



26 FIRE FIGHTING SYSTEM

26.1 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, insurance, site storage and preservation, installation, commissioning, performance testing, acceptance testing, training of Employer's personnel, handing over to MHPA and guarantee for two years of fire fighting 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:

26.1.1 Fire protection system

- i) Two (2) nos. horizontal centrifugal pumps along with self cleaning filters, local control panel, instrumentation and associated accessories for filling of fire water tank from the tail race.
- ii) Thirteen (13) nos. deluge system for fire protection of each GSU transformer (including spare GSU transformer),
- iii) Three (3) nos. deluge system for fire protection of each Bus Reactor
- iv) Four (4) nos. of deluge system for fire protection of governor oil pumping units,
- v) Four (4) nos. of deluge system for fire protection of main inlet valve oil pumping units,
- vi) Deluge system for fire protection of XLPE cables including power & control cables / trays in the cable tunnels and cable gallery, as per approved drawings,
- vii) Four (4) nos. deluge system for fire protection of each ICT (including spare),
- viii) Two (2) nos. deluge system for fire protection of each Auxiliary Power Transformer (33 kV / 11 kV) placed in DG area,
- ix) Wet sprinkler system for offices, conferences room/ meeting rooms/ stores, cable spreading room, electrical and mechanical utility areas etc. As per approved drawings,
- x) Fire fighting hose cabinets along with hydrant valve, branch pipe and hose reels as per approved drawings,
- xi) Portable fire extinguishers as per approved drawings,
- xii) Insulation for fire fighting pipes,



- xiii) All piping including embedded and exposed piping, pressure reducer station, valves, fittings, instrumentation and associated accessories necessary for the system including separate filling pipe from filling pumps to fire tank and pipe from fire tank to main fire header.

26.1.2 Fire detection system

- i) Intelligent, analogue, addressable type sensors/ detectors such as multi-sensors (smoke and heat), photo-electric detectors, optical beam detectors and thermal sensors/ detectors complete with necessary cabling distributed throughout the plant for detection of fire,
- ii) Digital linear heat sensing cable (LHS) along with associated accessories for detection of fire in the cable/ cable trays throughout the plant as per approved drawings,
- iii) Aspirator type smoke detection system complete with ancillary devices and remote display for generator, excitation cubicle, main control room and office and conference room.
- iv) Manual pull stations and notification devices such as fire horns/ alarms/ hooters/ bells, light or text display etc. Distributed strategically throughout the plant for manual intervention and audible and visual alarm as per approved drawings and bill of materials,

26.1.3 Alarm panels and misc. Components for the fire fighting system

- i) Local alarm panels as required distributed throughout the plant,
- ii) One (1) microprocessor based addressable analogue, intelligent type main fire alarm panel with minimum five loop panel located in control room,
- iii) Four (4) repeater panels, one located at main access tunnel entrance, second in the service bay, third in GIS/ transformer hall and fourth in ICT cum 145 KV GIS building
- iv) One (1) fire work station and TFT monitor
- v) Two (2) video display units along with necessary graphic software & associated accessories which shall be suitable for interface with the DCS system of the plant. One number shall be located in the control room and other shall be in machine hall floor.
- vi) One (1) fire alarm printing device to be located in the control room,
- vii) One (1) set of microprocessor based digital EPABX system for fire alarm system along with minimum 30 nos. Individual stations distributed strategically throughout the plant.

**26.1.4 Miscellaneous items**

- i) Fire rated penetration seals, fire barriers, fire dampers etc, as per approved drawings,
- ii) Signal and evacuation signs installed in the plant areas in accordance with the specification and the codes,
- iii) Five (5) sets of fireman suit and self contained breathing apparatus and other safety/rescue equipments,
- iv) Necessary pressure indicating devices for fire water headers and level sensing/ indicating and remote monitoring devices for fire tank.
- v) Coordination and provision of necessary contacts and/or ports for integration with plant SCADA system.
- vi) Spare parts in accordance to clause 26.8 "Spare Parts" of this section.
- vii) Tools and instruments in accordance to clause 26.9 "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.

26.2 Specific Parameters and Layout Conditions**26.2.1 Layout and General Arrangement**

The source of water for the fire fighting system shall be the cooling water sump provided at EL 1003.00 in each of the tailrace. The detailed scheme of interconnection of sumps, dry pits etc. Shall be as per clause 21.2 "Specific parameters and Layout conditions" of section 21-"Cooling Water System." Two (2) nos. Horizontal centrifugal pumps of adequate capacity shall be installed at EL 1010.0M for meeting the requirement of fire fighting system. The water circuit shall be provided with automatic self cleaning filters, Heat exchangers and necessary valves as shown in drawing. Both the pump shall be sufficient capacity to cater the load of fire fighting system. Each pump shall draw water through DN 250 embedded pipe and shall discharge water into fire water tank located outside the power house cavern, tentatively at EL 1130-1140 above MAT / VT portal. The exact location and elevation of fire fighting tank will be decided during detail engineering. The schematic arrangement has been detailed in drawing no. NH/DEM/MGD/FF/01.

The requirement of fire fighting system shall be made from cooling water sumps of tailrace. Accordingly, provision for two tapping from each interconnecting headers of sumps shall be made, one for HVAC primary cooling water pumps and one for fire fighting pumps. Single line diagram of cooling water system has been shown in drawing no. NH/DEM/MGD/CW/01.



The main fire water header drawing water from the fire tank shall be installed in the powerhouse spanning the length of the power house. Sub-headers in power house, control block, transformer cavern, cable tunnel, GIS building, pothead yard, ICT cum 145 KV GIS building shall be laid to distribute the fire water to deluge system for oil filled transformers, oil pressure unit, generators, sprinkler system and hydrants at various floors/area as shown in the schematic diagram drawing. To prevent excessive pressure in any of the headers/ pipe network due to elevation difference etc. Suitable pressure reducers/ orifices shall be provided.

The fire tank placed at El. 1130-1140 m (tentative) shall have a capacity of at least two (2) hours supply to meet the largest fixed fire suppression demand plus the maximum hose stream demand of not less than 1890 LPM meeting the NFPA standard. The tank shall have level switches for automatic starting and stopping of fire pumps

The type of fire fighting arrangement for various equipments with sensing devices is given below.

S. No.	Equipment/ Area	Fire sensing devices	Fire fighting arrangement
1	Oil pressure unit of governor and MIV	Temperature sensing bulbs	High velocity water (HVW) spray system
2	Generator	Smoke and heat detectors, Aspirator type smoke detectors, Manual pull station	High velocity Water (HVW) spray system,
3	Excitation cubicle	Aspirator type smoke detectors	Portable fire extinguishers and fire hydrants
4	Generator transformers & Reactors	Temperature sensing bulbs	High velocity Water (HVW) spray system,
5	Cable spreading area	Multi sensors (heat and smoke detector), digital linear heat sensing cable Manual pull stations	Water sprinkler system with electrically safe nozzle for cable spreading area.
6	Cable tunnel	Digital linear heat sensing cable Manual pull stations	Medium velocity Water (MVW) spray system for cable tunnel and fire hydrants



7	Control, Computer & Communication room	Multi sensors (heat and smoke detector), aspirator type smoke detection system Manual pull stations	Portable fire extinguishers and fire hydrants
8	Offices, conference room, pantry etc.	Multi sensors (heat and smoke detector), aspirator type smoke detection system/photoelectric detector Manual pull stations	Portable fire extinguishers Water Sprinkler System and fire hydrants
9	Control block floor Mechanical and Electrical Utility Areas	Multi sensors (heat and smoke detector), Manual pull stations	Portable fire extinguishers and fire hydrants
10	Power house floors(except M/c hall floor) Machine hall floor	Multi sensors (heat and smoke detector), beam detectors Manual pull stations	Portable fire extinguishers and fire hydrants
11	Transformer cavern (except GIS hall) GIS hall floor	Multi sensors (heat and smoke detector), beam detectors Manual pull stations	Portable fire extinguishers and fire hydrants
12	Pothhead yard area	Manual pull stations	Portable fire extinguisher and fire hydrants
13	DG room	Multi sensors (heat and smoke detector), Manual pull stations	Portable fire extinguishers Water Sprinkler System and fire hydrants
14	Bulk oil storage tank	Temperature detectors Manual pull stations	Portable fire extinguishers Water Sprinkler System/ fire hydrants
15	GIS floor/GIB floor and Other miscellaneous	Multi sensors (heat and smoke detector),	Portable fire extinguishers and fire hydrants



	areas	beam detectors Manual pull stations	
16	400 / 132 KV ICTs	Temperature sensing bulbs	High velocity Water (HVW) spray system,
17	Penstock Butterfly Valve	Suitable sensors	Portable fire extinguishers
18	Auxiliary Power Transformer (33 kV / 11kV)	Temperature sensing bulbs	High velocity Water (HVW) spray system,

It is the responsibility of the Contractor to complete the system in all respects. Any item/ equipments not covered below but which are necessary for safe working of the entire power plant, shall be furnished by the Contractor. However, the same shall further be finalised during detailed engineering.

