4.2 CONTROL AND RELAY BOARDS

4.2.1 General

Each control and relay board to be located in the Da Nhim Power Station and the Saigon Substation shall be of duplex switchboard construction so arranged that the front panel is provided for control equipment and the rear panel for the protective relays specified, and shall be furnished with measuring instruments, fault enunciators, selector and control switches, mimic diagrams, test blocks, terminal blocks, wiring and other miscellaneous devices as required in the Specification or shown on the drawings. Auxiliary relays to provide the specified controls, alarm and indication management shall also be provided on the relay panels.

The control and relay boards shall contain all the necessary provisions for the connection to the SCADA system to be established in the future.

Measuring transducers for making measurements of electrical quantities and temperatures shall be provided for indicating the measurements on the control boards, for signalling them to the programmable controllers and for telemetering to the SCADA station to be established in the future. The measuring transducers shall be mounted in the respective control and relay boards or in a separate transducer panels to be supplied by the Contractor.

4.2.2 Board Construction

The control and relay board shall be designed to form floor-standing, dead front, vertical duplex type board construction. The board construction shall generally conform to the requirements specified in Clause 1.6.4 of the General Specifications.

The measuring instruments, group fault indicators, selector and control switches and test blocks shall be arranged on the front of the control board. The selector and control switches shall be located at a convenient operating height. The measuring instruments shall be located above control switches for easy reading.

In addition, the control board shall contain the mimic diagram to form single line diagrams which will simulate actual electrical connections. The mimic diagram shall consist of the mimic buses and the mimic symbols of circuit breakers, disconnecting switches and earthing switches.

The mimic buses and mimic symbols shall be made of plastic strips permanently secured to the panel surface by concealed screws or other approved means, and shall be coloured in red for the 230 kV system.

The mimic buses shall be at least 10 mm in width and 2 mm thick. The mimic symbol of the switchgear shall be combined with its control switch, and shall be provided with position indicating lamps.

The arrangement of the equipment and instruments shall be subject to the Engineer's approval.

4.2.3 Measuring Instruments

All measuring instruments shall be the flush-mounted, back-connected, dustproof and heavy duty switchboard type. Each measuring instrument shall have a removable cover, either transparent or with a transparent window. Each instrument shall be suitable for operation with the instrument transformers under both normal and short circuit conditions.

All measuring instruments shall be approximately 110 mm square enclosures and shall be provided with clearly readable long scale, approximately 240 degrees, except for the synchronoscope. Scale plates shall have a permanent white circular or rectangular finish with black pointer and markings. The scale ranges shall be determined from the current transformer and voltage transformer ratios.

The maximum error shall be not more than one and a half (1.5) percent of full scale range.

The wattmeters, varmeters and watt-hour meters shall be of 2- or 3-element, 3-phase, 3-wire type.

Each wattmeter and varmeter shall be suitable for bi-directional measurement as required. Each watt-hour meter shall be provided with a reverse running stop and a pulse transmitter.

4.2.4 Selector and Control Switches

(1) General

All selector and control switches shall be rotary switchboard type with handle on the front and the operating contact mechanism on the rear of the panel. All contacts shall be enclosed in a cover or covers which can be easily removed when installed on the switchboards to afford complete accessibility to contacts and terminals. Each contact shall be readily renewable, and shall have adequate insulation and contact surface.

Each selector and control switch shall be provided with an escutcheon plate to show each operating position. The switch identifications shall be engraved on the escutcheon plates or on separate name plates. The entries on the plates shall be subject to the Engineer's approval.

(2) Selector switch

The selector switch shall be of maintained contact type round notched handle.

The synchronizing switches shall be of maintained contact type and shall be operable by use of an oval handle which is removal only at "OFF" position. One (1) removal handle shall be provided for each station.

(3) Control switch

The control switches for the switchgear shall be the discrepancy switch of illuminated, push-turn handle type integrated with light-emitting diode (LED) and combined with a flashing unit to provide flashing indication in case of discrepancy condition.

(4) Other switches

The audible alarm stop switch, lamp test switch and fault indicator reset switch shall be the momentary action, non-illuminated pushbutton.

The control source supply switch shall be of maintained contact type with a round notched handle.

4.2.5 Group Status Indicator

The group status indicators shall be provide visual indication of operating status and conditions of transmission line protection system. The group status indicators shall be light-emitting diode (LED) integrated, multiple indicator light units and shall be mounted on each control panel of the local control board. Each indicator shall have a marking plate to provide operating status and conditions.

Entries for each indicator shall be engraved with black letters on the marking plate.

The colour of LED shall be suitable for white illumination.

