

(d) Programmable Solid State System

Control systems employing microprocessors shall have their programs stored in non-volatile and reprogrammable memory. The Contractor shall supply all information and equipment necessary to enable the Department to re-program the control systems.

Following successful commissioning the Contractor shall supply to the Department a complete set of flowchart and program listing plus, if applicable a duplicate set of pre-programmed EPROM's.

The controller shall be equipped with all facilities necessary for the maintenance, operation and fault clearance by technicians with limited knowledge of electronics.

S11.02 CONTROL SYSTEM REQUIREMENTS

(1) Points of Control

- (a) Each valve, switch or other device shall be operable manually for maintenance purposes at the device. If the device is used for isolation purposes, it shall be fitted with provision for padlocking in the isolated position; indication of the device position shall be provided on the device. Electrical or pneumatic operation shall be provided where extended control is also required.
- (b) On the main control switchboard in the control room, control facilities shall be provided for starting, stopping and operational functions such as stopping, excitation, and load control.
- (c) Synchronizing facilities for the units shall be available at the control room on the separate synchronizing panel (or) a unit protection panel. Mimic monitoring diagrams for the control and indication of high voltage equipment shall be fixed on the front panel.

In order to control and monitor the plant in future, the contractor shall provide the spare module of Automation System for the purpose of control from a remote location. The confirmation of this requirement shall be indicated in System Configuration Diagram submitted together with the Bid.

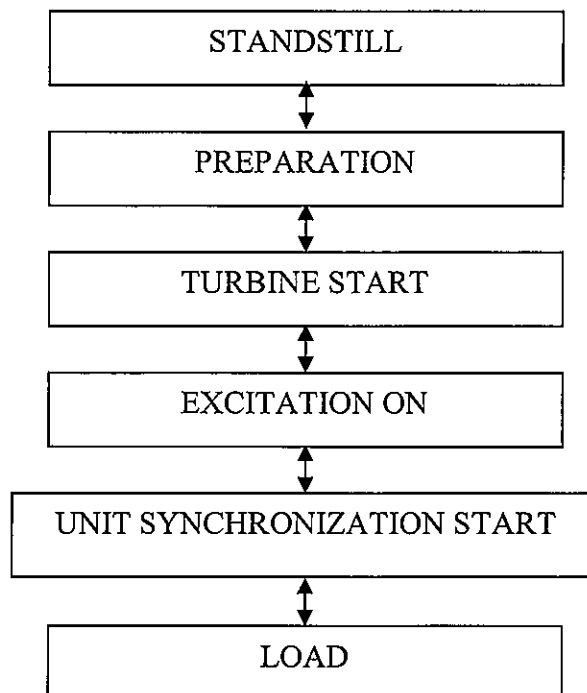
(2) Control Modes and Sequences

- (a) The system shall operate in two main operating modes, which are namely as local and remote (or) PLC operating modes. Operator can operate the generating set from operator control station PC inside control room as Remote Control Mode and operating the Unit from graphical interface HMI Touch Screen at Unit Control PLC namely Local Control mode. The selection shall be done at Unit control PLC Panel. The Contractor shall provide the selector switch on Unit Control PLC Panel as a local/remote selector switch.

The operator shall be able to select one of the following control modes from Operator Control Station PC: -

Manual mode: The unit and associated equipment shall be manually controlled at control panel of each unit.
Auto mode: All unit control sequences shall be carried out automatically once initiated by an operator.
Step mode: The operator shall be able to "step" through each step of the Auto sequences by initiating each step.

- (b) Unit Control Sequences (UCS): The UCS shall be capable of executing any control sequences selected and initiated by an operator in all control modes except the manual mode. Once a sequence is initiated, the UCS shall check that all permissive associated with the selected sequence have been satisfied prior to starting the control sequence.
- (c) Stopping shall be possible at any time. Unit emergency shutdown shall positively override any other control sequence to bring the unit safely, independently and quickly to a de-energized and stationary state. Protection system operations and operation of the unit emergency shutdown controls shall initiate a unit emergency shutdown.
- (d) Starting of the unit shall be possible both fully automatically and manually at control board or at the devices.
- (e) Similarly, stopping shall be possible fully automatically and under operator guide control. It shall be possible to restart following commencement of a normal stop sequence without waiting for the stop sequence to be complete.
- (f) The programming sequence shall be a step-by-step as shown on below figure as preliminary for basic information however the Bidder shall indicate clearly for the Start, Stop Sequence, with the process diagram (or) Flow Chart together with the Bid verifying that the Bidder has enough knowledge and capability for performing this project.
- (g) The preliminary sequence for programming PLC will be as below: -



(3) Synchronizing

- (a) The Contractor shall supply both automatic and manual synchronizing facilities to allow the generators to be connected to the power system. The manual equipment shall include duplicate synchrosopes, duplicate synchronizing indication lamps, duplicate reversing transformers, a synchroscope selector switch, running and incoming voltmeters, running and - incoming frequency meter, synchronizing sockets for each circuit plus one spare and keyed synchronizing selection plug.
- (b) The instruments shall be mounted on the main control board in such a position that one operator alone may synchronize effectively.
- (c) A synchronizing check relay shall be provided to supervise the closing of the circuit breaker. This relay shall be put in circuit via the synchronizing selection plug.
- (d) A control signal and indication shall be provided at the end of the starting synchronizing. This signal shall permit the automatic synchronizer to synchronize the unit to the system. The automatic synchronizer shall be put into circuit via the synchronizing selection plug.
- (e) Facilities shall be provided to allow synchronizing to be across either the generator circuit breaker or 33 kV Circuit Breaker.

S11.03 PROTECTION DESIGN REQUIREMENTS

(1) General

- (a) The protection requirements are shown on the single line diagram and equipment details specified herein.
- (b) Each trip relay or tripping circuit shall be separately protected by a fuse or miniature circuit breaker. All trip circuits shall be separately monitored. Protection circuits shall operate at 125 V DC.
- (c) It is operational important that some advance warning of impending trip action is given. This is generally to be achieved by the initiation of a first- stage alarm set to operate before the trip condition is reached: The aim of this is to allow the operator time to take action which will correct the condition or to unload and stop the machine thereby avoiding a shutdown and minimizing damage. In the case of high-speed trip devices, such as overall differential protection relays, no first stage alarm is required.
- (d) Protection devices shall operate either the emergency shutdown or the unit automatic stops latched trip relays. The emergency shutdown relays shall trip the machine off line instantly, shut it down and lock it out of service. The quick stop relay shall delay tripping of the circuit breaker until the unit is at no-load and thereby avoid disturbances to the power system and over speed conditions caused by the rejection of load. The wicket gate and turbine inlet

valve shall be tripped immediately, but the circuit breaker shall not be tripped until the unit load is less than 10 percent of full load. A reliable means of signaling the no-load condition shall be used, preferably by means of a direct output from the governor controls. Both trip relays shall also prevent any attempt to restart the unit. The failure of the quick stop sequence shall cause a unit shutdown. Failure of the unit to trip on electrical fault or shutdown shall operate the appropriate circuit-breaker failure protection. It will be necessary for the operator to manually reset trip relays, usually following an investigation in the case of operation.

- (e) The protection scheme shall detect all faults and operate to disconnect plant in a minimum of time to lessen permanent damage. All protection facilities necessary to achieve such a scheme are to be provided by the Contractor.
- (f) The Contractor shall ensure that each protection function is independent of others and can be individually isolated to allow each along to be taken out of service for testing or operational purposes. The Contractor shall provide facilities and equipment for in situ testing of protection systems. Facilities shall be provided in AC circuits to allow disconnection of protection relays and short circuit of current transformers so that testing by secondary injection can be performed. Test terminals shall also be provided in voltage transformer secondary circuits.
- (g) All shutdown and quick stop devices require a fault operation indicator on the protection panel. Electrical protective devices and mechanical protective functions in general will require duplicate, electrically separate initiating contacts; one contact is required for tripping and the other for operating an alarm relay with sufficient contacts to perform the alarm functions plus 1 space normally open contact.

(2) Electrical Protection

The protective systems shall be of solid-state types for Unit and Line Protection, and either Conventional or solid-state type for other protections. The electrical protection scheme is outlined on Drawing except of the excitation system protection, for which only some basic functions have been specified.

Comprehensive electrical protection is required for the excitation system and the Bidder shall provide full details of the proposed scheme with the Bid.

(3) Mechanical Protection and Alarms

The Contractor shall provide all of the devices for protection and alarm shown on drawing together with all necessary piping, valves, fittings and the electrical connections. For initiating devices shown on the drawings as having Stage 1 and Stage 2 settings, the Stage 1 setting shall be set to give an alarm for advance warning of a potentially damaging condition. The Stage 2 setting shall be set to initiate a quick stop of the unit Both Stage 1 and Stage 2 contacts shall be suitable for operation a 125 V DC.

(4) Equipment Details

The Contractor shall submit to the DEDE Engineer for approval, the proposed relay protective system that shall be based on the single line diagram submitted in his BID proposal.

The equipment listed here covers only the devices that are essential for proper operation. It is to be understood that all other associated auxiliary equipment and accessories, although not listed in this Specification, but necessary of the complete and sound functions of the main control board as described in this Specifications, and as generally accepted as the applicable standards, VSPP, shall be furnished by the Contractor.

Unit Protection Relays

- a) Generator Differential Protection (87G): Generator differential relays shall be either a constant percentage or a high impedance differential, 3-element type, and shall provide protection against phase faults for 3 phases and ground faults. The percent differential type or relays shall have a slope characteristic of 10 percent.

Volts/ Hertz (24): The protection element shall have both selectable definite/inverse time characteristic and could be used with a custom curve.