Suitable means or arrangement shall be ensured for isolation of fire and smoke in the power plant.

Fire fighting equipment pertaining to generators, shall be covered under "Section-6, Generator". However, interconnection of generator fire panel to main fire panel shall be in the scope of this chapter.

26.2.2 Design considerations

- A looped conduit system shall be provided so that if the conduit and all the conductors get severed at any point, the initiating device circuit, signal line circuit and notification appliance circuit shall remain functional,
- The implementation of the communication technology for fire signalling system shall be such to compensate for any failure to communicate a signal by eliminating the risk of missing even a single fire alarm signal,
- Addressable system in the control panel shall be advanced microcomputer based system,
- The time delay between the activation of an initiating device and the automatic activation of a local fire safety function shall not exceed ten (10) seconds,
- Detectors shall be located at strategic position and arranged in zones to facilitate proper indication of fire location, transmission of audio-visual signals to fire control panels and actuation of the appropriate fire fighting system,
- Detectors installed in concealed areas shall have suitable visual indication in a visibly located area.



- vii) Necessary fire barriers of suitable resistance rating and smoke control barriers shall be provided to prevent transmission of the fire and smoke from one area to another in accordance with relevant standards,
- viii) Contractor shall give due consideration to ensure aesthetic of the powerhouse areas. Necessary coordination with the architectural work contractor shall be made while finalising the system.
- ix) Necessary smoke and heat venting shall be planned for areas identified by fire risk evaluation, carried out by the Contractor, where either the heat or smoke or both shall be vented from its place of origin directly to the outdoors. The Contractor shall ensure the necessary co-ordination with ventilation contractor for the same to ensure proper functioning in emergency situations.

26.3 Rating and Functional Characteristics

26.3.1.1 Fire pumps

Each tank filling pump shall have a capacity to fill the tank within four hours with one pump. The Contractor shall coordinate with generator and transformer manufacturer to assess the water requirement for deluges/ sprinkler and incorporate the same while finalizing the pump capacity. The design head for pumps shall be sufficient to fill the fire tank.

The pumps shall be of horizontal centrifugal type complete with continuous duty electric motors with class F insulation (temperature rise limited to class B), control panels, cables, anchor bolts and other mounting materials. The motor shall be suitably sized to drive the pump continuously over the specified characteristics without getting overloaded.

26.3.1.2 Headers and piping

The fire header and piping shall be looped and of sufficient size to supply the flow requirements at any point in the loop considering the most direct path to be out of service. Fluid velocity in the main header shall normally not exceed 3.0 m/s. Pipe sizes shall also be designed to accommodate any future expansion/ water demands.

26.4 Performance Guarantee

The fire fighting 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.



26.5 Design and Construction

26.5.1 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	NFPA 851	Recommended practice for fire protection for hydroelectric generating plants
2	NFPA 72	National Fire Alarm Code
3	NFPA10	Standard for portable fire extinguishers
4	NFPA13	Standard for the installation of sprinkler systems
5	NFPA 14	Standard for the installation of stand-pipe, private hydrants, and hose systems
6.	NFPA 15	Standard for water spray fixed systems for fire protection
7.	NFPA 20	Standard for the installation of stationary fire pumps for fire protection
8.	NFPA 75	Standard for the protection of electronic computer/ data processing equipment
9.	NFPA 1221	Standard for the installation, maintenance, and use of emergency services communications systems
10.	TAC	Tariff Adversary Committee

26.5.2 Fire pumps

The material of pump impeller and casing shall preferably be high grade duplex stainless steel (AISI 329 or better) and cast steel (ASTM A 216 WCB or better) respectively. The selected impeller material shall have excellent abrasion and corrosion resistant properties. The material of shaft, sleeve and key shall be stainless steel (AISI 410 or better).

Pump bearings shall be grease lubricated. The pump shall be automatically operated as per the requirement of water in tank. Pressure gauges shall be provided at the inlet and outlet of the pumps. Pressure switches/ flow switch with suitable numbers of potential free contacts for remote indication and alarm shall be provided for each pump. Shut-off valves and check valves shall be provided to allow disconnection and



switching of each pump. Suitable alarm annunciation for non-functioning of the pumps shall also be provided in the control room/ unit.

Adequate arrangement shall be provided to prevent the pump from rotation in reverse direction.

26.5.3 Automatic self cleaning filter

Automatic self cleaning filters preferably wedge wire candle self cleaning type of heavy duty of suitable capacity shall be provided. The material for filter candle/element shall be stainless steel and body of carbon steel. The pressure drop shall not be more than 0.2 bars. Pressure sensors shall be provided for differential pressure indication across the filters.

The filter shall preferably be capable of removal of all material as small as 1000 micron.

26.5.4 Over head fire tank

The fire tank shall have suitable numbers of level switches working on two different principles for automatic starting and stopping of the fire pumps and remote level indication. The tank shall be of reinforced concrete and the civil works of tank shall be done by the other Contractor. The tank shall be suitably compartmentalised along with its level switches, level transducers and level indication for inspection, cleaning or repair maintaining 50% of design capacity. The tank "status" shall be properly annunciated in the main control room.

26.5.5 Piping, valves and appurtenances

All required pipes, flanges, fittings, supports, fasteners, valves and other related material necessary for completion of the system shall be supplied as a part of this contract. All embedded and exposed water pipes size 25mm and above shall be made of carbon steel of minimum schedule 40. Pipe size less than 25mm shall be of minimum schedule 80. Gravity drain pipes shall be of minimum schedule 20. Heavy duty gate valves suitable in fire application shall be used in fire fighting system for isolation and control. Pipes crossing roads, trenches etc. shall be provided with mild steel sleeves. Water pipes shall be insulated against condensation wherever required with approved type insulation and be provided with vapour proof cover. The piping and valves shall be in accordance with clause 5.7 "Piping, Fittings, Valves, and Heat Exchangers" of General Technical Specification (GTS).

Pipes exposed to atmosphere shall be insulated to withstand temperature of (-) 10°C.

Mechanical groove type coupling shall be provided for ease of dismantling of pipe & fittings which shall be finalised during detailed engineering.



26.5.6 Fire detection devices

26.5.6.1 Automatic fire detectors

The detectors spacing and rating shall be in accordance with the applicable standards/codes and shall have UL approval.

The smoke detectors shall be designed with minimised effect of environmental conditions like air velocity, altitude, humidity, temperature, colour of smoke, electrical and mechanical influences like abnormal pressure or vibration and the influence of aerosols and any particulate matter. It shall be plug-in type with detector base containing terminals for making connections. The detectors shall be assembled and engineered for flush or surface ceiling mounting with a standard outlet box.

Provision of visual indication of detector's alarm condition shall be visible from a distance of six (6) m and visually different from indications of other conditions. The openings of the smoke entry shall be at least thirty (30) mm below the ceiling level assumed to be smooth and flat.

A) Thermal detectors

Thermal/ heat detectors shall be designed to operate when the rate of temperature rise at the detectors exceeds a predetermined value irrespective of the actual temperature. It shall be possible to reset detectors after attending the alarm.

B) Multi sensors

Multi sensors shall be state of the art and operate on sensing of smoke and heat both. The selected sensors model shall be suitable for the different type of smoke.

The spacing shall be in accordance to the relevant standard.

C) Digital linear heat sensing cable

Heat sensing cable shall permits early detection of fire or overheating. The cable shall be digital type and set to give an alarm signal in the range of 80 to 90 deg. C.

D) Optical beam detectors

Beam detectors shall be reflector type linear optical beam smoke detectors operate on principle of light obscuration utilizing infrared beam. The beam type detectors are envisaged to used in machine hall and GIS hall area ceiling height 10m or above for detection of fire/ smoke along B & D line.

Any other suitable type detectors required can be acceptable subject to acceptance during detailed engineering.

26.5.6.2 Manual pull stations

The manual pull station shall be intelligent addressable type suitable for surface mounting. The manual pull stations shall preferably be located at



access ways within a distance of 1.5m from the exit doorway opening at each exit on each floor and distance to the nearest pull station measured horizontally on the same floor shall normally not to exceed 50m.

The coded manual pull station shall produce at least three (3) repetitions of the coded signal, with each repetition to consist of at least three impulses.

The lever of the manual pull stations shall get locked after manual activation till it is reset. The front colour of the station shall be fire red with white inscription as per relevant standards.

26.5.6.3 Aspirator smoke detectors

Generators, excitation cubicle and control & communication room shall be provided with aspirator type smoke detection system for earliest warning of a potential fire in incipient stage.

Suitable pipe work for drawing the sample air continuously from the generator housing/ other protection area shall be laid and the Contractor shall critically study the configuration of the area and the associated problems for designing and installing the smoke detection system. Aspirator type smoke detection system with display unit based on laser technology shall be provided.

Suitable interfaces shall be provided for supervision of the real time data through plant SCADA. Provision for multiple alarm levels at least three levels with programmable relays shall be made.