The group status indicators shall be suitable for operation on 220 V DC ungrounded circuits.

At least one (1) spare indicator light with LED shall be included in the group status indicators.

Pushbutton for light test shall be provided on each control panel.

4.2.6 Fault Annunciation System

The fault annunciation system shall be provided on each control board to provide automatic visual and audible alarms for abnormal conditions on each equipment and circuit. The fault

annunciation system shall consist of group fault indicator and audible alarms.

The group fault indicators shall be of light-emitting diode (LED) integrated, multiple indicator light units. Each fault indicator shall have a marking plate to indicate the actuated protective relays and abnormal conditions. Entries for each indicator shall be engraved with black letters on the marking plate. The colour of LEDs shall be suitable for white illumination.

The group fault indicators shall be suitable for operation on 220 V DC ungrounded circuit.

At least 25 percent spare indicator lights with LEDs shall be included in the group fault indicators.

A pushbutton for light test shall be provided on each control board.

Three types of audible alarms for fault annunciation shall be provided as follows:

(a)	Bell alarm	for heavy faults and troubles to provide tripping of the relevant circuit breakers
(b)	Buzzer alarm	for light troubles
(c)	Melody chime	for success of auto-reclosing of transmission lines

The audible alarm systems shall be provided with an audible alarm stop switch on each control board at convenient location. The audible alarm system shall be designed that the audible alarm shall not be sounded when the switchgear are controlled remotely from the SCADA station to be established in the future.

4.2.7 Indicating Lamp Assemblies

The indicating lamp assembles shall be provided on each control board for position indication of the circuit breakers, disconnecting switches and earthing switches.

The indicating lamp assemblies shall be of light-emitting diode (LED) illuminated, switchboard type suitable for 220 V DC service, with appropriate coloured lens. The lens shall be made of a material which will not be softened by the heat from the lamp.

Red indicating lamps shall be used for "ON" position of each switchgear, and green lamps for "OFF" position.

4.3 ELECTRICAL PROTECTIVE RELAYS

4.3.1 General

All the electrical protective relays shall preferably be digital relays suitable for operation with the current transformer secondary of 5 A for Da Nhim Power Station and 5A and 1 A for Saigon Substation and the voltage transformer secondary of 110 V under both normal and fault conditions.

The protective relays and their auxiliary relays shall operate successfully for any value of the DC supply voltage between 85% and 110% of the rated voltage of 220 V without exceeding the temperature rise limits for the operating coils.

The protective relays and necessary auxiliaries shall be mounted on the relay boards specified in Clause 4.2.

Each protective relay shall be of the flush-mounted, back-connected, dustproof, switchboard type, with rectangular case. Each relay shall have a removable transparent cover or a cover with a transparent window, with provision for sealing. Each relay shall be of a withdrawable type from the front of the panel with sliding contacts, without opening the current transformer secondary circuits, or disturbing external circuits, or requiring disconnection of leads on the rear of the panels. Each protective relay shall be equipped with an operation indicator and manual resetting feature.

Each protective relays shall be provided with two (2) electrically independent contacts of adequate rating for trip and alarm functions, and the alarm function only may be performed by a separate auxiliary relay if two (2) contacts are not available in the protective relay. Test facilities shall be provided as an integral part of each protective relay for testing of current and voltage transformer secondary circuits and trip circuit using secondary injection test equipment.

The protective relaying scheme for each circuit shall comply with the present protection scheme applied, except for the 230 kV transmission line protection specified in Clause 4.3.2 below.

4.3.2 Transmission Line Protective Relays

(1) General

The transmission line protective relays, four (4) sets in total, shall be supplied at the Da Nhim Power Station, the Long Binh Substation and the Saigon Substation for the protection of the following 230 kV transmission line circuits.

(a) Two (2) sets for about 240 km long, single circuit of transmission line between the Da Nhim Power Station and the Long Binh Substation.

A T-branch of the above transmission line is located at the point of about 110 km away from the Da Nhim Power Station, for connection to the Bao Loc Substation. The distance between the branch point and the Bao Loc Substation is about 100 m.

(b) Two (2) sets for about 18 km, single circuit of transmission line between the Long Binh Substation and the Saigon Substation.

One (1) channel of the 4-channel power line carrier terminal to be supplied under Section 5 will be allocated for signal transmission of carrier protection relaying for the 230 kV transmission line circuit.

The teleprotection signalling equipment for the protective relays shall be provided by the Contractor under Section 5.

