- ii) Engineering drawings of equipment.
- iii) Maintenance Manual describing any maintenance duties which need to be carried out on the Control system.
- iv) Troubleshooting Guide out-lining how to resolve numerous difficulties and problems, which operators may encounter with either the control system or the equipment being monitored by the Control system.

This documentation shall provide extensive cross-references and search facilities to aid during training and familiarization period and to increase efficiency afterwards.

A comprehensive diagnostic system shall be provided to assist the operator in minimizing the downtime. The system shall guide the operator:

- a) To analyse all available information,



- b) Diagnose the problem,
- c) Resolve the problem.

Any information that is available to the control system shall be presented to the operator in a clear and consistent manner. Necessary diagnostic screens containing status information shall be provided.

11.5.11 Process Control Networks

11.5.11.1 Central control room network

A separate control room network shall be used in the control room to link the Operator's Workstations, Engineering Stations, Training Simulator, and other peripherals. Central control Room network shall be redundant Optical Fibre cables, based on the TCP/ IP Ethernet Standards at 1GBPS data transfer rate. The separate Control Room Network shall ensure to relieve the Plant Control Network from print jobs and dedicate the later only for transferring process data.

The Control Room Network shall be extendable to connect Power House LAN installed in the power plant. The plant computers and servers shall be connected to this network, through routers and firewalls which shall be provided with the Central Control Room Network to restrict unauthorized access to the control room network and other process networks.

The network shall have redundant Network Attached Data Storage Systems necessary for automatic backup of online process data. The fibre terminations for the central control room Network (LAN) shall be housed together in a closed unit along with the necessary switches. The routers, serial and digital interfaces of communication network, Ethernet switches etc should be provided with surge protection devices of suitable rating.

11.5.11.2 Plant Control Network

The data transmission between the Local Control Boards and the workstations shall be implemented through a redundant fiber optic Plant Control Network. The network shall be based on ETHERNET standard and use of TCP/IP protocol. 1GBPS data transfer rate shall be used to guarantee fast and reliable data transmission. The two redundant optical fiber buses shall be routed through physically different paths.

11.5.11.3 Power House LAN

Redundant Fibre optic Power House LAN of 1 GBPS transfer rate complete with Gigabit Ethernet LAN switches for at least 24 connections spread across the powerhouse area, all necessary interfaces, routers for LAN/WAN connectivity, connectors, Power Supply, UPS and other accessories shall be provided. Suitable number of Wireless LAN hot spots with all necessary accessories including 24-port wireless switches, access ports etc, shall also be provided for coverage in the areas of Training Hall, Conference Room and Machine Hall Floor.



The Plant Computers / Servers / Printers shall be of latest technology and hardware, available at the time of supply and shall serve the supervisory and maintenance functions by various departments, laboratories and workshops in the powerhouse. The configuration of these computers shall be subject to the approval of the Employer. The two Servers shall be used for Administration Control of the Power house LAN, Management of Inventory and Web Server for the Intranet site. Latest Windows based Network Operating System shall be pre-loaded on these servers. All Plant Computers shall be preloaded with latest professional version of Microsoft Office suite along with any other application software required for performing their intended functions. All the two servers in Power house LAN shall be preloaded with latest Developer version of Microsoft Office suite along with any other application software required for performing their intended functions.

Each of these computers shall have a full HD resolution 22", flicker-free LED backlit flat screen colour monitor. These computers shall be furnished with all connectors, I/O cards, interfaces, UPS, software etc that are necessary to connect them to the Power house LAN. These computers shall be pre-loaded with all software necessary to access and process information of the power plant. Appropriate passwords and access rights shall allow the users of these computers to access relevant data of the power plant such as trends, reports, alarms etc.

11.5.11.4 Bus system

The data transmission shall be through redundant optical fiber cables.

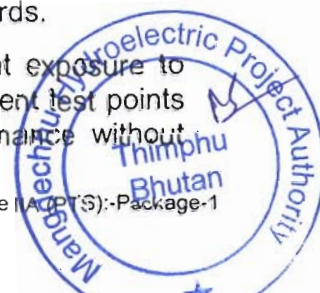
The bus systems shall be self-monitoring type. The main characteristics of the bus system shall be as follows:

- i) High reliability of communication realized by double bus (redundant) system. The two systems shall continuously operate separately only in case of traffic interruption on one bus, the other shall take over the traffic. By this principle all bus couplers, bus interfaces etc. shall be coupled with one active and one stand-by device forming a complete system,
- ii) The bus-systems shall be physically redundant installed on different routes,
- iii) Real time, full duplex data transmission rate, of at least 1Giga Bytes per second shall be provided,
- iv) Interfaces shall be according to relevant IEC standards,

11.5.11.5 Optical fiber

Design of optical fibers shall be in accordance with recommendations and practices of relevant IEC standards and ITU-T series standards.

Optical source safety shut off shall be provided to prevent exposure to laser light during maintenance. Equipment shall have sufficient test points to facilitate complete monitoring of the equipment performance without



service interruption. Fibre shall be designed to limit degradation after thirty years of intermittent exposure to stagnant water, ambient temperature and 100% relative humidity conditions.

The availability of 1 Gbps data channel between two remote stations shall be greater than 99.99% and this availability shall consider a maximum mean-time-to-repair (MTTR) of 2 hours.