26.5.7 Notification devices

If an alarm in a fire zone occurs, electric hooters/bells/horns/ speakers, light or text displays providing audible, tactile, or visible outputs or any combination thereof shall be actuated. The number of these items shall be sufficient to alert the complete zone. These devices shall have separate screw terminal for each conductor and the sounders/audible appliances shall generate sound in the range of 500-1000Hz different from the equipments and other devices provided in the area and in the building.

A minimum sound level of either 5dB (A) above any other noise likely to persist for a period longer than 30 seconds or 65dB (A), whichever is greater but not exceeding 120dB (A) shall be produced by the sounders at any point which can be occupied in the building. Audible notification appliances shall be so selected and placed that they are sufficiently intelligible with adequate audibility and clarity minimising any kinds of distortion in an electro acoustic system.

Visual notification appliances shall conform to the applicable standards and shall be surface mounted.



26.5.8 Fire suppression system

26.5.8.1 Hydrant systems and hose reels

Fire hydrants and its components shall be designed and installed in conformity to relevant code/standards. Hose reels with shut-off nozzle shall preferably be installed in recesses so that they do not form obstruction on a route of escape and shall be located in accessible positions at each floor level adjacent to exits in corridors on exit routes.

The spacing of hydrants shall be in accordance to the relevant national/international standards.

The space requirement, location, maximum overall size, component case, water supply for hose reels, materials, appliances etc. shall be in accordance with relevant standards. The hose stations shall be so positioned so that two streams can be directed to any location.

26.5.8.2 Water sprinkler and spray systems

Each of the high velocity water spray system shall consist of a deluge valve, pressure switches, distribution piping, nozzles, thermal/heat detectors and a deluge panel. The deluge panel shall provide a connection point from the deluge system to the powerhouse annunciation and detection system, as well as transferring the signal from the heat detectors to the electrically operated deluge valve.

Each deluge system shall consist of an electrically monitored isolating valve; normal dry/wet distribution piping, flow/ pressure switch and bulb type monitoring system which automatically gets activated at a rated temperature.

The Contractor shall coordinate the system design with all oil filled transformers manufacturer(s) to assure complete transformer protection system and to design the water requirement.

Each sprinkler system shall consist of an electrically monitored isolating valve; normal wet distribution piping flow/ pressure switch and glass type sprinklers which automatically get activated at a rated temperature.

All automatic sprinklers shall have temperature-sensitive sealing. The type, size and design of each sprinkler installation used in the system shall be appropriate to the hazards covered by the installation.

All exposed metalwork in systems shall be efficiently earthed to prevent the metalwork becoming electrically charged.

The temperature rating of a sprinkler shall not be less than 30°C greater than the highest expected ambient temperature of the location. Sprinklers shall be suitably coated with corrosion-resistant material.

The system design and equipments shall be in accordance with relevant standards. All sprinklers etc. shall be UL approved make.



26.5.8.3 Portable fire extinguishers

The type and number of portable fire extinguishers shall be determined on the basis of classification of fires anticipated in the area, the construction and occupancy of the individual property, ambient – temperature conditions etc. Portable fire extinguishers shall preferable be dry chemical (DCP), CO₂ type, foam type etc. and free from agents which are non eco friendly such as Halon.

26.5.9 Fire alarm, supervision and signalling system

26.5.9.1 Fire detection, alarm and supervision

The fire alarm and detection system shall be a completely supervised fire alarm reporting system, which shall be activated into the alarm mode by the activation of any of the alarm initiating devices in the event of fire. The system shall remain in the alarm mode until the initiating device is reset and the fire alarm control panel is reset and restored to normal.

All alarms coming from the detectors shall be line wise transmitted to the main fire alarm panel. The alarms of the system shall be transferred first to the respective panels for activating the fire suppression systems. In parallel, each line shall be printed out on a fire alarm printer and indicated at video display units (VDU).

26.5.9.2 Power supplies

Fire alarm systems shall be provided with at least two independent and reliable power supplies, one primary and one secondary (standby), each of which shall be of adequate capacity for the application and performance of the fire alarm system. The cables from SAB and plant DC system shall be provided upto Fire alarm panel and fire pumps. Further necessary cables, connections, interfaces etc. shall be in the scope of Fire fighting Contractor. The Contractor shall fully ensure that the changeover from primary supply to secondary supply and vice-versa shall be fully automatic without affecting the transmission of signal via the fire reporting system upon operation of the initiating devices.

26.5.9.3 Fire alarm control panels

The main and repeater fire alarm control panels shall provide automatic, supervised, multi zone detection and alarm system. Each fire alarm panel shall be of modular type, installed in a mounted steel cabinet with hinged door and cylindrical lock. The panels shall be clean, uncluttered and orderly assembled containing all necessary operating and supervising elements/ components, using a solid state technique. The start-up shall be automatic after restoration of power either primary or secondary. Signals and LEDs/LCDs together with visual annunciation shall be provided to indicate by zone any alarm, supervisory or trouble condition on the system as an integral part of the control panel with suitable identification.



The operational features of the modules shall have at least the following. Other additional features required to make the system fully functional shall also be incorporated in accordance with relevant standards.

- i) Monitoring electrical supervision of different circuits viz. initiating device circuits, circuits used for supervisory signal services viz. sprinkler water-flow, water level indicators etc.,
- ii) Monitoring electrical supervision of power supply, transmitter tripping circuit integrity etc.,
- iii) Trouble buzzer and trouble LEDs/LCDs against any fault due to loss of power supply, single break, open, or ground fault condition, panel fault and panel door open etc. impeding the normal functioning of the system,
- iv) Evacuation alarm signal switch and transmitter disconnect switch,
- v) Confirmation or verification of all smoke and heat detectors,
- vi) Provision of supervised addressable relay for HVAC shut-down which shall not be overridden at the HVAC panel,
- vii) Monitoring and control of fire sprinkler system, release of deluge system and other fire extinguishing system,
- viii) Control panels and field panels shall have suitable software programme enabling expansion and modification of the system without replacement of hardware or firmware viz. addition or deletion of zones etc.

An alarm condition in the circuit which shall automatically annunciate in the mimic and shall have at least the following functions to make the system fully functional. These alarms shall also be printed out.

- a) Transmission of signals to the plant SCADA system,
- b) Transmission of signal to the station security and surveillance system,
- c) Visual indication of the alarm device on the fire panel control panel display,
- d) Continuous operation and sounding of alarm notification appliances as per the applicable standards,
- e) Operation of smoke control system and de-activation of air handling units in the alarmed area,
- f) Automatic discharge of the respective fire suppression system with maximum 15 seconds delay for deluge system and 30 seconds for wet pipe system.

Provision of necessary contacts/ports for control, monitoring, supervision and alarm functions shall be made in the fire alarm control panels for duplicating these functions in plant SCADA system.



Unacknowledged alarm signals shall not be interrupted if a fault on a fire detector circuit or a signalling line circuit occurs while there is an alarm condition on that circuit.

All major devices installed in the panel shall have 10% spare capacity. Fire alarms, supervisory signals and trouble signals shall be distinctively and descriptively annunciate.

26.5.9.4 Fire Work Station and Video display unit

The video display unit shall show the plant appearance with fire zones with the alarm indication. The fire work stations provided in the main control room shall have 21" TFT flat screen colour monitor, dual processor CPU, minimum 2GB RD RAM, CD-ROM drive, key board, mouse etc.

The video display unit for machine hall and control room shall be at least 42" large screen LED display or better along with graphic display including all standard accessories.

If an alarm, fault or release occurs, the pertaining graphics shall be activated. After acknowledgement the horn shall be silent and the light shall remain steady and go off after resetting.

At least following information of activation shall be included in the graphics:

- i) Alarms,
- ii) Release signals,
- iii) Air conditioning and ventilation fire dampers and plant stops,
- iv) Release commands,
- v) Evacuation signal release for sections,
- vi) General plant evacuation release.

26.5.9.5 Signs and evacuation signals

For deluge areas, the warning signs and releasing signs according to applicable codes may be installed.

Laser type exit and evacuation route signs shall be installed throughout the plant as to be finalized during detailed engineering.

26.5.9.6 Fire alarm printing

Fire alarms printing shall be printed in the alarm printer installed in the central control room.

The printers shall have a memory, which enables the printing system to print out the alarms and events in the sequence they occur. The printer shall be colour laser printer capable of printing A4 size papers with the speed of at least 4 pages per minute.



26.5.9.7 Fire alarm bus interface

Signals going to the alarm printer shall also be transferred to the main data logger via a bus coupler system in the sequence they occur.

The signals shall be stored in the main data logger for at least one year, shall be reachable via the bus system from the common visual display unit, and be printed out through alarm/ event printer on request.

26.5.9.8 Fire telephone

An emergency EPABX fire telephone system shall be installed throughout the plant based on a two-way communication system connecting the individual locations with the central control room. The priority features shall be assigned to fire telephone stations in the main control room.