- b) Generator Under voltage Protection (27G): Generator under voltage 50 Hz relay for connection to the 110 V secondary of the voltage transformer on the generator terminals on at least 2 phases.
- c) Generator Reverse Power (32R) or Directional Over Current (67): Protect Generator against being motored by the Grid, where protection functions include a definite time trip at a pre-defined active power level.
- d) Neutral Over Current (50N): The protection element shall have adjustable pickup current with an adjustable time delay settings. Pickup shall be <1.5 cycles.
- e) Generator Overvoltage Protection (59G): An instantaneous 50 Hz overvoltage relay with compensation for frequency shall be connected to the 110 V secondary of the voltage transformer on the generator terminals. This protection element shall have 2 parts; a low set element will1 an adjustable time delay setting that closes its contacts on sustained moderate overvoltage and a high-set instantaneous element. The 2 elements shall have adjustable pickup voltage setting range. The low-set element shall have a high ratio at reset to pickup. The low-set and high-set elements shall be used for tripping.
- f) Negative Sequence Protection (46G) - (if applicable): The negative sequence current and one sensitive to the integrated product $(I_2)^2 \times t = 40$. The relays sensitive to the negative sequence current shall be definite time type adjustable within a range of 20-40% of asymmetry and 5 to 15 seconds of operating time. The relays sensitive to the integrated product $(I_2)^2 \times t$ shall be inverse time type.

- g) Over current Ground Relay (51NT)(51NG): The protection element shall be at least two phases, inverse time current characteristics, 5A CT 50 Hz, 0 to 12A current setting, ICS, 125 V DC, flush mount, adjustable operating time approximately 0.2 to 3 sec.
- h) Non-directional Over current Relay (51G): The protection element shall be at least 2 phase, inverse time current characteristics, 5A CT 50 Hz, 0 to 12A current setting, flush mount, ICS, 125 V DC.

Loss of Potential (60): The protection element is for detection of open voltage transformer fuses or other conditions that cause of loss of relay secondary voltage input.

- i) Out of Step Protection (78): The protection element is with current supervision and torque control to supervise this function, with mho circle to restrict the coverage of the function to the desired extent.
- j) Rate of Change of Frequency (81R): Protection element detect the changes in frequency either increasing or decreasing frequency and above or below nominal frequency.
- k) Auxiliary Tripping and Lockout Relays (86E, 86M) - (if applicable): Each relay shall be of the high speed, DC voltage operated, manual reset control switch type with cut-off contact provided to interrupt the operating coil. Number of contacts required shall be 5 electrically separate normally closed contacts and 5 electrical separate normally open contacts. All contacts shall be field interchangeable. Four relays are required.
- l) Under, Normal and over speed relay (12, 13, and 14) for Turbine over speed protection.
- m) Line Protection Relays
 - i) Transformer Differential Protection (87T): The protection element shall be high speed, variable percentage, differential type, and shall provide, protection against phase faults and ground faults. The relays, using the second harmonic restraint principle, shall provide positive protection against tripping on magnetizing inrush current. Relays with 2 restraint windings shall be provided. The relays shall have a variable or an adjustable percentage characteristic of approximately 15 to 60 percent.
 - ii) Non-Directional Overcurrent Relay (50/51F): The non-directional overcurrent protection element shall be at least two phase, moderately inverse-time characteristics, 5A, C.T., 50 Hz, polarizing current of 110 V, 0- to 12-A current setting, flush mount, adjustable operating time approximately 0.2 to 3 sec at ten times current setting, 1A that is, 125 V DC.
 - iii) Non-Directional Overcurrent Ground Relay (51NF): The non- directional overcurrent ground relays shall be at lease one phase, very inverse-time characteristics, 5A, C.T., 50 Hz, polarizing current of 110 V, 0.5- to 2.5-A current setting, flush mount, adjustable operating time approximately 0.05 to 1.7 sec at ten times current setting, 1A, ICS, 125 V DC.

- iv Current auxiliary Tripping Relays (51X, 51NX) -If applicable: For use with (a) and (b) above. These relays shall be high speed, self reset, 125 V DC, with four independent normally open contacts. The relay shall be designed to draw current at approximately 2.5A for the purpose of dropping ICS target of relays (a) and (b) above. Min. One relay is required.
- v Line Lockout Relay (86LI): One (1 per line) or more as required shall be supplied. The tripping logic and the detailed tripping circuits shall be submitted to the DEDE for approval.

S11.04 GROUP OPERATION INDICATOR

The indicator shall be of the lamp type, which contain two lamps in one window and shall be designed to indicate the sequence of operation of the control board automatically.

S11.05 FAULT INDICATOR AND AUDIBLE ALARM SYSTEM

The fault indicator combined with annunciator relays for alarm shall be used to show the operation of protective relays and items to be indicated shall be referred to the attached Drawings of protective relaying functions. The fault indicator shall be of the lamp type, which contains two lamps in one window.

The audible alarm equipment shall consist of an alarm bell for indicating fault, and shall be mounted inside the control board. The system shall be suited for operation by 125 V DC systems.

Fault indicating sequence shall be as follows:

When a fault occurs, the lamp shall light and flicker, and simultaneously an audible alarm shall be announced.

Manipulating by resetting push button switch shall stop the audible alarm.

Flickering of the lamp shall be stopped by manipulating the resetting push button switch, but the lamp will not go off if the fault continuous. When the fault is cleared the lamp will go off.

Red window indicator shall indicate heavy fault and white window indicator shall indicate heavy fault and white window indicator shall indicate light fault.

S11.06 CONTROL AND PROTECTION CUBICLES

(1) General

The control and protection switchboards shall be designed for control, indication, metering, recording, instrumentation, annunciation and protection according to these Specifications.

(2) Arrangement

The control and protection panels shall be of metal enclosure, free standing with back door for easy access to service and maintenance. Arrangement of auxiliary and related equipment and accessories are not indicated on the Bid drawings but the Contractor shall provide necessary information to complete and proper functions as per this section so that the Bidder shall submit the complete layout of Cubicle arrangement, front panel layout and construction showing the list of Components with the Bid.

Failure to submit this information will subject to rejection of the Bid.

Any modifications to the arrangement indicated or arrangement of equipment not shown on the drawings shall be subject to the approval of the DEDE Engineer.

(3) Details of Construction

Each main control panel section shall consist of an assembly made from not less than 3 mm leveled steel sheets and formed steel members as required to form a rigid self-supporting structure. No butt surface joints shall be made on the outside surfaces of the control board. No holes or fasteners shall be visible as viewed from the front of the panel. The control panel shall be designed without any permanent bottom braces and the bottom shall be opened. Each control panel shall be furnished with channel bases. The front and rear panels of the control board shall have bent angle or flanged edges with an outside radius not exceeding 10 mm.

(a) Control Panel/ Cubicle: The Control and Protection Panel shall consist of basic panel assemblies placed back-to-back at sufficient distance to provide a tunnel-type walkway between the assemblies. Bolted-on floor channels, top sheets, wiring trays, left and right end trims with access doors shall be provided to form a complete duplex control board with uninterrupted walkway running the entering length of the structure. The access doors shall be equipped with lock, latched and fully concealed hinges, and with handles for opening from the exterior and interior. End trims with access doors shall be readily removable so as to permit future boards to be installed at both ends.

(b) All outgoing wiring and any inter-section wiring shall be routed and terminated to screw type terminal blocks mounted on the interior side panels.

Wiring for control, instrumentation, and relay circuits shall be stranded copper switchboard type with 600V insulation. Minimum wire size shall be 2.5 mm and for control and annunciation, and 4 mm² for current transformer leads.

All wiring shall be installed in wiring channels and ducts as far as possible. There shall be no splices in the wiring and all connections shall be made at terminal studs or terminal blocks.

Twenty (20) percent spare terminal points shall be provided for future use. All outgoing cable and wire shall be routed through floor openings.

A 20-watt fluorescent light fixture shall be furnished in each board section to provide proper interior illumination. One 3-way switch shall be provided at each

end of the board and one 230 V AC, single phase, 3-wire 50 Hz convenience outlet shall be provided for each section. The lighting and outlet circuits shall be wired in conduits and terminated in a suitable junction box at both ends of the boards to facilitate the completion of wiring of the circuit in the field.

A grounding bus made of copper and equivalent to 95 mm² copper conductors shall be provided and fastened securely to the back panel inside of each section. All bus sections shall include provisions to facilitate ground connection in the field. The extreme end of the ground bus shall have pressure type lugs suitable for 95 mm² copper cable. All grounds in the structure shall be properly routed and terminated to the grounding bus.

All ventilating openings shall be provided with corrosion-resistant screens to prevent entrance of insects and rodents.

To prevent warping of panels, all heavy devices shall be adequately supported by means of rear-mounted brackets or straps. The equipment mounted on the panels shall be arranged and spaced to provide easy access for inspection and servicing.

The board shall be constructed to meet all the applicable sections of NEMA and ANSI Standards.

Switchboard insides and outside surfaces shall be cleaned by rinsing or other suitable method and a rust inhibitor shall be applied prior to priming. The finishing coat shall be the same as main control board.

Terminal boards shall be provided on both side panels with suitable cable supports for incoming control cables.

Wiring between terminals and all relays shall be of the type commonly used in switchboards, with wiring ties at proper intervals.

Terminal markers shall be of the permanent type marker strip and shall bear the wire numbers according to the connection diagrams.

Wiring markers shall be provided on each end of each wire with the same identification appearing on the terminal boards.

Auxiliary self-reset relays shall be multi-contact, high-speed type.

Timing relays shall have adjustable time delay with independent circuit opening and circuit-closing contacts as required. The relays shall not depend on oil despoths or other devices which are affected by temperature.

All relays shall be the surface mounted front connected type with a dust cover. Relays shall be fastened to small channels provided on the surface of the rear panel in each section of the board.