The optical fibre communication system shall be established by using All Dielectric Self Supporting (ADSS) optical fibre cable. The optical fibres shall be of at least 12 (Twelve) fibre and shall be of Dual-Window Single Mode (DWSM), ITU-T G.652.D type.

11.5.12 Audio visual alarm system

Each Local Control Board shall have its independent facilities for Alarm and Annunciation. The system shall be complete with Horns, alarm network / cabling etc. In addition to the above, all alarms shall be presented to the operators in the central control room through audio visual indications. Suitable provisions shall be provided at all Local Control Boards including Unit Control Boards such that the audible alarms shall be activated or deactivated and option shall be available for freely selecting the location for annunciation of audio alarms - either at operator workstations of Control Room or at respective Local Control Boards. Alarms may be acknowledged from only one operator station at a time.

- i) There shall be an alarm manager function catering to all the alarm services in the Central Control Room.
- ii) Proper mechanism for sorting and filtering of alarms shall be provided.
- iii) Each alarm shall be time tagged.
- iv) There shall be classification of alarms at least for four levels of priority each priority being associated with a distinguished colour code.
- v) Each raised alarm shall be provided with a suggestive course of action associated with its alarm display window to aid the operator in quick assessment of the fault.
- vi) There shall be proper filtering of the alarms thus eliminating non-significant alarms in a systematic manner.
- vii) Alarms are to be classified at least by the following views:
- viii) Alarms by degree of priority,
- ix) Alarms by mimic view,
- x) Alarms by functional subset.
- xi) During remote operation from the Central Control Room, the audible sound shall be silenced by automatic acknowledgement after 1 min.



11.5.13 Data logger and Data Storage System

An on-line Data Storage and Retrieval System shall be provided for the power plant. It shall be located in the Central Control Room area and shall be equipped with storage media for real time data storage and for archival purposes. The data logger of the system shall receive, update, print out and show on the VDU's all signals, events, alarms, status, status change, abnormalities and history data of plant and ambient conditions either periodically, on request or immediately in case of alarm.

All real time plant data shall be stored on high performance, high capacity and redundant Network Attached Storage (NAS) systems to store the plant history data up to minimum twenty (20) years. The information stored by these storage appliances shall be available on-line with automatic "hot" backup of on-line data and ready to be shared by clients and servers on the Central Control Room Network and Power house LAN. The NAS devices shall have open system architecture to connect them to other vendors' equipment. This centralized data storage system shall use fast read/write optical backup medium such as re-writable DVD-RW media using DVD writers or high performance tape drives. Storage media shall be provided for 20 years of storage.

One dedicated Relational Database Management System based on latest available version of ORACLE RDBMS database software, with necessary network user licenses covering all the workstations and computers shall be provided.

The Data Storage system shall be a 24 X 7 X 365 type storage database consisting of time tagged event logs with versatile data retrieval tools in the form of curves and in the form of chronological lists of tagged events. The Data Loggers and Retrieval System should be protected from both side i.e from power input side and from communication input side with surge protection device of suitable rating. These should be pluggable device and should have indication facility.

11.5.13.1 Trending and Charting

The system shall provide detailed variable monitoring functions for trending and charting. Detailed list of features and functions shall be approved by the Employer during detailed engineering. The trend curves of variables should have selectable sampling ranges. Both time and value scales shall be modifiable by the operator.

11.5.14 Video Display Units (VDU) and key boards

All monitors/ Video display units (VDU) supplied shall be flicker free, full HD resolution, flat screen LED backlit colour monitors of 24" or above diagonal screen size. The pertaining software shall be included in the scope of supply.

The desk shall be equipped with keyboards, assisting the operator in easy operation of the power plant. Special care shall be taken in designing the



keyboards taking ergonomics into consideration. The keyboards and keypads shall be of sealed membrane type suitable to withstand high humidity environments. It shall be possible to operate the plant via the coded numbers and via function groups and loops to be called up directly from the function keys of the keyboard.

11.5.15 Printers

The selection of peripherals shall take into consideration aesthetics with noise level not to exceed than 60 dB. All the printers shall be of heavy-duty, high speed laser type. Print speed for monochrome printers shall be at least 15 pages per minute and that of colour printers shall be at least 4 pages per minute. All peripherals shall be provided with necessary desks, paper baskets and noise absorption.

11.5.16 Control room layout design

11.5.16.1 General

The control room layout shall be state of the art and aesthetically designed in synchronization and resemblance to the control room furniture / equipment by specialized vendors having proven track record in this field.

Control Room Layout Design shall include, but not limited to the following:

- i) Modular control desks for operators and monitors
- ii) Modular printer tables
- iii) Modular computer tables
- iv) Control room chairs

All equipments, accessories and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) and IEC.

Various aspects should be considered and extreme care shall be taken while designing control room layout so as to create ideal work place. Physiological aspects such as line of sight & field of vision and cognitive factors such as concentration & perceptivity etc. shall be considered with special care.

11.5.16.2 Furniture

The contractor shall provide a set of ergonomically designed furniture from a reputed manufacturer especially designed for computer peripherals. The set of furniture shall include the following:

A) Control Desk:

The Modular open workspace console system to be installed shall provide conveniently organized work surfaces to install the control room

equipment and also to provide work surfaces for the operating personnel to carry out the operations.