26.5.10 Name plates and external indicators

For an easy identification, each detector and manual pull station shall be equipped with a nameplate showing at least line number, detector identification number and fire zone number.

26.5.11 Fire barriers, assemblies and interior finish

All fire barriers for isolating of bus duct gallery from transformer cavern towards transformer side shall have fire resistant classification for minimum 2-hour exposure rating. Openings in such barriers should be provided with fire door assemblies, fire dampers, penetration seals (fire stops), or other approved means having a fire protection rating consistent with the designated fire resistance rating of the barrier. Penetration seals provided for any electrical and piping openings should meet the requirements of suitable rating in accordance with applicable ASTM or other International Standards. All opening, cut-outs in walls, floors and other critical areas shall be sealed from fire protection angle as per relevant applicable codes as directed by engineer in-charge before issue of operational acceptance / certificate.

26.5.12 Cable and wires

The cable, wires and conduit/ raceways shall be in accordance with relevant standard. All control and loop cable used in fire protection system shall be fire survival cable designed to withstand 950 deg.C fires for at least three hours.

26.6 Drawings, Documents and Design Calculations

26.6.1 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."

**26.6.2 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)".

26.6.3 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) Pipe sizing and pressure drop calculation,
- ii) Selecting the pump capacity and working head for pumps,
- iii) Size of the fire tank,
- iv) Deluge system pressure drop calculation for transformers, generators, cables, OPU system etc.,
- v) Sprinkler system for stores, cable trays and offices area,
- vi) Selection of numbers and type of automatic fire detectors, manual pull stations including types and quantities of notification appliances like bells, horns, speakers, flashlights etc.

26.7 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."

26.8 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.	Complete pump with motor	1 no.
2.	Set of filter candle/ element for Automatic self cleaning filter	1 no.
3.	Multi sensors, photoelectric detector and heat detectors	5 nos. of each type
4.	Electric plug-in cards for the main and repeater panels	1 no. of each type
5.	Electric plug-in cards for the sub panels/local panels	1 no. of each type



S. No.	Description	Quantity
6.	Aspirator type detector module	2 nos. of each type
7.	LED installed in the system	10 nos. of each colour (Red, Green, Yellow, Blue, Amber etc.)
8.	Intelligence interface unit for pressure switch	5 nos. of each type
9.	Digital LHS cables	100 m
10.	Nozzles for HVW and MVW water spray system.	5 nos. of each type and size
11.	Deluge valves	2 no. of each type & size
12.	Sprinkler valve	2 nos. of each type & size
13.	Manual pull station	5 nos. of each type
14.	Hydrant valve	5 nos. of each size and type
15.	Pressure gauges	2 nos. of each type and size
16.	Pressure switches	2 nos. of each type and size
17.	Under voltage relays	2 nos.
18.	Over current and earth fault relays	2 nos.
19.	Fuses	10 nos. of each type
20.	MCCB and MCB	1 no. of each type
21.	Valves of size DN 80 and above	1 no. of each type

26.9 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".

26.9.1 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.



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26.10 Quality Assurance and Testing

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

request. This request shall especially be applicable to small mechanical and electrical works such as:

- i) Valves
- ii) Thermometers
- iii) Pressure gauges
- iv) Flow meters
- v) Water level gauges
- vi) Terminals & terminal racks
- vii) Indicating instruments & meters
- viii) Auxiliary relays
- ix) Contractors, fuses
- x) Motor protection switches
- xi) Control devices
- xii) Lights, bulbs, plugs, sockets
- xiii) Limit switches
- xiv) Level switches

The types or makes to be used shall be decided later by the Engineer in-Charge. All instrument scales shall be written in the ruling language of the contract and in the international SI- System of units.

4.6 Noise

The noise level caused by the installed Works shall not exceed the following values if not otherwise stated in the Particular Technical Specifications:

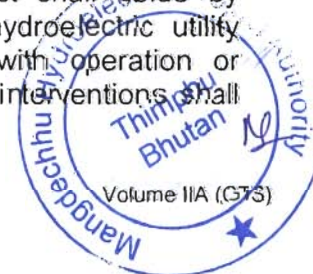
- i) Machine hall, workshops, etc. max. 85 dB (A) at any place 1 m distant from operating equipment.
- ii) Offices, control rooms, max. 55 dB (A) rooms, canteens, etc.

The noise level definition and measurement shall be in accordance with ISO. The values stated shall be adhered to taking a normal civil construction into account.

4.7 Safety

4.7.1 Safety of personnel

Where specific standards are not mentioned by the Employer, all equipment and services provided under this contract shall abide by international standards commonly accepted in the hydroelectric utility industry for safety of personnel whether involved with operation or maintenance. All operations and routine maintenance interventions shall



fully compatible and interchangeable for use in the other, without adjustment to the remaining parts.

The Contractor shall coordinate the supply of his sub-contractors to achieve a great degree of standardization throughout the "Electrical & Mechanical Works" and the stock of spare parts.

4.8 Identification Plates

4.8.1 General

Each important part to be delivered under this Contract shall be equipped with permanent identification plates in readily visible locations. Whether a part shall be considered as important in this respect shall be decided by the Engineer in-Charge.

The identification plates shall be protected during erection and especially during painting. Damaged or illegible identification plates shall be replaced by new ones. The identification plates of non-corroding, non-disintegrating material (except manufacturer's nameplates of small standardised components) shall be inscribed in the Contractual language.

The inscription shall be printed, stencilled, or hand-written, but in any case, waterproof, oil-proof and wear-resistant. Works (machines, transformers, etc.) nameplates shall be either of the enamelled type or be of stainless steel covered after stamping with a transparent paint. Wording, size and material of all labels and plates shall be subject to the Engineer in-Charge's approval.

4.8.2 Manufacturer's Nameplates

The following data shall be shown in accordance with the relevant standards:

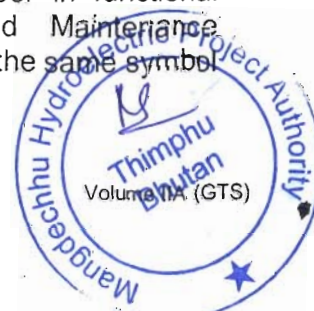
- i) Manufacturer's name and address
- ii) Work's serial number and date of manufacture
- iii) Main design data.

As a general rule, standardised components, such as small or medium-sized electric motors, transformers, instruments, etc., may be delivered with the manufacturer's standard nameplate.

The design of the Manufacturer's nameplates for the main components such as gates, cranes, valves, hoists, servomotors, pumps etc., shall be submitted for the Engineer in-Charge's approval sufficiently in advance.

4.8.3 Functional Plates / Instruction Plates

Each part appearing under a certain symbol or number in functional diagrams, piping diagrams, in the Operation and Maintenance Instructions, etc., shall be equipped with a plate showing the same symbol or number.



4.9 Colour Coding For Electrical Connections

Live parts of electrical connections shall be colour coded as follows:

Conductor Designation	Coding Alphanumeric	Symbol	Colour
a.c. network 3 phase	Phase 1	R	Red
	Phase 2	Y	Yellow
	Phase 3	B	Blue
	Neutral	N	Black
a.c. single phase	Phase	P	Red
	Neutral	N	Black
	Earth	E	Green-yellow
D.C. Network	Positive	a	Red
	Negative	b	Black

4.10 Workmanship

4.10.1 Finished Surfaces

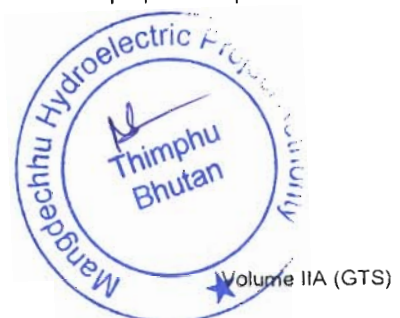
Where the finish is not indicated or specified, the type of finish shall be most suitable for the surface to which it applies and shall be consistent with the class of fit required. Surfaces to be machine-finished shall be indicated on the shop drawings by symbols.

4.10.2 Unfinished Surfaces

Unfinished surfaces shall be true to the lines and dimensions shown on the drawings and shall be chipped or ground free of all projections and rough spots.

4.10.3 Protection of Machined Surfaces

Machine-finished surfaces shall be thoroughly cleaned of foreign matter. Finished surfaces of large parts and other surfaces shall be protected with wooden pads or other suitable means. Unassembled pins or bolts shall be oiled or greased and wrapped with moisture-resistant paper or protected by other approved means.



4.10.4 Painting Systems

Annex-1 "Painting Schedule", indicates painting guidelines and materials considered suitable for the various parts of the Works. Painting in respect of standard items shall be acceptable as per manufacturer practice.

4.10.4.1 Painting Materials

The Contractor shall provide a complete, reliable coating system. Coating materials shall be standard products of a paint manufacturer with proven experience in the field of corrosion protection of the type of works to be supplied.