(c) Terminal Block, wire and Device Designations

Every point of terminal block and wire shall be assigned a designation, with identical designation on each corresponding terminal block and wire. This same designation shall also be indicated in the schematic and wiring diagrams. As a rule, a designation will not change until the wire is terminated or connected to other equipment. All wiring shall be designated at both ends by printing on wire designation sleeves. Wire designation shall be by permanent method unaffected by heat, solvents, or steam and not easily dislodged. Each designation on the terminal blocks shall be machine-lettered. Stamped, engraved or neatly marked with permanent ink on the removable marking strips provided for each terminal block. Approximately 20 percent of spare wire designation sleeves shall be furnished. Adhesive labels shall not be acceptable.

The name of NEMA standard device number of each device shall be marked on the rear of the panels directly behind or adjacent to the corresponding device.

(d) Indicating Lamps

All indicating and pilot lamp assemblies shall be of the low power, cool operating, 24 V, switchboard type, with color caps and integrally mounted resistors. The color caps shall be red, green, white, blue or yellow as required. All lamp bulbs shall be inter-changeable and shall be replaceable from the front of the panels.

(e) Test Switches

Test switches shall be of the built-in type or separate type as specified. Separate test switches shall be of the switchboard, back-connected type, finished in dull black for front-of-panel mounting. All test switches shall be arranged to isolate completely the instruments from the instrument transformers and other external circuits and provide means for testing either from an external source of energy or from the instrument transformers by means of multipole test plugs which shall be provided for the propose. A sufficient number of test plugs to make a complete test on one meter, instrument, or relay shall be furnished for each type of test switch. All test switches shall be arranged so that the current transformer secondary circuits cannot be open-circuited in any position while the test plugs or cover plugs are being inserted or removed.

(f) Terminal Blocks

The control boards shall be provided with terminal blocks for termination of all wiring devices mounted in the control boards and all external circuits. Terminal blocks for control wiring shall be of 600 V approved molded-block type with molded insulating barrier between terminals. Terminal blocks shall be sized to accept 25 mm² to 1.5 mm² conductors. Each terminal block shall have movable white marking strip for marking circuit designation. One spare blank marking strip for marking circuit designation and one spare blank marking strip shall be, furnished with each terminal block.

The arrangement of all terminal blocks shall be such that incoming and outgoing can be easily arranged for connection to terminals. Terminal block shall be located so that the accessibility to them will not be lessened by interference from structural members or panel instruments. Ample space shall be provided to terminal blocks for termination of all external circuits. Except as otherwise specified, extra terminals, in addition to that mentioned in Article 10.1, in quantity of not less than 25 percent of the active terminals, shall be furnished and mounted for circuit modifications and for future use.

(g) Nameplates

Nameplates shall be furnished and mounted by the Contractor. Each assembly, each piece of equipment mounted on an assembly, and each power and control circuit shall be provided with a nameplate. All nameplates shall be of laminated plastic material, black on the surface with a white internal layer. Lettering shall be machine-engraved into the nameplate to form white letters against a black background. All panel mounted nameplates shall be in accordance with the respective drawing. A sample nameplate, showing the style of engraving to be used, shall be submitted to the DEDE Engineer for approval. Nameplate engraving shall be subject to approval of the DEDE Engineer.

(h) Symbols and Mimic Buses

All symbols, devices and painted mimic buses, 10 mm in width, shall be provided on the main control board to form single line diagrams which will simulate actual electrical connections as indicated on the drawing entitled "Main Control Board Equipment Layout". Mimic disconnect devices for disconnect switches shall be manually operated. The mimic buses shall be painted on the front of the panels with lacquer or enamel. Color of mimic buses shall be as follows:-

33 kV	- RED
3.3 kV	- RED
0.4 kV	- GREEN

(i) Control and Instrument Switches

The control and instrument switches shall be of the multistage, rotary type, rated 600 V, 20A, continuous duty, for both AC and DC service, and shall be designed for switchboard mounting with all contact mechanisms behind the panels. All contacts shall be enclosed in a cover, or covers, which can be easily removed when installed on the control board to afford complete accessibility to contacts and terminals. Each contact shall be of the readily renewable, self-cleaning type and shall be of the wipe-type. A rectangular front-of-panel escutcheon plate shall be furnished and engraved showing the switch position of control and instrument switches. The switch identification shall be engraved on the escutcheon plate, or if necessary, on a separate adjacent nameplate furnished by the Contractor.

The types of control switch handles and colors preferred shall be provided as follows:

Circuit breaker control switches	- pistol grip (black)
Instrument selector switches	- round notched (black)
Synchronizing switches	- oval removable (yellow)
Raise-lower control	- oval (black)
Control selector switches	- oval (black)
Other cut-off switches	- oval (black)

The total number of contacts and the total number of contact arrangements shall be adequate for their required functions and shall include two normally open and two normally closed spare contacts.

(j) Indicating Instruments

Each indicating instrument shall be semi-flush mounted, back connected, dustproof, fully tropicalized, switchboard type with a dull black case for mounting on a steel panel. Each shall be suitable for operation with the instrument transformers shown on the drawings under both normal and short circuit conditions.

Except as otherwise specified; all indicating instruments shall be approximately 96 x 96 mm with a 250 scale.

Scale plates shall have a permanent white finish with black graduations and numerals. VAR meter scale plates shall be marked "IN (-)" at the left of the scale, "-0-" at the center and "- (+) OUT" at the right.

Auxiliary transformers shall be furnished where required to produce the correct magnitude and phase angle of measured quantities for the indicating instruments.

The maximum error of each indicating instrument shall not be more than one percent of full-scale range.

(k) Relays

All relay contacts shall be rated to withstand at least 30 A, 600 V for 3 seconds, and at least 5 A, 600 V on continuous duty; All -20 percent to +12 percent of rated DC voltage as specified and at a range of ambient temperatures of 10°C to 50°C. Each protective relay shall be suitable for operation with instrument transformer ratios and connections as shown on the metering and relaying diagrams under both normal and short circuit conditions. Each electro-mechanical relay shall be of the semi flush-mounted, back-connected, dustproof, fully tropicalized, switchboard type, with dull-back rectangular case and shall have a removable transparent cover, or a cover with a transparent Window, with provision for sealing. Each protective relay shall be the withdrawal type with built-in test facilities. Each relay shall be equipped with an operation-indicating target and contacts for operation of DC voltage rating as specified for each phase, with external front-of switchboard resetting

device. Loading resistors-, where needed to secure reliable target operation, shall be furnished.

Static relays shall be supplied as complete relaying system. All relays and components necessary to complete a system shall be fully tropicalized, contained in a common enclosure, and shall be complete with all interconnections and wiring for back-connection. Enclosures shall be rectangular, finished dull-black, dustproof, suitable for semi-flush switchboard mounting, with a removable transparent cover, or a cover with a transparent window, with provision for sealing. Operation indicating lights and identifying labels shall be provided with each relaying system and shall be clearly visible and identifiable. External appearance of the enclosure shall be compatible with cases specified above for electro-mechanical relays. All static relays shall be adequately protected against damage from incoming surges. Each relaying system shall utilize a DC-to-DC converter-type regulated power supply to provide transient surge isolation between the station battery and the electronic components of the relaying system,

All modules of static-type protective relays shall consist of highly reliable logic circuits and circuit components. All modules shall be mounted on plug-in circuit cards. Wiring boards shall be epoxy-fiberglass construction. Printed circuit wiring shall be employed with soldered or welded connections to circuit components. Wiring board shall be provided with heavy-duty circuit connectors with gold-plated contacts.

The stator temperature relay shall be connected to resistance temperature detector and 2 normally open contacts shall be provided and its operation shall be accurate and reliable without wrong-operation. The relay shall be adjustable to operate at temperature of 80° C to 120°C and shall be reset manually.

(I) Auxiliary and Control Relays

Additional auxiliary and control relays shall be used to complete the function of power circuit breaker tripping and reclosing, trouble alarm, or any indication, etc. as required in this Specification.

The coils of standard-speed relays shall be suitable for continuous duty at their normal operating voltage. All contacts shall be of the renewable type with ample current-carrying and interrupting capacity for the application, and shall withstand at least 30 A, 600 V at 3 seconds and at 5 A, 600 V at continuous duty. Auxiliary tripping relays of the mechanically latched-in type shall have manual reset- devices operable from the front of the panel by means of a red oval handle and shall have an operating time not to exceed 25 milliseconds. Auxiliary relays of the self-reset, standard-speed type shall have an operating time not to exceed 40 milliseconds. Auxiliary relays of the self-reset, medium speed type shall have an operating time not to exceed 30 milliseconds. Auxiliary relays of the self-reset, high-speed type shall have an operating time not to exceed 15 milliseconds without objectionable contact bounce. All auxiliary relays shall have sufficient number of electrically separate contacts for tripping, lockout and annunciator circuits specified.

(4) Control Sequences, Data Recording, Logging and Report

Unit Control Sequence shall be capable of executing any control sequence selected by operator in all Control Modes except Manual Mode. The design sequence shall be proposed with the Bid including the following steps of sequences: -

- a) Start and Synchronize Sequence
- b) Normal Shutdown Sequence
- c) Emergency Shutdown Sequence

Data Recording, Logging and Reporting in Controller's HMI PC shall be provided with the simultaneously recording and trending up to 6 parameters received by Control System in any define period. The operator shall be able to select the section of interest including the following items: -

- a) Status Alarm and Indication
- b) Audible signals and messages
- c) Alarm logging and Indication
- d) Status alarm List
- e) Trending and Report

S11.07 TESTS

(1) Factory Tests

All control system equipment shall be tested at factory in front of DEDE Engineer and the test program with procedures shall be submitted to DEDE for approval.