The facility is intended to be a state of the art facility for control operations. Aesthetics, convenient organization, flexibility, finish, durability are very important attributes of the console system. All materials and accessories used in the construction of console system should be of high quality and finish should be of international standards for control centres.

The System should be non-welded modular construction system with provision for extension and expansion. The modular construction shall allow adding and relocating the modules to meet the future requirements. Material of construction shall be in extruded aluminium with powder coating in approved colour.

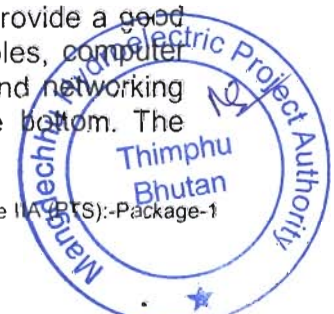
Control desk surface shall be made of high quality 12 mm Acrylic Solid Surface on 25 mm thick MDF and shall be powder coated aluminium sturdy structure. The top layer of the surface shall be capable of withstanding day to day usage of the work surface (Free usage) without losing the high quality finish. The surface should have following features.

- i) Non-porous (does not hold dust).
- ii) Seamlessly joined (no joints will be visible throughout the desk)
- iii) High scratch resistant
- iv) Repairable (in case of any scratches / requiring just normal buffing to regain its normal form)
- v) Homogenous (Textures visible on top surface are present throughout the depth)
- vi) Boiling water resistant
- vii) Bacteria, Fungi and Termite proof
- viii) High temperature resistant (180 degrees no change)
- ix) Flammability (Class 1/Class A as per ISO)
- x) High Impact resistant etc,

Shutters made of high grade MDF board of 18 mm thickness with auto closing hinges shall be provided. The colour of the board in desk surface & shutters and architectural design on acrylic solid surface shall be decided during detailed engineering. The support legs for the vertical support system should be provided with leveling mechanism for compensating minor flooring variations.

The CPU cabinet with rotatable trolley/sliding tray should be integral part of each module. Proper cooling arrangement shall be considered while designing console.

All the cable trays shall run internally. The system should provide a good cable routing system with concealed cabling for power cables, computer monitor cables, instrumentation cables, telephone cables and networking cables. The cable entry to the console shall be from the bottom. The



separation necessary between network and power cabling shall be taken care of. All trays should be easily accessible during installation and maintenance. The horizontal cable tray shall have arrangement to accommodate plug connectors and sockets of varying sizes.

Vertical Support should have adequate height & base depth and minimum 2.5 mm thick suitable extruded aluminium beam to hold Mounting base, Tabletop surface and TFT, Tilting tray, Side & top aluminium profiles for stiffening and providing strength and wire-way. Suitable flexible arms moveable in all directions shall be provided for TFT monitors. Foot extension in Cast aluminium, powder coated in approved colour/shade.

The structure frame shall consist of extruded aluminium top and bottom horizontal beams and vertical support tensioned together to form an integrated, finished, robust frame. All frame assemblies and equipment support are built-off the structural frame. Structure shall be powder coated (the colour code shall be approved during detailed engineering).

A Valence of extruded aluminium should run throughout the length of console providing light on work surface top to maintain the appropriate lux level on table top. Also it shall be possible to mechanically dim the light on work surface.

The Edges of the tabletop shall be cut at an angle to give impressive look.

The system shall have receptacles for receiving incoming UPS power supply and outgoing feeders with proper mounting of MCBs, spike arresters etc., and necessary jacks for telephone & powerhouse LAN. The control desk shall accommodate operator stations each equipped with two VDUs, hidden keyboard and mouse, integrated telephone set, microphone, writing pad, emergency push buttons etc., and shall also have adequate working space. Arrangement with arm extension and tilting facility shall be provided for the telephone sets.

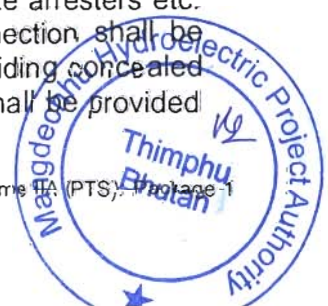
B) Computer Tables

The tables shall be of modular construction and have MDF board of approved colour with matching colour steel work. Suitable arrangement for placing the CPU below the top of the table using CPU trolley or any other means may be provided. Retractable keyboard holder using MDF board may also be provided. Arrangement for providing concealed wiring along with necessary jacks for telephone and powerhouse LAN shall be provided in an aesthetic manner. Power and LAN cable entry to the console shall be from the bottom and shall be unobtrusive.

C) Printer Tables

Printer table shall be of modular type. Desktop shall be made of 25 mm thick MDF and shall be powder coated aluminium sturdy structure.

All tables shall have receptacles for receiving incoming UPS power supply and outgoing feeders with proper mounting of MCBs, spike arresters etc. Boxes having provision for network and telephone connection shall be provided on table with each printer. Arrangement for providing concealed wiring along with necessary jacks for powerhouse LAN shall be provided.



in an aesthetic manner. Power and LAN cable entry to the console shall be from the bottom and shall be unobtrusive.

D) Chairs

It shall be Industrial grade with Aluminium extrusion at back and armrest. Chairs and control desk should look of same family for better aesthetics, ergonomics, comfort etc., Chairs shall have synchronized tilting mechanism Multiple locking systems, ABS for seat, Mesh back with extra lumbar with fine tuning Knob for depth adjustment and height adjustable back, with swivel & depth & Height multi-dimensional adjustable arm pad & option of PVC padding, gas lift for height adjustment and Nylon base with castors.