The Contractor shall submit for the Engineer in-Charge's approval full details of the preparation, type of materials, methods and sequences he proposes to use to comply with the requirements for the protection of the Works.

Painting of the repainted surface shall be in accordance to the relevant standard and shall be detailed by the Contractor for Engineer in-Charge's acceptance.

4.10.4.2 Galvanising

Unless otherwise specified, all structural steel including ladders, platforms, hand rails and the like and all exterior and interior steel surfaces of outdoor Works, as well as bolts and nuts associated with galvanised parts shall be hot-dip galvanised, electrolytically galvanised or sheradized, as may be appropriate to the particular case.

A) Material:

For galvanising, only original blast furnace raw zinc shall be applied, which shall have a purity of 98.5%.

The thickness of the zinc coat shall be:

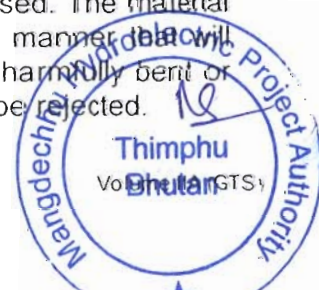
- i) For bolts and nuts, approx. 60 micrometer
- ii) For all other parts, except for hydraulic steel structures or parts intermittently or permanently submerged in water, approx. 70 micrometer

B) Galvanising of hardware:

Bolts, nuts, washers, locknuts and similar hardware shall be galvanised in accordance with the relevant standards. Excess spelter shall be removed by centrifugal spinning.

C) Straightening after galvanising:

All plates and shapes, which have been warped by the galvanising process, shall be straightened by being re-rolled or pressed. The material shall not be hammered or otherwise straightened in a manner that will injure the protective coating. Materials that have been harmfully bent or warped in the process of fabrication or galvanising shall be rejected.



D) Repair of galvanising:

Material on which galvanising has been damaged shall be re-dipped unless the damage is local and can be repaired by soldering or by applying a galvanising repair compound; in this case, the compound shall be applied in accordance with the manufacturer's instructions.

Soldering shall be done with a soldering iron using 50/50% solder (tin and lead). Surplus flux or acid shall be washed off promptly and the work shall be performed so as not to damage the adjacent coating or the metal itself. Any member on which the galvanised coating becomes damaged after having been dipped twice shall be rejected.

4.10.4.3 Painting Guarantee

The guarantee period for all painting shall be 3 years, starting from the issue of the "Taking-Over Certificate". This painting guarantee period shall be effective regardless of any other guarantee periods for the project or parts of the project, or any "Defects Liability Certificate", issued prior to the elapse of the painting guarantee period.

At the end of the painting guarantee period the anti-corrosive protection of the painted or galvanised surfaces shall not have a degree of rusting higher than RE 1 (one) on the European scale of degree of rusting for anti-corrosive paints, (the corrosion committee of the Royal Swedish Academy of Engineering Sciences, Stockholm).

4.11 Metal Work**4.11.1 Embedded Metal Work**

The contractor shall supply & install all anchors, fasteners, embedded metal work, piping, & sleeves associated with & required for the equipment to be installed under this contract, except if otherwise mentioned in the specifications.

As far as practicable, the supports shall be of consistent design throughout. Attachments to concrete shall wherever practicable be by means of embedded inserts.

The Contractor shall be responsible for the determination and details of all loads and forces exerted by his equipment and transferred to the foundation.

The Contractor shall show the location and full details of all embedded components on his drawings and shall be responsible for the completeness and accuracy of his drawings and the information supplied to others.

Any steel work which is to be built into the concrete foundations shall not be painted or coated unless otherwise approved or specified.



DESIGN AND MANUFACTURE



4.11.2 Miscellaneous Metalwork

Except where otherwise indicated elsewhere in the Particular Technical Specifications, the Contractor shall fabricate and supply the following:

Walkway, platform, staircases, handrails etc shall be provided for convenient and safe access to all operating equipment and points of lubrication. Also chequered plate/grating covers shall be provided for MIV removal hatch, Runner removal hatch, equipment handling hatches and openings/trenches for cables, cable trays, pipes, ducts or any other trench/opening required for completing the floors around and over the works supplied under the contract.

The material for all handrails shall be stainless steel. Gratings for hatches, platform, walkways, staircases etc shall be factory made, fabricated mild steel electro forged type conforming to relevant standard. The Electro-forged grating shall be confirming to BS:4592 for welded pattern and permissible deflection due to uniformly distributed load. Appropriate structural support for gratings on both sides of span should be provided for maximum feasible length. Grating shall be hot dip galvanized confirming to IS: 2629 and mass coating as per IS: 4759.

The grating shall be of approved make. The design of grating and chequered plate covers shall be based on the loading in the area/floor in which the grating is provided as per IS-4247 and shall be subject to approval by employer. The minimum thickness of chequered plate and grating plate/bar shall be 8mm and 5mm respectively.

Curbing for dismantling hatches in main floors will be provided by the civil contractor



5 MECHANICAL WORKS AND STEEL STRUCTURES

5.1 General

All mechanical Works and steel structures of any mechanical or electrical installation shall comply with this General Technical Specification and the requirements of the Particular Technical Specification.

The Works shall be of an approved, reliable design providing the highest possible degree of uniformity and interchangeability.

All Works shall be pre-assembled in the manufacturer's premises to an utmost extent.

Revolving parts shall be truly balanced both statically and dynamically that when running at normal speed and at any load up to the maximum, there will be no vibration due to lack of such balance.

5.2 Materials

Materials shall be new and of high-grade quality, suitable for the purpose, free from defects and imperfections, and of the classifications and grade meeting specification requirement and shall be subjected to acceptance by the Employer. Material specifications, including grade or class shall be shown on the appropriate Contractor's detail drawings submitted for review.

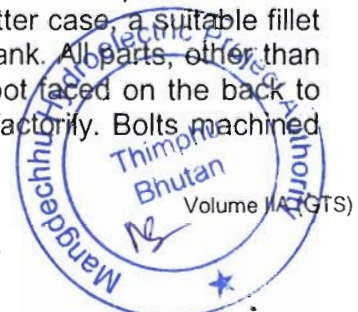
All materials or parts used in the equipment shall be tested in conformity with the standards accepted by the Employer.

Certified Material Test Report for the materials of major/important components and/or materials for special application shall be furnished to the Employer as soon as possible after the tests are performed. Each test certificate shall identify the components for which the materials are used and shall contain all information necessary to verify compliance with the contract.

5.3 Bolts, Screws, Nuts, etc.

All bolts, studs, screws, nuts, and washers shall be to the ISO standard (metric system) except other standards will be considered for specific applications. The extent to which other standards are proposed shall be indicated by the Contractor.

Where mild steel bolts and nuts are used, they shall be of the precision cold forged washer faced type if commercially available in the size required. Alternatively, approved hot forged bolts and nuts, machined so that the undersides of bolt head and nut are faced and parallel to one another when assembled, may be used. In the latter case, a suitable fillet shall be machined between the bolt head and shank. All parts, other than structural steel work, bolted together, shall be spot faced on the back to ensure that nuts and bolt heads bed down satisfactorily. Bolts machined



from bar stock shall not be used without approval of the Engineer in-Charge. All bolting material shall be adequately treated against corrosion before dispatch from the workshop. Mild steel nuts and bolts shall be zinc or cadmium plated. Stainless steel bolts, nuts washers and screws shall be used in water or when exposed to high humidity, for holding renewable parts and parts made of stainless steel.

All bolts or studs which will be subject to high stress and/or temperature shall be of approved high tensile material with nuts of approved material. All bolts and studs larger than 60 mm in diameter, which are not accessible for tightening, and untightening by commercially available pneumatic impact wrenches shall be drilled for heaters or shall have an extension for pre-tensioning by hydraulic tools.

Washers shall be provided under bolt heads and nuts unless otherwise approved by the Engineer in-Charge. All ferrous nuts and bolts on Works items where dismantling may be required during the life of the Works shall have their threads coated with an approved anti-seize compound. When in position, all bolts or studs shall project through the corresponding nuts by at least one thread, but this projection shall not exceed three threads, unless more length is required for adjustment. All nuts and set screws shall be securely fastened, to prevent loosening due to vibrations, using spring washers, lock nuts, split pins, self-locking inserts or 'Loctite' as appropriate for the purpose and material used.

The Contractor shall supply the net quantities plus 5 percent of all permanent bolts, screws and other similar items and materials required for installation at the Site. Any such rivets, bolts, screws, etc., which are surplus after the installation of the Works has been completed shall become spare parts and shall be wrapped, marked and handed over to the Employer.

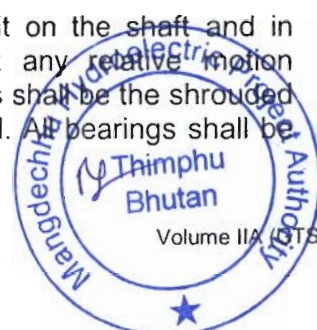
5.4 Corrosion resistant bolts and nuts

Corrosion resistant steel or bronze shall be used for bolts and nuts when either or both are subjected to frequent adjustment or frequent removal, such as adjusting bolts for packing glands on removable screens or strainers, on adjustable bearings, rubber seal holders, etc. Bolts on manholes shall be of high-strength stainless steel. Protective measures against electrolyte corrosion shall be foreseen where necessary.