Factory tests of complete cubicles shall include tests of continuity of all panel wiring, I/O individual functions; Graphical Indication simulation test at HMI PC, all control indications, annunciations and alarm devices, measurement of insulation resistance, etc. The Contractor shall submit the list of test to DEDE Engineer for approval.

(2) Site Tests

The following site tests shall be performed before start-up the unit: -

- (a) Inspect and prove continuity of all control, indication, protection and alarm circuits;
- (b) Test insulation resistance of all circuits, at appropriate voltages.
- (c) Prove correct operation of all control, indication, protection and alarm circuits.
- (d) Prove correct operation of all indicating instruments by secondary injection.

<i>SECTION 12</i> <i>MAIN TRANSFORMER</i>

SECTION 12 - MAIN TRANSFORMER

S12.01 SCOPE OF WORK

The work to be done under this section consists of the design, manufacture, testing, delivery to site, installation, ISO 9001 certificate, TIS standard or PEA standard, placing in successful service and guarantee of Two (2) set of generator transformers of minimum capacity at 3,150 kVA.

S12.02 PURPOSE AND FUNCTION

The transformer will step up the generator voltage from 3,300V (nominal) to the transmission line voltage of 33 kV (nominal). Transformer will transfer power from a generator, rated for 3,150 kVA, 0.8 P.F, 3-phase and 50 Hz. The generator will be star-connected and grounded through a resistor.

The layout and component list with dimensional drawings for transformer shall be submitted with the Bid.

S12.03 STANDARDS

The transformer shall be manufactured and tested in accordance with the latest TIS 384, JEC 204, VDE and DIN, or equivalent; unless otherwise specified in these specification HV and LV bushing shall be in accordance with the latest DIN 42531 and DIN 42530 respective, or equivalent; unless otherwise specification.

S12.04 TYPE OF TRANSFORMER

The transformer shall be 3-phase, 50 Hz, two windings, outdoor type OA (oil-immersed, natural air cooled circulation), and Hermetically Sealed corrugated tank (or) Conservator Tank with self-standing on concrete platform.

S12.05 MEGAVOLT AMPERE RATING

The continuous rating shall be at 3,150 kVA minimum, based on an average copper temperature rise of 60°C and hottest spot of 75°C over an ambient maximum temperature of 45°C. Thermally upgraded paper shall be used.

S12.06 VOLTAGE RATINGS, CONNECTIONS AND TAPS

The high voltage winding shall be Star connected with a solidly grounded neutral for operation at 33 kV, line-to-line, and shall be equipped with 4 full capacity, off-load taps at ± 2.5 percent, ± 5.0 percent based on 33 kV.



The low voltage winding shall be delta connected for operation at 3.3 kV.

All voltages are based on the turn ratio of the transformer at no load.

S12.07 INSULATION LEVELS

The Insulation level of HV windings and connected parts of transformers shall be as follows:-

Nominal System Voltage (kV, rms)	Insulation	
	Impulse Test Voltage Full-wave (kV, peak)	Power Frequency Test Voltage, 1-min (kV, rms)
33	170	70

S12.08 IMPEDANCE AND LOSSES

The percentage impedance shall be 6.0 percent at 75°C, based on 3,150 kVA and rated voltage. No-load losses and load losses shall be not more than 3,800 and 33,000 watt respectively.

S12.09 SHORT CIRCUIT CAPABILITY

When connected for normal, full-load operation, the transformers shall be capable of withstanding, without injury, a 3-phase short circuit on the terminal of any winding for duration of 2 seconds. It shall be assumed that rated voltage shall be maintained behind the reactance of system and generators.

S12.10 SOUND LEVEL

The transformer shall be designed to operate without exceeding the average sound levels prescribed by NEMA TR 1.

S12.11 HIGH FREQUENCY INTERFERENCE

The transformer shall be designed to operate without causing interference directly or indirectly to television reception and telephone communication circuits, and shall not cause radio interference in excess of the suggested tolerance limits of NEMA TR 1.

S12.12 BUSHINGS AND CONNECTORS

The transformer shall have the high voltage and low voltage leads brought out from the tank through bushings best suited for the voltage of the winding and with a high factor of safety.

Outdoor bushings shall be in accordance with ANSI C76.1 and shall be rated as follows:-

Bushing	Impulse Full-wave (kV, peak)	Low-Frequency (kV, rms)	
		Dry 1-min	Wet 10-sec
HV. Bushing for 33 kV system	170	70	70
LV. Bushing	40	10	10

All bushings shall be provided with threaded bushing studs and connectors.

Suitable connectors for bus, etc., shall be supplied, with all bushings, subject to the DEDE Engineer's approval.

Neutral bushings will be connected to a copper bus or copper conductor. There shall be no connection of the neutral lead to the inside of the tank.

Bushing arrangements, stud dimensions and connectors shall be subject to the approval of the DEDE Engineer.

All bushings shall be designed to eliminate harmful stressing of any parts due to temperature changes and to provide for conductor expansion. All porcelain used in the bushings shall be homogeneous, free from laminations, cavities or dielectric quality. The glazing shall be uniform in color and free from blisters, burns and other defects. All porcelain parts shall be one piece, well vitrified, tough and impervious to moisture.

S12.13 OFF-LOAD TAP CHANGER

The transformer shall be equipped with a full megavolt ampere capacity off-load tap switch. The tap changer shall include operating wheel or handle, indicating pointer and dial, and means for locking in any desired position. The locking device shall be arranged to prevent locking the tap switch in an intermediate position. The tap switch position indicator shall be visible from ground level while operating the tap switch. The tap switch shall provide 4 full capacity 2-1/2 percent voltage adjusting steps-2 above and 2 below the 33 kV.

The complete tap changing mechanism shall be built to meet all operating conditions and shall have high electrical, mechanical and thermal safety factors to withstand the full short circuit current of the transformer without damage. The switch contacts shall be silver-plated.

S12.14 CONSTRUCTION

The core shall be manufactured of high-grade, grain-oriented, non-aging sheet steel laminations having smooth surfaces. The core steel and all insulation associated with the core shall be designed so that no detrimental changes in physical or electrical properties will occur during the life of the windings.

The laminations of core type transformers shall be glass tape wrapped or bolted. Core bolt insulation shall be suitable for 130°C (Class B) minimum.

The core stack shall be grounded internally through grounding links located on top of the core to permit testing of the individual core packages for grounds.

The core steel and windings shall be suitably braced to prevent displacement or distortion during transportation and conditioned for permissible short circuit and overload. Suitable lifting attachments shall be provided for untanking the core and coils with a minimum of headroom. The design and location of lifting points shall be such as to preclude distortion of the core or damage to the core bolt insulation under lifting stresses. Lifting stress shall not be transferred between top and bottom clamps through the core iron.

All windings shall be copper. The winding insulation materials throughout shall be thermally upgraded and shall be 105°C (Class A) or higher.

Non-brazed electrical connections shall be compression type, 2-bolt connectors.

All fabricated steel shall be free from distortion and constructed according to the approved Drawings.

All oil-filled compartments mounted on the side of the main tank shall have a 12 mm minimum raised lip to prevent dripping of oil with the covers removed.

To maintain oil tightness, gasketed joints shall be designed and constructed to ensure even and effective pressure without overstressing the gasket, even under conditions experienced during vacuum filling of the main tank. When installed in position, the outer edges shall be protected by metal-to-metal stops or fire-resistant stop gasket material.

A relief vent shall be mounted on the cover adjacent to and projected beyond the expansion tank, discharging at a level above it. A sealed diaphragm shall be installed in both the top and bottom of the vent. The vent shall be equipped with a screen to prevent fragments of ruptured diaphragm from entering the transformer. The vents shall have the highest point not less than the height of their conservators and shall be designed to have the vent outlets face towards the ground with this height approximately 50 cm above ground level in order to protect splash over of oil in case the pressure relief device is operated. The pressure relief vents shall be equipped with alarm contacts.

Two ground pads shall be fitted at diagonally opposite corners of the base. Each pad shall include a clamp type terminal and bolts suitable for a 95 mm² stranded cable. Bolt holes in the pads shall be 35 mm deep.

A ladder shall be located on the side of the transformer tank for climbing onto the transformer. It shall extend from the base of the transformer to a minimum of 0.50 m above the cover, with an adjacent handhold to assist in moving from ladder to cover. The lower part of the ladder shall be equipped with a barrier and locking device to prevent its use by unauthorized personnel.

S12.15 BASE

The base shall be designed to permit moving the assembled and oil-filled transformers on skid plates or rollers. Length and spacing of each pair of reinforced parallel rolling areas shall be such that the fully assembled transformers, with or without oil, can be safely tilted 15 deg. Internal reinforcing shall not prevent draining of all liquid from the tank.

The transformers shall be provided with fixed structural steel skids suitable for skidding or rolling the transformers in any direction. Eyes for attaching hauling equipment shall be supplied on each side of the transformer, so that the transformer may be hauled in all four directions relative to the transformer tank. Location of the eyes shall be approved by the Engineer.

S12.16 TRANSFORMER TANK OR CORRUGATED TANK

The transformer tank and assembled radiators, the conservator tank, shall be suitable for filling with oil in the field. The completely assembled transformer with oil shall withstand a pressure of 1.00 kg/cm² or 125 percent of maximum operating pressure measured at the elevation of the cores.

S12.17 CONSERVATOR TANK (If applicable)

A conservator tank shall be mounted above the radiator bank. The tank shall have a minimum capacity of 10 percent of the oil volume of the transformer tank and cooling system and shall be suitable for operating under vacuum. It shall be equipped with dehydrating breather, accessible from grade level and designed to permit capping, a 50-mm valve with plug at the top of the tank, a sump and 25-mm drain valve at the lower end of the tank, and a manhole for inspection and cleaning. The connecting pipe to the main tank shall be 50 mm diameter minimum and shall project at least 25 mm inside the expansion tank. A brass gate valve of the rising stem type with a handle which clearly indicates the position of the valve gate shall also be provided.