11.5.16.3 Illumination

The contractor shall ensure compatibility of the control room lighting with the control and monitoring facilities to be provided, i.e., Large Screen Display and other facilities. The contractor shall provide "luminous ceiling" for the control rooms. Such "luminous ceiling" shall consist of concealed light fittings and architectural diffuser panels/diffuser bounce light of suitable size to ensure even lighting, perfect light distribution and minimal glare on display screens and control surfaces. LED luminaries suitable for false ceiling & low wattage lamps (CFL) down lighters shall have to be provided to maintain 500 lux level, the quality class of direct glare limitations as 1 and better aesthetic look. Sufficient quantity of emergency lightings powered through 220 V DC / inverter shall be provided.

Proper coordination with supplier of illumination systems shall have to be done for wiring required for luminaries and installation of control panel to enable the lighting levels in different parts of the room to be independently adjusted to take account of:

- i) Control room operator preference
- ii) Night-time conditions and daylight conditions.

Lighting fixture and outlets for the air-conditioning system shall be integrated into the suspended ceiling by means of special carriers and shaped metal frames matching the selected type of openings and meeting the additional load.

The contractor shall coordinate with air-conditioning and fire fighting agencies while finalizing the positioning of illumination fixtures and design of false ceiling. The illumination fixtures should not foul with air conditioning ducts/diffusers/ fire fighting nozzles.

11.6 Drawings, Documents and Design Calculation

11.6.1 Design memorandum

The Contractor shall submit to Employer a design memorandum prepared in accordance to clause 1.6 "Record and Documentation" of "Section General Technical Requirements."



11.6.2 Drawings and documents

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in "Section 2 – Technical Documents" of "General Technical Specification (GTS)".

11.6.3 Design calculation

The Contractor shall submit the design calculation in accordance to Clause 2.4 of "General Technical Specification (GTS)" covering at least the following, for review / acceptance.

- i) Calculations to prove the overall availability of the system in accordance with "performance criteria and guarantee" for top order event as specified.

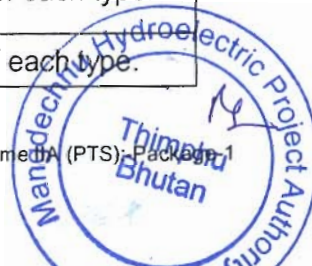
11.7 Delivery, Installation and Commissioning

The Contractor shall follow the requirements of Delivery, Installation and commissioning elaborated in clause 1.7 "Delivery, Installation and commissioning" of "Section 1 – General Technical Requirements

11.8 Spare Parts

Recommended spare parts shall be supplied in accordance to clause 1.8 "Spare Parts" of "Section 1 – General Technical Requirements". Specified spare parts to be supplied under this section are as follows.

S. No.	Description	Quantity
1	Time Synchronizing network cables with connectors	1 no.
2	Power supply modules/unit	2 nos. of each type.
3	Network Interface Cards of type / model used	1 no. of each type.
4	Other plug in cards type / model used	1 nos. of each type.
5	Data storage drives of each type / model used	1 no.
6	Modem of type for every ten (10) or less installed.	1 no. of each type.
7	Repeaters of each type / model used (if applicable).	2 nos. of each type.
8	Optical fibre coupling unit	2 nos. of each type.
9	Connectors, patch chords etc. of type / model used	2 nos. of each type.
10	Networking components.	1 no. of each type.



S. No.	Description	Quantity
11	Recorder of type /model used.	1 no. of each type.
12	Synchronizing device with all accessories	1 no. of each type
13	HMI panel of type / model used	2 nos. of each type.
14	Measuring transmitter of type / model used.	2 nos. of each type.
15	Sensors /transducers of type and model used.	2 nos. of each type.
16	Indicating instruments of type / model used.	2 nos. of each type.
17	Relays of type / model used.	2 nos. of each type.
18	Router / gateway with necessary firewall functionality	1 no. of each type.
19	Optical fibre consumables requirement for 2 years for all networks	1 no. of each type.
20	Programmable controller of type	2 nos. of each type.
21	Network switch of type	2 nos. of each type.
22	Meter reading instrument (MRI for SEM)	1 no.
23	LED luminaries complete with all accessories & fittings	10 nos of each type used
24	CFL down lighters	10 nos.
25	CFL Lamps	10 nos.

11.9 Tools & Instruments

The Contractor shall supply all necessary tools and instruments etc. for installation, repair and maintenance in accordance to clause 1.9 "Tools and Instruments" of "Section 1 - General Technical Requirements".

11.9.1 Special tools

The Contractor shall list and supply all special tools. List of such tools including their make and detailed specification, shall be submitted for acceptance by the Employer.

The proposed list of special tools must include the following in addition to tools recommended by manufacturer(s):

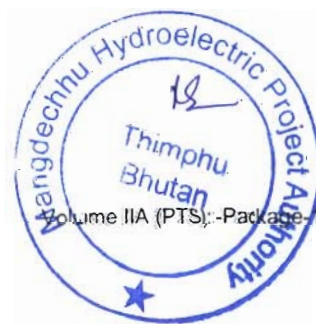
- i) Two (2) sets of fibre optic networking and maintenance tool kits.