5.5 Drives and Gears

Gears shall be designed so that all stresses are within allowable limits when the maximum loads are being handled. On request of the Engineer in-Charge, the manufacturer shall submit the calculation of the gears.

Where practicable gear wheels shall be forced fit on the shaft and in addition, shall be keyed adequately to prevent any relative motion between the wheel and shaft. Couplings and collars shall be the shrouded or protected-type, free from projections of any kind. All bearings shall be



mounted in dust-proof housings. Base of bearing supports shall be machined, and shall rest on machined-surfaces.

5.6 Lubrication, Lubricants, Fuel

Efficient means of lubrication, suitable for use under Site conditions, shall be provided for all moving parts.

The contamination of the air, water and soil by lubricants and fuel shall by all means be avoided by applying of an appropriate design and layout of the Works in conformity with the latest recognised standards for modern engineering practice.

The number of different lubricants, transformer oils, oils for pressure systems, etc., used in the items of Works throughout the Works shall be limited to a minimum in order to facilitate keeping stocks and maintenance.

The Employer reserves the right to request the use of certain types of lubricants, oils, etc. The Contractor shall not be entitled to claim extra payment for this request. All different types of oils, lubricants, etc., shall be subject to the written approval of the Engineer in-Charge.

Unless otherwise stated in the Particular Technical Specifications, the first oil or grease filling for bearings, pressure oil systems, transformers, etc., including the necessary quantity for flushing and for the first oil change shall be included in the Tender Price.

5.7 Piping, Fittings, Valves and Heat Exchangers

5.7.1 General

Unless otherwise stated, all piping fitting, valves shall be designed for at least 1.5 times of the working pressure but minimum for "nominal pressure" PN 16 and tested with 1.5 times of the design pressure.

5.7.2 Valves

Generally, valves shall be leak-proof in either flow direction (except for non-return valves) when the design pressure is applied.

All valves with design pressures higher than PN 16 and diameters larger than DN 100 shall be workshop-tested to relevant IS for tightness and soundness of materials.

Valves shall close clockwise and be provided with position indicators and padlock kit. The drive units of motor-driven valves shall also be provided with hand wheels for manual operation. The hand wheel shall be operable under all conditions and shall be independent of the motor drive. Further, it shall not be rigidly coupled to the motor drive and shall not compulsory turn when the motor is energised.



To facilitate operation, large valves and gates shall be provided with by-pass lines for pressure balancing, if required.

All valves shall be readily accessible for both operation and maintenance, and where necessary for ease of operation the spindles shall be extended and an approved form of pedestal hand-wheel provided at convenient operating floor level.

Shut-off valves shall be suitable for opening and closing against full unbalanced pressure, including closure against free discharge. If necessary, bypasses are to be provided to meet these requirements.

Material of valve body and other parts shall be as mentioned below for all type of valves:

Part name	Valve size	Application	Material/ Grade	Standard/
Valve body	DN 50 and below	Water	Stainless steel (ASTM A276 Type 316/ ASTM A182 Gr. F 316 or better)	
Valve body	Above DN 50	Water	Cast/ Forged steel (ASTM A216 Gr. WCB/ ASTM A105 or better)	
Valve body	All	Air and oil	Stainless steel (ASTM A276 Type 316 or better)	
Valve spindle/ shaft & pins	All	Water, air & oil	Stainless steel (AISI 410 or better)	
Disc/ ball/ Wedge	All	Water, air & oil	Stainless steel (ASTM A 351 Gr. CF8 or better)	
Gland seal/ seat	All	Air and oil	PTFE	
Seat/ body lining	DN 200 and Above	Water	PTFE	
	Below DN 200	Water	PTFE/ EPDM(Peroxide cured)	

Unless otherwise specified in Particular Technical Specification, valve type used in water, oil and air application shall be as per below:

1) Water application

- i) All the valves connected to penstock (such as penstock / spiral case drain valve or any valve for cooling water or fire fighting system tapping) shall be heavy duty forged gate type. The same shall be capable of open under 100% unbalance condition.
- ii) Penstock drain valve, fire fighting system tapping and other tapings from penstock shall also have guard valves.

- iii) All valves connected to tail race and draft tube shall be heavy duty gate valves.
 - iv) All valves for flow regulation shall preferably be heavy duty globe type.
 - v) All valves which are to be frequently opened and closed shall be heavy duty gate valves.
 - vi) All valves used in ejector system, fire fighting system shall necessarily be heavy duty gate valves.
 - vii) Generally, all valves upto DN80 shall be heavy duty gate valves (except in flow regulation).
- 2) Oil application
- i) Generally, all valves shall be heavy duty ball/ gate/ needle/ globe type made of stainless steel.
 - ii) All valves for flow regulation shall preferably be heavy duty globe type.
- 3) Air application
- i) All valves shall be heavy duty ball type made of stainless steel.

Use of butterfly valves shall be avoided and if need be, the same should only be used in water outlet circuit, where pressure is less. All butterfly valves shall preferably be Resilient Seated and no part of valve body or stem shall expose to media. Heavy duty gear operator units with hand wheel shall be provided for butterfly valves size DN200 and above. Butterfly valves shall comprise of following :

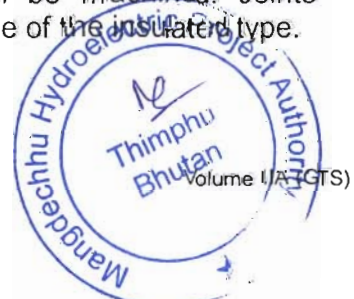
- a) Heavy duty non corrosive bronze/ acetal copolymer bushing.
- b) Heavy duty sealing with self adjusting double U- cup seal for positive sealing in both directions.
- c) Machined and hand polished disc edges.
- d) Valve body lining shall preferably be integrally moulded and bonded.

All pressure reduction valves; safety valves and similar components shall be workshop-tested and provided with a work certificate 2.3 to DIN 50049.

5.7.3 Piping and Fittings

All required piping shall be furnished complete with flanges, joints, expansion joints, gaskets, packing, valves, drains, vents, pipe suspensions, supports, etc.

Metric flanges shall be used throughout. Welded flanges shall be weld-neck or slip-on flanges. The raised face shall be machined. Joints between stainless and normal steel flanges shall be of the insulated type.



If the piping crosses over joints of civil structures of different settlement, the piping shall be provided with flexible joints to allow for vertical, horizontal, and angular deviations.

Piping installation shall be sloped to prevent trapping of air bubbles. Where required suitable venting system shall be provided.

Adequate clearance shall be given to parallel pipes to allow for easy maintenance without disturbing other lines. All overhead piping shall have a minimum clearance of 2.00 m from operating floors and platforms.

Where required water piping shall be provided with anti-condensation insulation with vapour proof cover.

Piping shall be of heavy duty class carbon steel confirming to ASTM A53/ ASTM A106 or equivalent IS as per Employers approval confirming to the requirement. Pipe sizes < 100 mm and all sizes of oil pressure pipes shall be seamless type. The minimum pipe wall thickness shall be the normal or standard wall thickness as stated in the applicable standards.

Bends and flanged shall preferably be of the forged type below DN 200. Mitered/Fabricated bends and flanges shall be allowed for larger sizes.

All piping shall be acid-treated to guarantee clean surfaces, completely free from welding residues. This treatment shall be applied to workshop and site manufactured piping. The entire piping arrangement shall be subjected to the pressure test in section at the site.

Oil pipes shall generally not be embedded in concrete. Oil pipes crossing civil structures shall be routed through sleeves embedded in the concrete. All oil piping shall be hydrostatically tested at a pressure 100 % greater than the maximum working pressure. As far as possible, oil pipes shall be prefabricated in the Contractor's workshop. They shall be welded except at terminal points and as necessary for erection and future dismantling.

5.7.4 Pipe Supports and Hangers

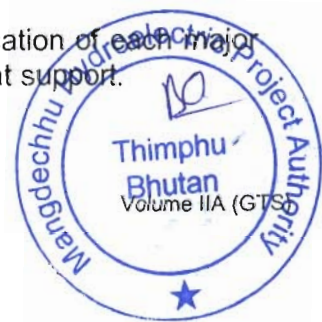
All pipe work and accessories shall be mounted and supported in a safe and neat manner.

All brackets, stays, frames, hangers and supports for carrying and staying the pipes, including their fasteners shall be included in the supply and completed by the Contractor at the Site. Pipes and fittings shall be supported at or near flanges wherever possible.

Supports and hangers shall be designed and arranged so that any pipe can be withdrawn without disturbing the others.

All heavy valves and other mountings shall be supported independently of the pipes to which they connect, to the satisfaction of the Engineer in-Charge.