S12.18 RADIATORS OR CORRUGATED TANK

The transformer shall be provided with a sufficient number of radiators to permit operation at the self-cooled ratings without exceeding the specified temperature rise.

Radiators shall be mounted on the transformer tank or corrugated tank.

Radiator valves shall be provided on each radiator connection to the interconnecting pipe, so that any radiator may be removed for repairs without taking the transformer out of service. Not required for hermetically sealed type transformer.

Radiators shall be equipped with provisions for draining.

S12.19 CONTROL

Suitable terminal blocks with a minimum of 20 percent spare quantity shall be provided to accommodate all wiring and cables.

All conduit and wiring between each item of equipment and the main control cabinet shall be provided.

S12.20 OIL

A sufficient quantity of oil shall be supplied in drums with 10 percent extra to allow for spillage. The oil shall have a dielectric strength, when shipped, of at least 30 kV as measured in accordance with ANSI specifications. The oil shall be mineral oil complying with the latest ANSI standard on insulating oils. Three certified copies of test reports stating the dielectric strength of the oil shall be supplied to the Administration prior to energizing the transformer.

S12.21 ACCESSORIES

The transformers shall be furnished and equipped with the following accessories:

- (1) HV and LV bushings, with terminal connectors.
- (2) Bird guard cap (bushing cover), ultra-violet and track resistant material, e.g. Polypropylene, neoprene, etc; which is suitable for exposure to sunlight.
- (3) Arcing horns, corrosion-proof, according to DIN 42531.
- (4) Tap changer
- (5) Thermometer pocket with contacts.
- (6) Oil level gauge with contacts.
- (7) Buchholz relay with contact.
- (8) Pressure relief device with contact.
- (9) Nameplate with connection diagram.
- (10) Oil drain valve with plug or cup, installed at the lower part of the tank.
- (11) Sludge drain plug, installed at the bottom of the tank.
- (12) Earthing terminal, with solderless clamp type connector suitable for steel stranded conductor diameter of 9.0 mm (size 50 mm²); complete with lock-washer of stainless steel or better.
- (13) Lifting lugs.
- (14) Lifting eyes on the cover
- (15) Oil conservator with dehydrating breather and oil level gauge with contacts. The cylinder of dehydrating breather shall be of transparent glass. The dehydrating breather shall be easy replaced and filled with silica-gel not less than 1.0 kg. It is not required for hermetically sealed type transformer.

S12.22 TESTS

The transformers shall be tested at the Contractor's works in accordance with ANSI C57.12.90. The following tests shall be made on the transformer.

Routine test

- (1) Resistance of high and low voltage windings on all taps.
- (2) Exciting current and no-load loss on rated voltage connections at rated voltage and 110 percent of rated voltage (to be performed after impulse test).
- (3) Impedance and load test at rated current on the rated voltage connection and on the tap extremes (1 transformer only for tap extremes).
- (4) Polarity and phase relationship tests.
- (5) Ratio of all taps.
- (6) Control components and auxiliary wiring tests. Where applicable, tests shall be performed on each transformer in accordance with the relevant standard:
 - Dielectric.
 - Control wiring.
 - Mechanical.
- (7) Applied and induced voltage tests.
- (8) Temperature rise test.
- (9) Mechanical tests, including pressure tests to establish the integrity of the tank and cooling system.

SECTION 13
LINE PROTECTION EQUIPMENT AND SWITCHYARD

SECTION 13 – LINE PROTECTION EQUIPMENT AND SWITCHYARD

S13.01 SCOPE OF WORK

The works to be done under this section consist of design, manufacture, supply, testing and delivery to site with installation and guarantee for:-

- Switch yard construction such as transformer base, fence base, cable trench in switchyard, fence, take off structure. Contractor shall submit equipment and switch construction to DEDE for approval.
- 9 (nine) sets of 33kV drop out fuse with fuse link
- 9 (nine) sets of Lightning arrester
- 3 (three) sets of Voltage transformer for 33kV Outgoing Line Protection
- 3 (three) sets of Current transformer for 33kV Outgoing Line Protection
- 1 (one) set of Vacuum (or) SF6 circuit breaker for 33kV Outgoing Line
- 1 (one) set of Disconnecting Switch for 33kV Outgoing Line
- 3 (three) sets of Current transformer for 33kV Outgoing Line Metering
- 1 (one) set of 33kV Line protection cubicle

S13.02 PURPOSE AND FUNCTION

The line circuit breaker shall conducted electrical power from powerhouse to PEA transmission line via step up power transformer. This specification covers the requirements for motor operated remote controlled; three phase Vacuum (or) SF6 Line Circuit Breaker for PEA 33kV distribution system which shall be operated by HMI PC in Operator Control Room. Line CB configuration shall be outdoor design and the manufacturer shall be ISO 9001:2000 and ISO 14001:2000 certified.

S13.03 DESIGN RATINGS AND STANDARDS

33kV Line Equipment shall be designed, manufactured and tested as per latest version of ANSI, NEMA or IEC standards. Certified type test reports shall be provided for DEDE approval. Line Circuit Breaker shall have the rating as below:

Rated voltage, kV.....	36
Impulse level (BIL), kV	150
Continuous & Load break current, A	1,250
Interrupting Current, kArms sym.	25 min
Closing and tripping coil voltage (DC).....	125
Motor spring charger voltage (DC).....	125

S13.04 EQUIPMENTS

All equipment in this section shall comply with IEC, NEMA, ANSI or equivalent and they shall have the ratings as below:-

- (1) Line circuit breaker, outdoor type, 36 kV, 1,250 A, 25 kA minimum
- (2) Disconnecting switch, outdoor type, 25.8kV, 600 A
- (3) Lightning arrester, outdoor type, 30 kV, 10kA
- (4) Current transformer, outdoor dry type class resin, 33kV, 400/5A
- (5) Voltage or potential transformer, outdoor dry type class resin, 33,000/110V
- (6) Drop out fuse cutout, outdoor type, 38kV, 12kA, 100 A
- (7) Line protection cubicle. Same specification as generator protection in Section-11 having line protective function according to single line diagram MHS-EM-001 and remotely operated by HMI PC from Control Room. Metering and Protective Relays shall be selected and supply similar with equipment used in Section-11 and also having reference in PEA.

Bidder can submit alternative proposal for the Switchyard layout equipment however the rating shall be not be less than the rating as shown in this specifications.

S13.05 DETAILED REQUIREMENTS

The 33kV switchyard equipment, metering and protection system shall meet the requirements and shall comply with the standards and protection system shall be complied and approved by DEDE (or) PEA.

The contractor shall design the 33kV line protection system and metering system which is to be installed in switchyard according to the well proven associations by the reputable international certification such as:-

- 10 CFR 50 Appendix B Nuclear Quality Program
- ABS Marine Type Approval
- CE (Europe)
- CSA (Canada)
- ENA (UK)
- IEC, including IEC 61850-10 Conformance
- IEEE, including IEEE 1613 Reliability
- ISO 9001:2008
- ISO/IEC 17025
- KEMA
- RUS (for rural electric cooperatives)
- UL
- VPP Star Safety

Control circuits including potential and current transformer secondary circuits, batteries, DC controls, AC auxiliary power supplies, supervisory alarms and communication circuits connected to the function of the protection equipment shall be protected against conductive, electrostatic and electromagnetic influences of transients of neighbouring circuits.

Both ends of each cable connecting relays to voltage and current transformer secondary circuits, batteries, DC control, AC auxiliary power, supervisory alarms, tripping and communication circuits, shall be marked with slip-over ferrules of different colours and numbering.

Each relay system shall be provided with test plug facilities for secondary injection testing and current circuits, potential circuits, tripping circuits' and all other output contacts. All test switches shall be arranged so that the current transformer secondary circuit cannot be opened circuit in any position while the test plugs or cover plugs are being inserted or removed. Test plugs shall be furnished with each type of test switches. All digital relays shall be adequately protected against damage from incoming surges and shall meet ANSI SWC test standard.

All modules of digital type protective relays consist of highly reliable logic circuits and circuit components. All modules shall be mounted on plug-in circuit cards. Wiring boards shall be epoxy-fiberglass construction. Printed circuit wiring shall be employed with soldered or weld connection to circuit components. Wiring board shall be provided with heavy-duty circuit connectors with gold-plated contacts.

The instruction manuals shall be prepared with the object of providing sufficient detailed technical information of each type of protective relay to enable DEDE to efficiently carry out commissioning and routine testing, to provide guidance in the tracing of faults and to permit order of replacement parts. In this regard, each instruction manual shall give full details of circuit operation, circuitry and components. All technical data, operating time curves, sample calculations and other characteristics shall be based upon 50 Hz Operation.

The settings for the relay functions shall be programmed by via software from laptop and it shall also be approved by PEA for setting values. And the method of parameter uploading and correction shall be trained to DEDE operator before commercial operation of the plant.

Lock-out and Non-lockout Relays

Lock-out relays shall be high speed half-cycle type, solenoid operated, mechanically latched, with pistol grip manual reset handle. Non- lockout relays shall be similar but without the latch and reset features. Output contacts shall be rated for 2A at 125 VDC. Sufficient contacts shall be supplied for all stated functions.

Auxiliary Relays

Auxiliary relays shall be rail-mounted socket type with sealed case and coils and contacts rated for 125 VDC.

Protection Circuits

Relay protection circuits for 33kV line equipment shall be by 125 VDC and shall be supplied. Loss of supply relays shall monitor the supply and shall alarm the control system upon loss of DC. All VTs and CTs circuits shall be supplied with test switches for isolation during testing and shall be installed at 33kV Line Protection Cubicle.