- ii) Two (2) sets of crimping tools for installation of networks and cabling of each used type.
- iii) One (1) set of protocol conformance test equipment complete with all accessories, tools and software for testing each protocol standard used in the control system.
- iv) One (1) set of network performance analyser, network testing and certification tools.
- v) One (1) no. of optical time domain reflectometer with certification tools and accessories.
- vi) One (1) no. optical loss test set.
- vii) One (1) no. of fusion splicing equipment with accessories.

11.10 Quality Assurance and Testing

The Contractor shall follow the quality assurance and testing requirements specified separately in "Quality assurance and Testing Specifications (QTS)".



13 CABLING SYSTEM**13.1 Scope of Work**

Scope of work under this section covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, installation, commissioning, performance testing, acceptance testing, handing over to MHPA and guarantee for two years of cabling system as per the specifications hereunder, complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation.

The scope of work shall be a comprehensive functional system covering all supply and services including but not be limited to following:

13.1.1 Cables and accessories

- i) 33 KV XLPE power cable
- ii) 11 kV XLPE power cable
- iii) 650/1100 volt grade XLPE power cable
- iv) Control & Instrumentation cables
- v) Cable terminals, termination kits, cable lugs, cable glands, button tape (strap and stud), and cable junction boxes and all other accessories

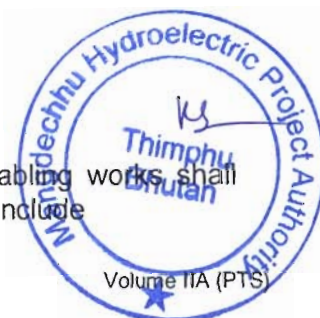
13.1.2 Cable routing and support systems

- i) Cable trays, connectors, hardware etc.
- ii) Flexible / adjustable cable support system including pre-fabricated structures/fixtures, strut channels, embedment, hardware etc.
- iii) Cable ducts, conduits, channels, joints etc.
- iv) Spare parts in accordance to clause 13.8 "Spare Parts" of this section.
- v) Tools and instruments in accordance to clause 13.9 "Tools and Instruments" of this section

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s) / best international practices.

13.1.3 Interfacing & Co-ordination**A) Cables & Cabling Works**

All the Power, Control & instrumentation cables and cabling works shall be in the scope of Contractor of Package-1. This would include



- i) All cables and cabling works for equipment supplied under Package-1.
- ii) All cables and cabling works from main control/distribution panels up to LCC / marshalling kiosk etc. for the equipment supplied under Package-2, Package-3 & Package-4. However all cables and cabling works from individual equipment supplied under Package-2, Package-3 & Package-4 to their respective LCC / Marshalling kiosk etc. or any other panel / equipment supplied under same package is included in the scope of respective packages i.e. Package-2, Package-3 & Package-4.

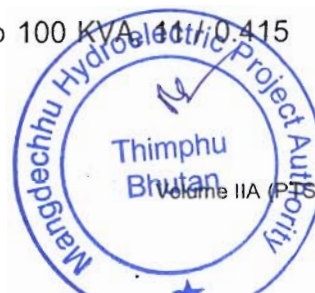
B) Cable schedule

Preparation of cable schedule of entire E&M works for successful commissioning of plant as a whole with proper co-ordination and inputs / data / details / drawings etc. from Contractor of Package-2, Package-3 & Package-4. However, Contractors of Package-2, Package-3 & Package-4 shall prepare their own cable schedule for interconnection of their respective equipments to LCC/ Marshalling kiosk etc. whatever the case may be and shall also indicate properly the terminals for termination of cables (if any) by Contractor of Package-1.

13.2 Specific Parameters and Layout Conditions

13.2.1 Layout and General Arrangement

- 1) The 33KV power cables shall be required to interconnect the following:
 - i) Two (2) nos. from 33 KV GODO switches at Pot yard to 33 KV Metal clad switchgear in potyard.
 - ii) Two (2) nos. from 33 KV Metal clad switchgear in pot yard to 5 MVA, 33 / 11 KV auxiliary power transformers (APTs) in Pot yard
- 2) The 11kV power cables shall be required to connect / interconnect the following:
 - i) Four (4) nos. from 11 KV panel in power house to 4 MVA, 13.8 / 11 KV Unit tap-off transformers
 - ii) Four (4) nos. from 11kV panel in power house to 2.5 MVA, 11 / 0.415kV Station Auxiliary Transformers
 - iii) One (1) no. from 11 KV panel in Pot yard to 11 KV GODO switch in Pot yard
 - iv) Two (2) nos. from 11 KV panel in pot yard to 5.0 MVA, 33 / 11 KV auxiliary power transformers (APTs) in pot yard area
 - v) Two (2) nos. from 11 KV panel in pot yard to DG sets in DG building in pot yard area
 - vi) One (1) no. from 11 KV panel in Pot yard to 100 KVA, 11 / 0.415 KV Auxiliary transformer in pot yard