The Contractor shall supply drawings showing the location of each major anchor and support and the weight to be carried by that support.



5.7.5 Heat Exchangers

Specification of the material of the heat exchanger shall be:

Item Description	Tubular type	Plate Type
Material for Cooling tube / plate	Cupro-nickel (90:10)	Stainless Steel (316L or better)
Thickness of cooling tube / plate	Generating unit :1.0mm or more Other : 0.5mm or more	0.6mm or more
Frame / body	Mild/cast steel	Mild/cast steel

5.8 Mechanical Instruments

All mechanical parts of instruments shall be suitably protected against shocks and vibrations, heat, humidity and splash water, etc.

Pressures gauges shall be provided with a damping liquid, e.g., glycerine, to compensate vibrations. Pressure gauges without damping means are not permitted, unless approved by the Engineer in-Charge.

5.9 Pumps

Materials of the Impeller, Shaft and Sleeves of the pumps shall be stainless steel. The pump casing for horizontal centrifugal and submersible pumps shall be cast steel and ductile/ improved cast iron respectively.

The impeller diameters shall be neither maximum nor minimum impeller size for the selected pump size. The pumps shall withstand corrosion and wear by abrasive matters within reasonable limits. Leakage water shall be directed to suitable drainage facilities.

Each pump shall be fitted with:

- i) Check valve at the discharge side
- ii) Air and drain valve
- iii) Pressure gauge & pressure / flow switch.

The size of the pump motor shall be at least 10 % higher than the maximum power required by the pump at any operation point

For non submersible type, pumps and motors shall be mounted on common frames, while in case of submersible type, the same shall be contained in the common casing and designed as a package unit with incorporated suction strainer and check-valve.

The motors of submersible pumps operating in potable water shall not be filled with oil or other media detrimental to potable water.



6 ELECTRICAL WORKS

6.1 General

The electrical items of Works of any electrical or mechanical installation to be provided under this Contract according to the Particular Technical Specifications shall - if not stated otherwise therein-fulfil the requirements of this Section.

All components shall be of an approved and reliable design. The highest extent of uniformity and interchangeability shall be reached. The design shall facilitate maintenance and repair of the components.

The Works shall be pre-assembled to the highest possible extent in the Contractor or Sub-Contractor's workshop, complete with all devices and wired up to common terminal blocks.

The power supply and control cables shall be laid up to these common terminal blocks. The required control and protection devices, instruments, etc., within the different scopes of work shall be supplied and connected by the relevant Contractor.

Unless otherwise agreed, ratings of main electrical Works (infeeds, bus-ties) as selected or proposed by the Contractor, whether originally specified or not, shall generally include a safety margin of 10% under consideration of the worst case to be met in service. Prior to approval of such basic characteristics, the Contractor shall submit all relevant information such as consumer lists, short circuit calculations, de-rating factors, etc.

Short-circuit calculations shall be evaluated giving full evidence that every electrical component can withstand the maximum stresses under fault conditions, for fault levels and durations obtained under the worst conditions, e.g., upon failure of the corresponding main protection device and time delayed fault clearing by the back-up protection device.

All Works shall be suitable for the prevailing climatic conditions.

Outdoor installations needing protections shall be protected against solar radiation by means of adequate covers, where required.

The Contractor shall ensure that all the supplied Works is insensitive to any signals emitted by wireless communication equipment.

6.2 Standards

The design, manufacture and testing of all Works and installations shall strictly comply with the latest edition of the relevant IEC publications.

6.3 Colour Code

In general, the colour code for electrical Works shall be as described in the Particular Technical Specifications.



The manufacturer's painting systems shall be used to the maximum possible extent, but shall by all means be subject to the approval of the Engineer in-Charge. Final coats of paint shall be matching adjacent installations, where required.

6.4 Electric Motors

6.4.1 General

All motors shall be of approved manufacture and shall comply with the requirements of this Chapter. Motors of the same type and size shall be fully interchangeable and shall comply - as far as applicable - to IEC standard motor dimensions.

The general construction shall be stiff and rigid; no light metal alloy casings will be accepted. All precautions shall be taken to avoid any type of corrosion.

All motors shall be fitted with approved types of lifting hooks or eyebolts as suitable.

AC motors shall have squirrel cage type rotors.

6.4.2 Motor Voltages and Power Ratings

The service voltages and corresponding power ratings for electric motors to be used in the Project shall be as follows:

A) Motors up to 100 kW

1	Service voltage	3-phase a.c. 415/240 V, 50 HZ
2	Mode of starting	direct-on-line up to 50 kW above 50 kW with suitable starters

B) Motors up to 0.75 kW

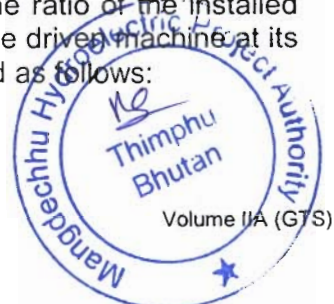
1	Service voltage	single-phase a.c. 240 V, 50 HZ
2	Mode of starting	Condenser

C) Motors intended to work on the d.c. System

1	Service voltage	220 V D.C.
2	Mode of starting	Resistor

6.4.3 Rating

The rating of the motors shall be adequate to meet the requirements of its associated equipment. The service factor, being the ratio of the installed motor output to the required power at the shaft of the driven machine at its expected maximum power demand, shall be applied as follows:



Sl. No.	Power Demand of Driven Machine	Service Factor
1	Up to 5 kW	1.2
2	More than 5 kW	1.1

A.C. motors shall be capable of operating continuously under rated output conditions at any frequency between 95% and 105% of the rated frequency and/or with any voltage variation between 90% and 110% of the nominal voltage. A transient over voltage of 130% of the nominal voltage shall as well be sustained.

Further, the motors shall be capable of maintaining stable operation when running at 70% nominal voltage for a period of 10 seconds. The pullout torque for continuously loaded motors shall be at least 160% of the rated torque and for intermittently loaded motors 200% of the rated torque.

D.C. motors shall be capable of operating continuously under rated output conditions at any voltage between 90% and 110% of the nominal voltage with a fixed brush setting for all loads. Unless otherwise approved, the speed drop between no-load and full-load shall not exceed 10% of no-load speed.

6.4.4 Starting

A.C. motors shall be designed for direct on-line starting. They shall be capable of being switched on without damage to an infinite busbar at 110% of the nominal voltage with an inherent residual voltage of 100% even in phase opposition. For starting the motors from the individual main and auxiliary busbars, a momentary voltage drop of 20% referred to nominal voltage should be taken into consideration. With 85% of the nominal voltage applied to the motor terminals, each motor shall be capable of accelerating its associated load to full speed with a minimum accelerating torque of 5% of full load torque.

The maximum starting currents (without any tolerance) shall not exceed the following values: -

- i) 5 times of rated current for L.V. motors rated 100 kW or above
- ii) 2 times of rated current for D.C. motors (by means of starting resistors)

Generally, all motors shall be able to withstand three cold starts per hour, equally spaced. In addition, each M.V. motor shall be capable of enduring two successive starts with the motor initially at operating temperature. Each L.V. motor shall be capable of withstanding three successive starts under the same conditions or once every twenty minutes without detrimental heating.

Motors for frequent automatic starting shall have an adequate rating. In the motor list the Contractor shall state the frequency of starts permitted in compliance with the motor design.



6.4.5 Windings and Insulation Class

The insulation of all motors shall be of class F but maintain in operation the temperature limits of class B materials. It shall be suitable for operation in damp locations, for occasional contact with corrosive gases and vapours and for considerable fluctuations in temperature.

The stator winding shall be suitably braced to withstand the forces due to direct-on-line starting and transfer conditions as mentioned before. The winding envelopment and tails shall be non-hygroscopic. The stator winding shall withstand the maximum fault current for the period determined by the associated protective devices.

The rotor winding (if applicable) shall be designed to give trouble-free continuous service including repeated direct-on-line starting. The rotor shall be subjected to a 120% over speed test for 2 minutes without showing any winding dislocation.

6.4.6 Ventilation and Type of Enclosure

All motors shall be of the totally enclosed fan-cooled type, protection class IP 54 according to IEC Recommendation 144. Cable termination points shall be of class IP55.

They shall have a closed internal cooling air circuit re-cooled by an external cooling air circuit drawn from the opposite side of the driving end.

Where motors are installed outdoors, a weatherproof design shall be chosen. L.V. motors of IEC size 132 and above shall be equipped with automatically controlled heating elements for protection against internal condensation of moisture during standstill periods. Such A.C. heater shall be suitably fixed inside the motor casing; the leads shall be led to a separate L.V. terminal box.

Motors installed outdoors and directly subjected to solar radiation shall be rated such as not to exceed a maximum metal temperature of 85°C. Where necessary, such motors shall be provided with sun shields.

Vertical motors shall be provided with a top cover to prevent the ingress of dirt, etc.