Metering

Active and reactive energy metering shall be provided for revenue, statistical and efficiency measurement. High accuracy metering of kWhr and kVARhr are required at control room and it shall be connected to Unit PLC via data communication cable. Metering shall comply with IEC 60687. Metering test block shall be provided in the CT and VT circuit to provide isolation and testing connection facilities for the meter.

All metering shall be a digital type meter with TCP/IP communication and can be recording information and shall be shown at HMI LCD Screen of operator control station and shall be printed out the data logging, alarm list, metering values and other information. Meters shall have a backlit LCD screen for display of quantities and phase vectors, and controls for selection of measured and calculated quantities. Meters used for monitoring distribution line electrical quantities shall be of revenue metering accuracy class. The meters shall include software to allow the control system to perform:

- Waveform capture
- Waveform record harmonic analysis
- Total harmonic distortion (THD) analysis
- Typical history and real time trends

Wiring, Setting and Testing

The Contractor shall supply, before elaborating the wiring diagrams, block diagrams in one drawing for each type of feeder protection. These block diagrams shall include schematic information concerning trip circuits, control circuits, secondary circuits of voltage and current transformers with polarity marks, DC power supply, supervisory alarms and teleprotection circuits, etc. These block diagrams shall be updated during the factory test, erection and commissioning phases.

The protection system shall be completely wired, tested and inspected at the factory before shipment.

Wiring used within the switchboard shall conform to DEDE standard. The only work necessary to be performed at site shall be the connection of the external devices, the commissioning procedure and the site tests.

Test devices shall be provided for relay test facilities. Each test device shall be furnished with each relay and arranged to isolate completely the relay from instrument transformers and other external source of energy or from instrument transformers by means of multipole test plugs which shall be provided for the purpose. A sufficient number of test plugs to make a complete test on one relay shall be furnished for each type of test device. All test devices shall be arranged so that the current-transformer secondary circuits cannot be open-circuited in any position while test plugs are being inserted or removed.

It shall be possible to perform complete test of a protective relay, interposing relays, if any, and circuit breaker by injection of analogue values through the test blocks, without disconnecting any wire (or) connector.

DC-Supply

The power supply shall be based on 125 V lead-acid station batteries.

All relays shall be equipped with a self monitoring alarm system, especially for DC supply and abnormal level of stabilised DC voltages but not necessarily limited to only these two. The DC supply of all the protection relays and communication shall be monitored by means of an auxiliary contact of the related mini CB's which will provide an alarm in case of fault on the DC supply.

The DC supervision relays shall indicate a delayed, independent and separate alarm for each supervisory relay and also a local and remote alarm in case of a missing DC supply and DC/DC converter failure of DC supply.

Interface Requirements

The protection scheme(s) shall include all hardware and software to allow remote setting/configuration/fault analysis by connecting with Engineering Laptop and have to install software for maintenance purpose for the followings:-

- On and Off line communication
- Relay Settings
- Relay configuration
- Switching of setting group
- Extract disturbance records
- Access to relay monitored parameters

Access to relay display and setting parameters will be keyed by different authorization levels (password).

Disturbance records requirements

The internal disturbance recorder shall have the capability to store at least the last 5 disturbance records with a minimum total storage capacity of 3 seconds (typical). This records shall be stored in the relay memory, backed by a battery or non-volatile memory. Battery low voltage alarm facility shall be provided for monitoring of status of the battery.

S13.06 DEDICATED PROTECTION

In addition to dedicated protection devices described below, auxiliary tripping relays and auxiliary tripping and lockout relays shall be provided with line protection.

Each auxiliary tripping and lockout relay shall be of the high-speed type, DC voltage operated, electrical reset with cut-off contact provided to interrupt the operating coil. All contacts shall be electrically separate contacts and rated to carry 30A, 300V, for 3 seconds, 5A, 300V, continuous, and be capable of interrupting of 0.2A of inductive current ($L/R \leq 40$ ms) in a 125 V DC control circuit.

Loss of DC control circuit shall be monitored by loss-of-potentiala DC alarm relay. (27XB, 27XR). Each relay shall be provided with an auxiliary relay, standard speed with slow dropout characteristics.

Similarly, loss-of-AC control supply shall also be monitored by a loss-of alarm relay (27 XM). Each relay shall also provide the contacts for alarms similar to loss-of-DC alarm relay.

S13.07 LINE PROTECTION

The line protection relay shall be a digital microprocessor type providing the protection functions as per PEA standards and meet the requirements of PEA line protection. This numerical relay is the basic device in each unit connection scheme.

SECTION 14
COMMUNICATION SYSTEM

SECTION 14 – COMMUNICATION SYSTEM

S14.01 SCOPE OF WORK

The contractor shall design, supply, deliver, install and commissioning start-up for one complete set of Personal Computer (PC) with Ethernet LAN system together with related accessories for the communication between New Control Room and existing Control Room of this Project site.

- (1) Number of PC required One (1) Set
- The scope requirements for this PC Set shall consist of:
- a) 24" Monitor with display output
 - b) Main Board (Mother board)
 - c) Hard Disk Drive
 - d) Graphic VGA Card with display outputs
 - e) RAM Cards
 - f) Power Supply Module
 - g) PC Casing with Ventilation Fans
 - h) Ethernet Card (LAN Card)
 - i) DVD/R-W Combo set
 - j) HDMI Port (in/out)
 - k) USB Ports (3.0 and 2.0)
 - l) Serial, Parallel, PS/2 Ports
 - m) Optical Mouse (wired or wireless)
 - n) Keyboard
 - o) PC Table and Chair
 - p) LAN Cable
 - q) Accessories

- (2) Licensed Software One (1) Set

S14.02 PURPOSE, TECHNICAL SPECIFICATIONS, AND PERFORMANCE DATA REQUIREMENTS

- (1) Purpose
- The purpose of this requirement is for the communication between existing Power Plant Control Room and New extended control room to send and receive the plant parameters from New Turbine and Generator Unit and related equipment supplied under this contract so that Operator can monitor and control the new unit from existing control room.
- (2) Technical Specifications and Performance
- | | |
|------------------|----------------------------------|
| Type: | Indoor, mounted on PC Table |
| Operating System | Window 7 (or) XP (or) better |
| Number of PC | 1 Set |
| Power Supply | 230Vac, single phase |
| Back-Up Power | UPS for 5 minutes |
| Processor | Intel Quad-Core (minimum) 64 bit |

Processor Speed	3 GHz (minimum)
HDD	1TB (minimum)
Power Supply Unit	400W (minimum)
RAM Card	4 GB (minimum)
VGA Card	2 GB (minimum)
Ethernet Card	1 ea.
Ethernet Protocol	IEEE 802.3, TCP/IP protocol
Switching Hub	1 ea. (minimum 4 ports)
DVD/R-W Combo set	1 ea.
VGA Card 2 GB (separate)	1 ea.
Serial, Parallel, PS/2 Ports	1 Lot (min 1 Port for each type)
USB 3.0 Ports	2 Ports (min)
Primary Powers Supply	230 Vac., 50 Hz
Back-Up Power Supply	UPS 230Vac (or) Inverter 230Vac
Mode of Control	Monitoring and Control
Standard Applied	IEEE, IEC, UL, ANSI, NEMA

(3) Accessories : The following accessories shall be supplied:-

- | | |
|-------------------|--|
| a. Mouse | 1 ea. Optical (wire or wireless) |
| b. Keyboard | 1 ea. 108 key (Thai & English) |
| c. PC Table | 1 ea |
| d. Operator Chair | 1 ea. adjustable for height with wheels |
| e. UPS | 1 Unit (burden to suit with 5 min. time) |
| f. Printer | 1 Set (Laser or Inkjet) |
| g. Others | Cables, extension cord 230Vac, 10A |

The Bidder shall submit Manufacturer's literatures such as catalogs and technical information of PC, Monitor, and Main Components including License software with the Bid.

S14.03 SCADA SYSTEM

The purpose of this requirement is for the communication between existing Power Plant Control Room and DEDE office to send and receive the plant parameters from Turbine and Generator Unit and related equipment supplied under this contract so that DEDE can monitor and control the unit.

The SCADA system is connected directly via Ethernet to the PLC's For this reason it is possible to operate the whole plant with the SCADA system

All-important analogue signals are saved in an one second resolution for one month. As well the analogue data's are stored in a 1 hour resolution for one years. It is also possible to make a data export and generate CSV-files. The displayed is English.

An UPS (1000VA) is used for a safety supply of the SCADA PC.

The Screened image:

- Overview image
- Images with generator data
- Set point and limit values for each unit
- The single line of the whole plant
- Event list
- Alarm list (all occurred alarms are save)

Hardware

- 1 pc. PC Hardware /24 hour operation Dell Optiplex XE2 Mini Tower Intel Core i5-4570S 2,9 Ghz 8 GB DDR3 RAM 1660MHz 2x500GB SATA HDD RAID1 AMD Radeon R5 250 1 GB Broadcom NetXtreme 10/100/1000 Gigabit Network adapter
- 1 pcs. 32” TFT Monitor (1920x1080)
- 1 pcs. Color printer
- 1 pcs. UPS 1000 VA

Software

- WinCC Runtime professional V13 (2048 TAGs)
- Microsoft Windows 8.1
- Virus program (License for one year)
- Remote Maintenance software

<i>SECTION 15</i> <i>GROUNDING SYSTEM</i>

SECTION 15 - GROUNDING SYSTEM

S15.01 SCOPE OF WORK

The work to be done under this section consist of the design, manufacture, testing and installation of Grounding system in the Powerhouse and the transformer switchyard.

S15.02 GROUNDING WORKS

All metal parts such as steel structures, turbine casing, and all electrical equipment supplied by the Contractor including cable racks and conduits shall be connected to the ground mesh.