- vii) One (1) no. from 11 KV GODO switch near Butterfly valve house cavern to 500 KVA, 11 / 0.415 KV transformer in Valve house chamber
 - viii) One (1) no. from 11 KV GODO switch near Surge shaft to 500 KVA, 11 / 0.415 KV transformer at Surge shaft
 - ix) Two (2) nos. from 11 KV panel in Pot yard to 11 KV panel in Power house for interconnection of two switchgears
 - x) One (1) no. spare cable laid between the 11 KV switchgear in Pot yard to 11 KV switchgear in Power House with proper end sealing,
 - xi) Any other interconnection (s) not mentioned specifically but necessary for the satisfactory completion of scope of work.
- 3) The 415V/ 240V AC and 220V DC cables shall be required to connect / interconnect the following in power house Cavern, Transformer cum GIS cavern, Outdoor pothead yard, Valve house chamber, Surge shaft and other adjoining areas of power house.
- i) Different auxiliary service boards,
 - ii) Various distribution boards to local control cubicles / equipment.
- 4) Control and instrumentation cables shall include all cables required for the installation of the complete instrumentation, control and protection systems in power house Cavern, Transformer cum GIS cavern, Outdoor pothead yard, Valve house chamber, Surge shaft and other adjoining areas of power house.

13.2.2 Design considerations

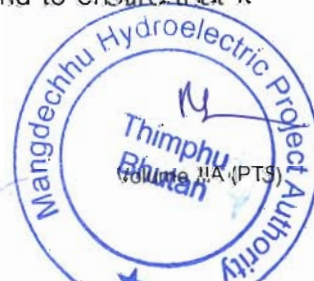
The number of cores and sizes of the cables required for various circuits from panel to panel shall be worked out during detailed engineering.

However, minimum sizes of the cables conductor shall be taken as:

- i) 2.5 mm² copper for control cable conductor,
- ii) 1.5 mm² copper for instrumentation/measurement cable conductor,
- iii) 4 core x 6 mm² copper for connection between CT junction boxes and panels having red, yellow, blue and black colour cover,
- iv) 4 core x 4 mm² copper for connection between PT junction boxes and panels having red, yellow, blue and black colour cover.

The cables covered by this specification shall be supplied in one length or in standard length as approved by the Employer.

Normally all LV cables, unless otherwise specified, will be un-armoured and will be laid in cable trays. However any cable laid directly (without cable tray/pipe etc.) either underground or overhead shall be of armoured type. The armouring shall always be earthed at one end to ensure that it can not become live if a fault develops within the cable.



13.2.3 Construction methodology**13.2.3.1 Fixing of supports**

The fixing arrangement shall be approved by the Employer. Strut channels shall be embedded for fixing of the supports and shall be provided, installed and supervised during concreting for correctness of positioning and alignment by the Contractor. Anchor fasteners shall be used wherever required to fix the anchors / supports. Field welding for support system shall not be allowed except fixing of strut channels / supports to embedment. All such welds shall be treated with galvanized compound. Welding to cable trays in any case shall not be allowed.

13.2.3.2 Cable routing

For the main cableways, a system of cable racks and trays as well as cable ducts and trenches shall be provided. The cables for emergency lighting, fire alarm systems, etc., shall be run on separate trays.

The 11kV, 33kV XLPE cables, power and control cables shall be run separately on racks / trays, in cable trenches / cable tunnels and on columns, walls, ceiling and pulled through pipes. The Contractor shall be responsible for carrying out proper dressing of the cables and supply non-magnetic/moulded fiber-glass cable fixing cleats, fasteners and clamps wherever necessary to hold the cables firmly to the trays.

Contractor shall take proper care in the handling of cables against external damage of any kind. Necessary rollers etc. shall be used while pulling and laying of the cables. Employer shall have the right to stop the work in case of improper handling of the cables.

Cables shall be properly clamped at regular intervals with the help of non-magnetic/moulded fibreglass strip clamps/PVC sleeved clamps, of suitable size. Contractor shall submit typical drawings along with tender giving proposed clamping arrangement and give distance of clamping at bends and in regular run of cables.

13.2.3.3 Cable markers and cable binding

Suitable cable markers of Aluminium with punch marks shall be provided and suitably tagged to the cable permanently so that cable could be easily identified.

13.2.3.4 Cable binding/strapping

All control cables after glanding shall be neatly routed and bonded with the help of cable straps and studs inside the panel. Complete routing in panel shall be such that it gives a neat appearance and good workmanship.

For L.T. Power cables, suitable holding clamps will be provided in the panel if required. The Contractor shall do the cable glanding suitable for each cable size at both ends of termination of each cable.

13.3 Rating and Functional Characteristics

The power, control and instrumentation cables shall have the following properties:

- i) Oxygen index Min. 29,
- ii) Smoke density Min. 40% light transmittance,
- iii) Acid gas Max. 20% by weight,
- iv) Flame propagation shall meet IEC 60332-1, IEEE 383.

13.4 Performance Guarantee

The power and control cabling system along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system.

13.5 Design and Construction

13.5.1 Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose:

S.no.	Standards	Description
1.	IEC 61537	Cable tray systems and cable ladder systems for cable management
2.	IEC 60331	Tests for electric cables under fire conditions
3.	IEC 60332	Test on electric and optical fibre cables under fire conditions
4.	IS 1554	Specification for PVC insulated (heavy duty) Electric cables
5.	IS 7098	Specification for cross linked polyethylene insulated PVC sheathed cables
6.	IS 1255	Code of practice for installation and maintenance of power cables up to and including 33kV rating



13.5.2 Cables**13.5.2.1 Power cables – 33KV/11 KV system**

33kV/11KV power cable shall be of heavy duty, FRLS, stranded circular copper conductor, cross linked polyethylene (XLPE) insulated provided with conductor screening and insulation screening, laid up, extruded PVC inter sheathed and armoured. The insulation and screening shall be extruded, semi-conducting and with copper tape screening (at least 0.075 mm thickness).