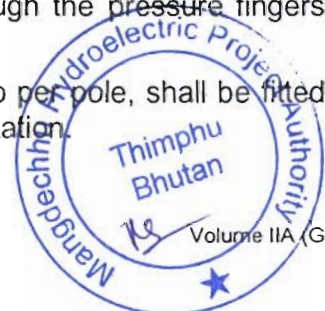
6.4.7 Brushgear and Commutators

Brushgear for D.C. motors shall be designed to ensure constant brush pressure. Carbon brushes shall be provided which stand at least 6 months of operation without replacement. Each brush shall be independently adjustable but should not require adjustment throughout its life. A design of brushgear which permits the brush holder to touch the commutator as the brushes wear or which passes current through the pressure fingers will not be accepted.

A sufficient number of brushes, not less than two per pole, shall be fitted to ensure that vibrations do not affect the commutation.



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The minimum safe wearing margin of commutators shall not be less than 20 (twenty) per cent of the total thickness of the commutator bars and the minimum safe diameter shall be clearly marked on it.

6.4.8 Terminal Boxes and Earthing

The terminal leads, terminals, terminal boxes and associated equipment shall be suitable for terminating the respective type of cables as specified in these General Technical Specifications and in the Particular Technical Specifications.

The terminal boxes shall be of ample size to enable connections to be made in a satisfactory manner. Supports shall be provided at terminal boxes as required for proper guidance and fixing of the incoming cable.

The terminal boxes with the cables installed shall be suitable for connection to supply systems with the short-circuit current and the fault clearance time determined by the motor protective devices.

A permanently attached connection diagram shall be mounted inside the terminal box cover. If motors are provided for only one direction of rotation, this shall be clearly indicated.

Terminal boxes shall be totally enclosed and designed to prevent the ingress of moisture and dust. All joints shall be flanged with gaskets of neoprene or similar material. For motors above 1 kW, the terminal box shall be sealed from the internal air circuit of the motor.

Depending on the size, the terminal box of L.V. motors shall be fitted either with an approved cable sealing-end or with a gland plate drilled as required and provided with suitable fittings for cable fixing and sealing. Such openings shall be temporarily plugged or sealed during transportation.

For earthing purposes, each motor shall have adequately sized bolts with washers at the lower part of the frame. In addition, each terminal box shall contain one earthing screw. Each equipment/panel shall be earthed by at least two separate earthing strips.

The cable termination philosophy to be adopted shall be such that extensive grouping of signals by large scale use of field-mounted group. JB'S at strategic locations (where large concentration of signals are available, e.g. switchgear) is done. Termination / Junction boxes shall have either maxi- terminal or cage clamp type terminals

6.4.9 Tests

Each motor shall be factory tested and shall undergo a test at site. The following tests shall be performed under full responsibility of the Contractor.

A) Workshop Tests:

- i) Measurement of winding resistances



- ii) No-load and short-circuit measurements
- iii) Measurement of starting current and torque
- iv) Efficiency measurement (type test)
- v) Heat test run
- vi) Dielectric test
- vii) Measurement of insulating resistance
- viii) Over speed test

B) Site Tests:

- i) Measurement of insulation resistance
- ii) Measurement of motor vibrations
- iii) Measurement of starting time.

6.5 Cubicles and Panels

All control cubicles/panels, switch gear panels and other cubicle/panel enclosures shall be UL/Lloyds register of shipping/VDE approved and would be of cold rolled sheet steel. Cubicles/panels shall have full modularity along X-Y-Z axis made out of folded profile based structure with reference to the requirement of combinability of the panels which shall be finalized during detailed design with respect to the layout. Such structure shall be made by a sheet of not less than 1.5 mm. However, doors can be extracted through a sheet of 2mm which could be of rigid construction and the sides where no instruments/MCB/relay is to be installed can be provided with a cover sheet of not less than 1.5mm which shall be approved during detailed design based upon the construction of panel. Further top and bottom of the panels should not be less than 2mm. The structural frame shall have provision at a regular interval to facilitate retrofitting components without need of drilling holes.

In case of junction boxes, small starter panels and muslin kiosks shall be made out from a single sheet of thickness not less than 2mm which should have minimum weld interface except weld seal at the enclosing envelope. Door specification however, remain the same as of cubicles/panels having specific PU seal with reference to the IP class mentioned in the specification either under GTS or PTS.

Cubicles shall be fitted with close fitting, hinged, lift-off doors capable of being opened through minimum 120 deg. The doors shall be provided with door handles with integral lock and master key. The doors shall have PU seal for perfect sealing and longer life.

Cubicles and panels shall be vermin proof. Removable gland plates shall be supplied and located to provide adequate working clearance for the termination of cables. Under no circumstances shall the floor/roof plate be used as a gland plate. The cables and wiring shall enter from bottom or top as approved or directed by the Engineer in-Charge.



The cubicles and panels shall be adequately ventilated, if required, by vents or louvers, and shall be so placed as not to detract from the appearance. All ventilating openings shall be provided with corrosion-resistant metal screens or a suitable filter to prevent entrance of insects or vermin. Space heating elements with thermostatic control shall be included in each panel.

Where cubicles are split between panels for shipping, terminal blocks shall be provided on each side of the split with all necessary cable extensions across the splits. These cable extensions shall be confined within the panels with suitable internal cable ducts.

Unless stated otherwise, all cubicles and panels shall be provided with a ground bus with 40mm x 5mm or higher (as per requirement) copper bar extending throughout the length. Each end of this bus shall be drilled and provided with lugs for connecting ground cables ranging from 70 to 120mm².

The standard phase arrangement when facing the front of the motor control centres and switchboard shall be RYB from left to right, from top to bottom and front to back. All instruments, devices, buses and other equipments involving 3 phase circuits shall be arranged and connected in accordance with the standard phase arrangement, where possible. Electrical clearances shall conform to applicable standards and shall not require cutting away of adjacent framework.

All instruments, control knobs and indicating lamps shall be flush mounted on the panels. Relays and other devices sensitive to vibration shall not be installed on doors or hinged panels, and no equipment shall be installed on rear access doors.

The instrument and control wiring, including all electrical interlocks and all interconnecting wiring between sections, shall be completely installed and connected to terminal blocks by the manufacturer.

The arrangement of control and protection devices on the panels and the exterior finish of the panels shall be subject to the approval of the Engineer in-Charge. The interior of all cubicles and panels shall have a matt white finish preferably.

Switched interior light and socket outlets shall be provided for all cubicles and control panels.

All cubicles and control panels shall be provided with nameplates, identifying the purpose of the panel and all of its components.

6.5.1 Starters and contactors

Motor starters and contactors shall be equipped with short circuit protection and local disconnecting devices. Preferably, all starters shall be from one manufacturer. The control circuit voltage shall be obtained from a 415/240 V isolating transformer with primary circuit breaker and secondary fuse. The secondary winding of this transformer shall be

grounded. The operating coils of the contactor shall be connected between the grounded side of the transformer and the control contacts.

Starters and contactors shall comply with IEC 292.1 and be suitable for direct on-line starting, uninterrupted electrical duty, and capable of 30 operations per hour. They shall be installed in ventilated enclosures for indoor installation and weatherproof enclosures for outdoor installation, unless otherwise approved by the Engineer in-Charge. The enclosures shall be complete with locks, cable sealing boxes, conduit entries, cable gland plates, bus bars, internal wiring, terminal boards, etc. as required by the duty of the starter or contactor.

Starters and contactors shall be of minimum size compatible with motor size and capable of satisfactory operation, without damage, for a period of 5 minutes at a voltage 25 percent below nominal, at nominal frequency.

Thermal type overload and phase failure relays shall be supplied with starters for motors of 7.5 kW or greater. For motors of less than 7.5 kW, suitable rated 3-phase thermal overloads will be acceptable. Ammeters to read current in one phase shall be provided for motors above 7.5 kW.

Each starter shall have sufficient number of auxiliary contacts required for interlocking and indication purposes plus two spare convertible contacts for Owner's use.

6.5.2 Moulded Case Circuit Breakers

All moulded case circuit breakers shall be of 2 or 3-pole type as required, having thermal time delay and instantaneous trips with "On-Trip-Off", indicating/operating mechanism. Circuit breakers used in combination type motor starters or contactors shall have the operating mechanisms interlocked with the starter or contactor cover so that the cover cannot be opened unless the circuit breaker is open. The breakers shall comply with applicable section of IEC 157/1 or equivalent standards.

6.5.3 Control relays

Relays used as auxiliary control devices in conjunction with motor starters and magnetic contactors shall be of the type designed for machine tool application featuring contact convertibility. All contacts shall have a minimum thermal current rating of 10A over a range of 6 to 600 V AC.

6.5.4 Pilot devices

Pilot devices such as selector switches, push-button starters and thermostats shall be of heavy duty type and, where mounted outdoors, shall be housed in weather proof enclosures specially designed for the environment.

All electrical contacts for control, alarm and shutdown shall have a thermal current rating of not less than 10 A at 220 V DC.