The Contractor shall design the grounding system, after studying of soil receptivity and maximum ground fault. The calculation shall be submitted to the Department for approval.

The ground mesh shall be designed to keep total potential rise in the project area, step and touch voltages within allowable values during ground fault.

The actual ground resistance shall be measured after the ground mesh is installed.



<i>SECTION 16</i> <i>ELECTRICAL AUXILIARY EQUIPMENT</i>

SECTION 16 - ELECTRICAL AUXILIARY EQUIPMENT

S16.01 SCOPE OF WORK

The work to be done under this section consists of the design, manufacture, testing deliver to site, installation, commissioning and the guarantee of electrical auxiliary equipment within the powerhouse and related structures. The scope includes all engineering, materials and equipment required for the Works.

S16.02 WORK INCLUDED

The equipment covered under this section includes:

- Cable trays and supports
- Conduit, boxes and fittings
- HV cable
- 750 V wire and cable
- Control cable
- Station clocks
- Forebay water level transmitter
- Motor Control Center

S16.03 CODES AND STANDARD

All materials, equipment and methods of work shall comply with the latest edition of applicable laws, codes and standards listed in this contract.

S16.04 CABLE TRAYS AND SUPPORTS

Cable trays complete with support system, fittings, barriers hardware, etc., shall be provided to facilitate and support of power, control and metering cables.

Cable trays shall be made of aluminum or galvanized steel. Sections of tray shall consist of a 1-piece corrugated, ventilated bottom contained within longitudinal side members supplied in convenient lengths. Elbows, tees, bends, etc., shall be of similar construction. Tray connectors shall provide a grounding path between tray connectors shall provide a grounding path between tray sections. The complete tray system shall provide a smooth surface free of sharp protrusions or nicks which could damage cables. Where cable trays are positioned so that cables may be subject to damage from above, ventilated covers shall be provided.

Trays shall be supported by suitable structural steel frames, brackets, rods, etc., as applicable, secured by concrete inserts to be provided in cable trenches. Distance between supports shall not exceed 2.6 m. The maximum deflection for fully loaded trays, midway between supports, shall not exceed 5 mm.

Power and control/metering cables shall be installed in separate trays to the degree practical, and in instances where combined, a solid dividing barrier shall be provided. Power cables shall be similarly divided with respect to voltage.

S16.05 CONDUIT, BOXES AND FITTINGS

Conduit, embedded in concrete and exposed, shall be provided to facilitate the installation of all conductors, cables and wires not contained in the cable tray system. Conduit shall be provided where the cable in the tray would be subject to damage and also provided from the cable tray system to motors, push buttons, control equipment, etc.

All conduits shall be rigid heavy wall, galvanized steel according to ANSI C80.1 with threaded joints. Minimum size shall be 25-mm. inside diameter for embedded conduit and 20-mm inside diameter for exposed conduit.

Where conduit is to be installed in concrete structures, all joints or connections shall be watertight, each joint being painted with red lead paint and allowed to dry before being encased. Where services are concealed within an enclosure, the conduits shall be neatly arranged and coordinated with other service pipes.

Conduit runs which are exposed, or are run in open ceiling spaces, shall be neat in appearance and run parallel to the structural lines of the building, and suitable conduit fittings and covers shall be used. Where a single conduit run is attached to reinforced concrete walls or ceilings, it shall be fastened by lead or expansion type anchors only, using malleable iron 1-hole straps at intervals not greater than those given below.

Space Between Support Straps

<u>Conduit Size</u> (mm.)	<u>Horizontal Run</u> (m.)	<u>Vertical Run</u> (m)
20	1.50	2.0
25 and 30	1.75	2.5
over 30	2.50	2.5

Cover screws for all conduit fittings or junction boxes shall be carefully cut to length to avoid damage to wires.

At the completion of the installation, all blockages shall be cleared and all outlet and pull boxes cleaned out.

All open ends of conduit shall be capped with proper threaded caps or bushings with steel pennies immediately after installation. The use of wooden plugs will not be permitted. Empty conduit for future equipment shall be capped flush with the finished floor.

Conduit shall be of adequate size for all wires and cables which have to be pulled in. The number of wires or cable in each conduit shall not exceed the requirements of the current edition of the National Electrical Code. The pull for any group of wires shall not be so excessive as to damage or distort them, and only an approved greaseless compound may be used to facilitate pulling.



All metallic conduit and fittings shall form a continuous bonded path and shall be grounded.

Wherever rigid conduit is to be underground, it shall be protected by 2 coats of approved bituminous paint.

Conduit runs shall be sloped to ensure suitable drainage. Conduit runs that may trap water shall be provided with drain plugs or other suitable means of draining off periodically.

Conduit shall be firmly secured at the entrance to all equipment, using 2 locknuts and a bushing, or the equivalent thereof, at each entrance.

Conduit terminations at equipment subject to vibration shall be liquid-tight, flexible type with a plastic jacket and of a length not exceeding 0.5 m.

All bends in conduit shall be made cold and the radius of bend shall not be less than 9 times the conduit diameter. No bend which flattens the conduit by more than one-tenth of its diameter shall be permitted.

All threads on conduit shall be cut neatly, the ends shall be square and the inside edge reamed smooth to remove burs.

When the number of right-angle bends in one run exceeds 3, junction or pull boxes shall be provided. In no case shall a conduit run be greater than 30 m. Pull boxes shall be used to break up longer runs.

Additional accessible pull boxes shall be installed where necessary, so that throughout the entire system wire or cables may be pulled in or withdrawn with reasonable ease.

The flexible conduit shall be secured to the rigid conduit and equipment terminal box by suitable connectors. A continuous ground shall be assured by bonding the equipment frame to the rigid conduit by a copper ground strap or by means of a bare copper conductor of size equal or larger than the equipment feeders.

The ground conductor shall be secured to the rigid conduit by a suitable grounding clamp, spiraled neatly around the flexible conduit and terminated in a suitable lug bolted to the equipment frame.

All conduit fittings and boxes for receptacles or switches in weatherproof areas, or when used on exposed conduit, shall be of cast construction, with threaded conduit hubs. Pressed steel boxes with conduit knockouts used on exposed conduit or flush fixtures in indoor areas shall be properly secured with locknuts and bushings.

Wherever encased conduit crosses a structural expansion joint, approved expansion fittings with bonding jumpers shall be provided.

S16.06 750 V WIRE AND CABLE

Conductors, cables and wires shall be provided for a complete functioning installation, and shall include for power, control and metering systems.

In addition the Contractor shall supply and install 750 V cable for main power supply of lighting system, emergency valve and reservoir water level detector which supplied by other Contractor.

All conductors shall be stranded copper minimum No.12 AWG (4 mm^2) for power and No.14 AWG (2.5 mm^2) for control.

All conductors shall be sized for adequate loads connected and shall limit voltage drop to 2 percent in branch feeders and 1 percent in the main feeders and also be in conformance with the National Electrical Code.

Conductors for use on 400-V and 230-V systems shall have 750-V, Insulation voltage.

Conductors for use in cable tray on 400 V and 230-V systems and for all control or metering shall be multi-conductor with a PVC jacket. Power conductors contained in conduit throughout their length (lighting, etc.) may be single conductor.

Wire connectors for systems up to 6 mm^2 shall utilize non-solder crimp type connectors applied with a tool approved for the connector. Larger connectors shall utilize split-bolt type connectors and be insulated with 3 one-half layers of vinyl electric tape.

Wire terminations shall utilize compressor type connectors other than at locations where screw clamp connectors are provided in equipment.

All conductors shall be identified at both ends with ferrule type slip-on plastic wire markers which shall clearly identify the wire numbers in agreement with schematic and wiring diagrams.

All cables shall be identified at both ends with permanent plastic or metal tags in agreement with wiring diagrams and circuit lists.

The cables for the resistance temperature detectors shall be shielded with twisted leads and have a minimum copper section of No.16 AWG (1.5 mm^2)

S16.07 CONTROL CABLES

The Contractor shall read the Drawings as a whole and make adequate provision for all conductors and connections, particularly so for the multi-conductor control cables required for interconnections between various control, metering and relaying panels in the powerhouse and control area. It shall be noted that the Drawings do not show the control and DC cables required for connections to the control, metering and relaying equipment. All control cables shall be brass shielded.

The Contractor shall supply and install the control cables for remote control, remote indication of emergency valve for penstock and control cables for reservoir water level detector and acoustic flow measuring instrument which supplied by other Contractor. The cables shall be installed from powerhouse to marshaling board in emergency valve house.

The Contractor shall supply and install the control cables with seven strands for control, metering and relaying interconnections between the equipment of powerhouse, switchyard and the control area.

The following minimum conductor sizes shall apply.

Control, instrumentation circuits	No.14 AWG (2.5 mm ²)
Current transformer circuits	No.10 AWG (6 mm ²)

All control, cables used for protection, metering and control shall have the following characteristics.

Type of installation	- cable trays
Voltage	- 750 volts
Number of conductors	- multiconductor as required (maxim 12 12 conductors)
Conductor size	- as required
Conductor material	- soft, annealed, tinned copper
Shielding material	- brass
Conductor insulation	- heat, moisture and ozone-resistant, cross- linked polyethylene, color coded

Conduction color sequence	Conductor	Base	Tracer
	<u>Number</u>	<u>Color</u>	<u>Color</u>
	1	black	
	2	white	
	3	red	
	4	green	
	5	orange	
	6	blue	
	7	white	black
	8	red	black
	9	green	black
	10	orange	black
	11	blue	black
	12	black	white
Outer jacket	- PVC.		

S16.08 STATION CLOCKS

The Contractor shall supply 4 station clocks, Quartz type.

The clocks shall be for wall mounting.

Location of clocks shall be in the control room and in the Machine Hall.