13.5.2.2 Power cables - 650/1100 volt grade

These cables single or multicore (2 / 3 / 3.5 cores) shall be at least 650 / 1100 volt grade, heavy duty, FRLS, stranded Aluminium / Copper conductor, cross linked polyethylene (XLPE) insulated and PVC inter sheathed.

Cables for DC system shall be of copper only.

13.5.2.3 Control and instrumentation cables

The control and instrumentation cables shall be multi core, FRLS, colour coded/numbered, annealed stranded high conductivity Copper, single conductor, insulated with PVC insulation and PVC sheathed. The outer sheath shall be of specially formulated PVC compound.

13.5.3 Colour scheme and identification

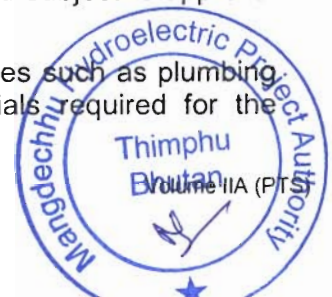
To facilitate easy identification of phases a colour scheme of red, yellow and blue for phases and black for neutral shall be adopted for power cables. Multi-core control cables shall be colour coded / numbered for identification of cores as per IS: 1554 1988 / IEC.

All the cables shall carry manufacturer data in a permanent, legible manner at an interval of at least three (3) meter run. The manufacturer's data shall include the name, cable size, and voltage rating together with any other information. Permanent sequential marking to indicate length of the cable shall be embossed at every meter along with Employer's name (MHPA).

13.5.4 Accessories**13.5.4.1 Termination kit**

The termination kits required for 11kV and 33kV XLPE cables terminations shall be heat shrinkable type. Any other latest type having proven performance in the field can also be accepted subject to approval of Employer.

The Contractor shall supply all hardware consumables such as plumbing metal, sealing compound, tapes and other materials required for the



making of these terminal connections of various sizes of cables and should leave at least 5% of these items for future use by the Employer.

13.5.4.2 Cable lugs

The Contractor shall ensure that no bimetallic action takes place, between the conductor of the cable and the cable-connecting lug by filling the lugs with suitable compound. The lugs shall be of standard quality conforming IEC / IS and of make approved by the Employer.

13.5.4.3 Cable glands

The cable glands shall be made of brass duly electro tinned in order to avoid corrosion and oxidation of the surface. Glands shall provide neat, tight, dust and vermin proof termination. Gland shall be provided with rubber ring to hold the cables firmly when check-nut is slightly tightened. Gland shall be complete with suitable washers etc.

13.5.4.4 Compression type terminals for control wiring

These terminals are required for copper conductor of control wiring. They shall be crimped to the conductor while other end will provide flat surface for better connections. The connectors shall be made of Copper electro tinned.

13.5.4.5 Button tape (strap and stud)

This consists of perforated cable strapping with holes conveniently spaced for assembly and moulded studs. The strapping shall be made of NYLON Grade 220 or other elastic material to give proper performance. The studs shall be made of 'NYLON'.

13.5.4.6 Self adhesive marker

Self-adhesive marker in the form of strips of any one character, which can be easily peeled from the backing cards and can be applied on the cable, shall be supplied. The strips shall be water- proof duly marked with special formulated ink with specific thermo-setting adhesive to withstand high temperature.

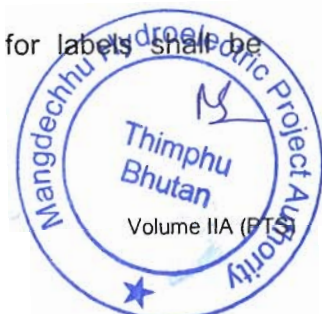
Suitable plastic ring type ferrules marked with engraved indelible ink for control cables and sticker type ferrules for power cables shall be supplied. These shall be marked as per cable schedule such that each core of each cable can be identified easily.

13.5.4.7 Aluminium strip

Aluminium strip of adequate size for making tags for labels shall be supplied.



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13.5.5 Cable trays and support structure

The cable trays including accessories like bends, elbows, tees, cross etc. shall be of perforated (long slots) type, for proper ventilation of the cables, made out of 14-gauge mild steel sheet. The trays shall have minimum 50 mm edge height. The cable trays shall be fully galvanized and the Employer reserves the right to test galvanizing as per approved standard in presence of its representative. Stainless steel cable trays shall be provided for humid premises and the area prone to water dripping and spray.

Supports and screws and bolts for cable trays shall be made of the same materials as the cable trays they support. Tray support system shall be flexible/adjustable type having pre-fabricated sections and supports that can be assembled and bolted for quick and easy installation. Trays provided in tiers shall have minimum 300 mm spacing between tiers.

Ladder type tray with double bends may be used as decided/approved by the employer during detailed engineering.