S16.09 MOTOR CONTROL CENTER

The enclosures shall be type 1 gasketed, in accordance with NEMAS ICS 1-110 Standards, indoor installation and made of steel sheet having a minimum thickness of 2.5 mm.

Module or compartment of enclosures shall be provided with a hinged door to allow full access to the inside mounted equipment; the doors shall be suitably gasketed to make the compartment dust-tight and provided with key locks.

Bus bars for power circuits shall be of copper liberally dimensioned for the specified current ratings, short-circuit and continuous current, all joints and connections of bus bars shall be silver plated.

The phase arrangement shall be A, B, C, counting front to back, top to bottom, of left to right, as viewed from the front of the enclosure.

Each phase shall be suitably identified by marks as follows:

- | | |
|-----------|----------------|
| - Phase A | - black |
| - Phase B | - white |
| - Phase C | - red |
| - Neutral | - green |
| - earth | - green/yellow |

Admissible temperature rise shall be 65°C above the ambient air temperature as per NEMA ICS 2-322 Standard.

Bus supports shall be suitable for polluted atmosphere and shall be made of flame retardant material.

Each enclosure shall be provided with a copper ground bus having a minimum cross section of 100 mm².

A suitably dimensioned ground bolt can be provided instead of the ground bus for the smallest panels, boards or cabinets.

The steel structure and all metallic parts of the enclosures shall be connected to the ground bus.

Grounding terminals and connectors for 95 mm² copper ground conductor shall also be provided at either end of the ground bus.

All enclosures shall be provided with thermostatically controlled space heaters operated at 230 V 50 Hz from an external source.

Heaters shall have individual automatic miniature circuit breakers.

Each vertical section shall be provided with one space heater.



The thermostat range shall preferably be 0-50°C.

The cable entry shall be located at the bottom of the enclosures according to the actual layout.

Enclosures shall be supplied complete with cable glands. Removable plates for fitting the cable glands shall be provided preferably at bottom of the enclosures.

Suitable base channel frames complete with anchor bolts and nuts shall also supplied.

The motor control center will be used to supply the power and/or the control of 400 V motors up to 22 kW.

The motor control centers shall be class II type B in accordance with NEMA ICS 2-322 Standards.

Unless otherwise stated in the Special Technical Specifications or shown in the Contract Drawings, the power circuit of motor control centers shall have the following main characteristics:

- | | |
|--|---|
| - System | three-phase, four wires, grounded neutral |
| - Nominal voltage | 400 V |
| - One-minute power frequency withstand voltage | 2,200 V |
| - Rated frequency | 50 Hz |
| - Rated continuous current: | |
| Main bus bars | 400 A |
| Vertical buses | 200 A |
| Neutral bus | 200 A |
| Branch circuits | as per the associated circuit breaker |
| - Rated short-time withstand current for 1 sec | 35 kV (RMS sym) plug-in contacts included |

Motor control centers shall be made up of individual modules arranged in vertical sections with separations between each other including selector switches for Lead-Lag Function, Counters, Local and Remote Operation.

The manufacture shall has type test certificate for proposed LV Switchgear type so the Bidder shall submit the type test reports of related model with the Bid.

The vertical sections shall be bolted together to form a rigid, free standing assembly of uniform and neat appearance.

The module sizes shall be multiple of one basic unit to facilitate interchangeability.

Modules of similar function shall be interchangeable.

The door of each individual module shall have a key lock and shall be so constructed that it cannot be opened when the relevant main circuit breaker is in the "ON" position.

Modules provided for motor control (Combination Motor Control Units) shall be of the fully draw-out type, i.e., contacts for power terminals on both incoming and outgoing sides shall be draw-out type.

Modules provided for non-motor loads (Feeder Tap Units) shall also be of the fully draw-out type.

Power and control terminals shall be installed close to each module and physically separated from each other.

Suitable interlocks shall be provided to prevent on-load withdrawal of draw-out type units.

When the draw-out units are taken out, suitable devices shall avoid accidental contacts with live parts. Automatically operated shutters or similar devices would be accepted.

Motor control centers are typically composed by an Incoming Feeder, some Feeder Tap Units and some Combination Motor Units as required by the Contractor's load.

Contractor shall follow the prescriptions given here below.

The Incoming Feeder cubicle shall be of fixed type, equipped as follows:

- non-automatic molded case circuit breaker, draw-out or plug-in type;
- voltmeter with scale 0-500 V;
- Voltmeter switch to read the three line-to-line voltages upstream of main circuit breaker;
- voltage transformers 400/100 V;
- aux protective fuses.

The Feeder Tap Unit shall be draw-out type, equipped with molded case circuit breaker with built-in thermo-magnetic protective device.

Combination Motor Control Units shall be fully draw-out type. They shall consist of:

- molded case circuit breaker with built-in magnetic protective device;
- magnetic contactor (in the starters for reversing motors, two contactors mechanically and electrically interlocked shall be provided);
- auxiliary relays;
- timer relays;
- thermal overload relay;
- 400/230 V, single-phase, auxiliary transformer of adequate capacity to feed the control circuit;
- indicating lamps;
- Auxiliary protective fuses.

The circuit of every Combination Motor Control Units shall include the necessary devices, contacts and/or relays for the remote signaling or draw-out not available due to operation of thermal and magnetic protective devices, control voltage loss, etc. A local indication shall also be provided by means of an indicating light with amber cap.



As a general rule, the motor control centers shall have only provisions for the signaling of motor operation.

The necessary push buttons, selector switches and/or any other necessary devices shall be supplied by the Contractor for control of the motors control center.

Control units for motors requested to re-start after a brief interruption of voltage supply shall be equipped with the necessary relays and/or devices.

The Contractor shall be fully responsible for the good coordination of equipment supplied under his scope of work.

Particular care shall be applied in coordinating the equipment for combination motor control units in order to protect the contractors and thermal overload relays in case of short circuit faults.

To provide facility for inclusion of interlocks, the motor control circuits shall be developed with suitably located breaks provided on the terminal block and bridged up with jumpers.

When requested, the Contractor shall supply the auxiliary relay required to multiply the auxiliary contacts of the main equipment, in order to reproduce the approved schematic diagrams.

S16.10 FOREBAY WATER LEVEL TRANSMITTER

One forebay water transmitters shall be provided. The transmitter shall sense the forebay water level to the control room. A digital readout shall be provided in the control room to show the actual elevation of the water column in meters. All electronics, panels, and any special shielded cables shall be included in the supply.

S16.11 TELEPHONE SYSTEM (Not Applicable)

Exchange

- (a) A Private Automatic Exchange (PAX) of not less than 6 direct line and 20 lines extension capacity shall be installed in the Power Station Control Room with extensions listed in paragraph (f) below.
- (b) The exchange shall conform to current design standards, emphasis being placed on maintenance and fault clearance by replacement of plug-in printed circuit boards. For this reason it is essential that the exchange should be of a type already in use in Thailand and supported by adequate manufacture's service facilities. One spare card of each type use including ring and tone generators shall be provided.
- (c) The exchange shall be powered by the Power Station 125 VDC battery.

- (d) The exchange shall be provided with an operator's console installed in the control room.
- (e) The exchange shall have the following facilities:
- (i) Priority cut-in on selected extension;
 - (ii) Barred access on selected extension to outgoing calls on tie circuits;
 - (iii) Conference facilities; and
 - (iv) Two both-way dialing tie circuit connection for further use.
- (f) The location of the extension telephones shall be as follows:

LOCATION	TELEPHONE TYPE	ADDITIONAL EQUIPMENT	Qty
Office	Desk		1
Diesel Room	Heavy duty industrial	Noise concealing mic. acoustic shield. Loud ringing bell.	1
Machine Bays	Heavy duty industrial	Noise canceling mic. acoustic shield. Loud ringing bell.	2
Main Transformer Bay	Heavy duty industrial	Noise canceling mic. Weatherproof acoustic shield. Loud ringing bell	1
Residence	Desk		6
Control Room	Operator's Console		1

- (g) The Contractor shall supply and install as above specified and also wiring, cabling, conduits to make the completed system and proper functions.

S16.12 TESTS

In addition to the equipment tests specified elsewhere, the following tests of the electrical equipment shall be conducted when the installation is complete, but prior to commissioning.

- Check direction of rotation of all motors and reverse connection, if necessary.
- Check all motors for correct clearances and alignment and for correct lubrication. Lubricate in accordance with manufacturer's instructions.
- Megger all bus ways, cables and control connections to prove insulation resistance is of acceptable value. Minimum acceptable resistance is 1 megaohm.

- Check each motor controller and contractor before placing same in continuous service, and make adjustments as required. Check all overload relay ratings and breaker trip settings. Check all control, interlocking and instrument wiring for proper operation.
- Provide a tabulated list of all overload relay heaters and fuses installed and their various locations.
- Test each lighting control and power circuit with 1,000-V megger for short circuits, improper grounds, insulation and operation. Each panel shall be tested with mains disconnected from the feeder, branch circuits connected and switches closed, all fixtures in place and permanently connected, lamps removed or omitted from the sockets and all wall switches closed.
- Test feeders with the feeders disconnected from the branch circuit panels. Each individual power equipment shall be connected for proper operation. In no case shall the insulation resistance be less than 1 megaohm.

Where tests indicate that the insulation was damaged by handling or during installation, such wires and cables shall be repaired or replaced at no cost to the client.

- Prove correct operation of surge tank water level transmitter.
- Prove correct operation of single side band transceiver with antenna.
- Prove correct operation of telephone system.

S16.13 HV CABLE END TREATING MATERIAL

The HV cable end treating material shall be used for indoor and outdoor end treatment of 3.3 kV and 33 kV cross linked polyethylene insulated power cables described in the preceding clause.

The end treatment shall conform to the applicable requirements of ICEA Standards 5-66-524.