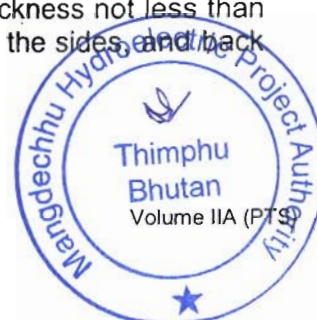
All the vertical cable trays & the trays which consist of instrumentation cables shall be provided with full covering.

13.5.6 Cable sealing and fire proofing

Modular Multidiameter Cable sealing system consisting of frames, blocks and accessories to be installed wherever cables enter/leave/cross walls, floors, panels, terminal boxes or cubicle. Cable sealing to be with Multidiameter type peel-able blocks of different sizes to be provided for simple, easy and quick to assemble & re-assemble. 30% spare block on the frame to be provided with usable Multidiameter blocks with center plug, so that these spare blocks can be used for expansion in future for wide range of cables, solid blocks should not be used on frame. Cable sealing system should have been type tested for fire / water / smoke tightness. Modular Multidiameter Cable sealing system consisting of frames, blocks and accessories to be installed wherever cables enter/leave/cross walls, floors, panels, terminal boxes or cubicle. Cable sealing to be with Multidiameter type peel-able blocks of different sizes to be provided for simple, easy and quick to assemble & re-assemble. 30% spare block on the frame to be provided with usable Multidiameter blocks with center plug, so that these spare blocks can be used for expansion in future for wide range of cables, solid blocks should not be used on frame. Cable sealing system should have been type tested for fire / water / smoke tightness.

13.5.7 Cable junction boxes

Junction box shall be constructed of sheet steel of thickness not less than two (2) mm. Ample wiring space shall be provided at the sides and back of the enclosure for incoming and outgoing circuits.



Removable plates with gaskets shall be fitted at the top and bottom of the box to provide the entry for conduit or cable. The door shall be provided with suitable gasket and fitted with a lock type handle. The door shall be hung on hinges having brass bodies and stainless steel pins.

Each cable junction box shall be provided with terminals of adequate rating on the terminal strip of suitable thickness.

13.5.8 Terminal blocks

Terminal blocks shall be in accordance to clause 1.5.2.2 "Terminal Blocks" of "Section-1- General Technical Requirements".

13.6 Drawings, Documents and Design Calculations

13.6.1 Design memorandum

The Contractor shall submit to Employer a design memorandum prepared in accordance to clause 1.6 "Record and Documentation" of "Section 1- General Technical Requirements."

13.6.2 Drawings and documents

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in "Section 2 - Technical Documents" of "General Technical Specification (GTS)".

13.6.3 Design calculation

The Contractor shall submit the design calculation in accordance to Clause 2.6 of "General Technical Specification (GTS)" covering at least the following, for review / acceptance.

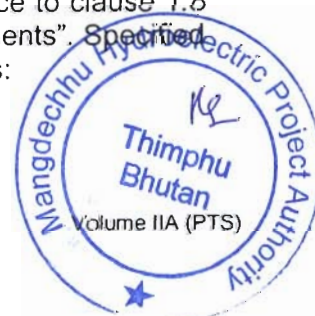
- i) Calculation for voltage regulation, temperature rise during normal operation and fault level and short circuit calculation for selecting the cable size,
- ii) Cable schedule.

13.7 Delivery, Installation and Commissioning

The Contractor shall follow the requirements of Delivery, Installation and commissioning elaborated in clause 1.7 "Delivery, Installation and commissioning" of "Section 1 - General Technical Requirements."

13.8 Spare Parts

Recommended spare parts shall be supplied in accordance to clause 1.8 "Spare Parts" of "Section 1 - General Technical Requirements". Specified spare parts to be supplied under this section are as follows:



S. No.	Description	Quantity
1.	Cable 33kV	100 m of each type used
2.	Cable 11kV	200 m of each type used
3.	LV power cable of each type & size $\geq 6\text{mm}^2$	200 m of each type used
4.	Control cable of each type	200 m of each type used
5.	Instrumentation cable of each type	200 m of each type used
6.	Termination kits -33 kV	
i)	Outdoor type	4 nos. of each type used
ii)	Indoor type	4 nos. of each type used
7.	Termination kits -11 kV	
i)	Outdoor type	4 nos. of each type used
ii)	Indoor type	4 nos. of each type used
8.	Lugs of each size	
i)	For cables $\leq 10\text{ mm}^2$	100 nos. of each type used
ii)	For cables $> 10\text{mm}^2$	50 nos. of each type used
9.	Junction/terminal boxes of each size	20 nos. of each type used
10.	Cable tray of each size	50 m of each size used

13.9 Tools and Instruments

The Contractor shall supply all necessary tools and instruments etc. for installation, repair and maintenance in accordance to clause 1.9 "Tools and Instruments" of "Section 1 - General Technical Requirements".

13.9.1 Special tools

The Contractor shall list and supply all special tools. List of such tools including their make and detailed specification, shall be submitted for acceptance by the Employer.

The proposed list of special tools must include the following in addition to tools recommended by manufacturer(s)

- i) Two (2) sets of hydraulically operated crimping tools,
- ii) Two (2) sets of control cable crimping tools,
- iii) Two (2) sets of wire cutters for all sizes of cables,
- iv) Two (2) sets of wire strippers for all sizes of cables.

13.10 Quality Assurance and Testing

The Contractor shall follow the quality assurance and testing requirements specified separately in "Quality assurance and Testing Specifications (QTS)".