(2) Performance

The transmission line protective relays shall provide highly reliable, directional comparison carrier relaying system together with three-step distance relaying scheme, and their performance shall be suitable for the following requirements:

(a) The protective relays shall be capable of simultaneous high-speed tripping of the circuit breakers at both ends of the protective section against all type of phase and ground faults, except for conductor-breaking not accompanying ground fault, in the line protective section.

(b) The protective relays shall not result in a maloperation of the associated circuit breakers in the event of external fault, switching operations, out-of-step, power swing, and any phenomena under all weather conditions.

(c) High-speed tripping of the circuit breaker at each end shall be performed by the back-up protection in the event that the main protection system fails to operate for any causes, or when the carrier relaying system is out of service.

(d) The protective relays shall, without interrupting the tele-protection operation, permit a periodical automatic inspection of the carrier equipment at a predetermined interval and manual inspection as well.

(e) The protective relays shall be designed to ensure easy and correct inspection and

adjustment of the equipment.

(f) High-speed single-phase reclosing of the circuit breaker shall be performed in combination with automatic reclosing equipment.

(3) Protective relaying system

The protective relaying system shall be the directional comparison carrier relaying system using the directional distance relay of three zone type. Zone 1 and zone 2 relays shall be operated only for faults in the protective direction. Zone 3 relay shall be non-directional and shall be capable of being independently off-set in both directions. The zone 2 and zone 3 relays shall have a time delay setting range of 0.2 to 1.0 second and 0.5 to 3.0 seconds respectively. The reach of each zone shall be individually adjustable.

The main protection against all types of phase and ground faults shall be performed by the zone 1 relay. The backup protection shall be conducted by the zone 2 and zone 3 relays with time delay for phase and ground faults. The operating time of each zone relay shall be substantially independent of the magnitude of fault current.

The phase and ground fault distance measuring elements shall be separated. Common relays will not be accepted.

The protection system shall be designed to ensure that sensitivity of protection is adequate for operation of the distance relay under the minimum load operation of the transmission system. Suitable measure shall be provided to prevent maloperation of the relay in the event of power swing. The protection system shall be provided with the voltage balance relay to prevent maloperation due to a voltage transformer secondary circuit failure or a voltage transformer failure.

In addition to the distance relays, the protection system shall contain overcurrent relays for backup protection against phase and ground faults. The overcurrent relays and time delay setting shall be designed that the overcurrent relays will not operate before operation of the distance relays.

The protection system shall be suitable for the automatic reclosing operation.

(4) Automatic reclosing system

The automatic reclosing system shall be made to perform high-speed reclosure programmes by means of a selector switch which makes it possible to select one reclosing scheme from among those listed below:

(a) "1ϕ : Single-phase reclosing for single phase-to- ground fault. Final tripping for multiple-phase faults.

(b) "0" : Final tripping for all types of faults.

The number of reclosing operation shall be one (1) time (O-CO). The automatic reclosing operation shall be effected following tripping either as a result of first zone relay operation or when a blocking signal from the opposite end distance protection is interrupted.

When successful reclosing has been made, the reclosing system shall be reset automatically and shall make ready, fast enough to allow repetitive reclosing operations for the next fault. However, in the event that the next fault occurs within 3 minutes just after a successful reclosing, the following reclosing operation will be cancelled.

When an unsuccessful single-phase reclosing has been made, or if the fault still presents at the instant of reclosure or if the fault recurs within the preparation time of the auto-reclosing equipment, the associated circuit-breakers shall trip all three phases and auto-reclosure shall be locked out.

The automatic reclosing system shall be locked out when the carrier equipment is out of service. If, after the tripping of a circuit breaker, it fails to bring about reclosing conditions even though the time limit for performing reclosing function has elapsed, then the reclosing circuit shall be released.

Provisions for adjusting the non-voltage time of between 0.2 and 2.0 seconds shall be provided.

4.4 PROGRAMMABLE CONTROLLERS

4.4.1 General

The programmable controllers shall be provided to perform automatic sequence control and data acquisition of each generating unit for the Da Nhim Power Station, and shall communicate with the supervisory computer system specified in Clause 4.5 below.

The programmable controller shall employ function-oriented microcomputer system using 32 bits micropocessors and each controller function shall be arranged in one or more printed circuit boards.

The programmable controller shall be housed in the metal enclosure to be constructed in conformity to the requirements specified in Clause 1.6.4 of the General Specifications.

4.4.2 Programmable Controller Function

The programmable controllers shall include the following functions:

(1) Sequence control function

The sequence control function shall include the logic for the following sequences for the unit automatic control:

(1) Ordinary start sequence

(2) Ordinary stop sequence

It shall be possible to operate these sequences by the master control switch on the main control mode, under both automatic and manual control modes.

(2) Sequence monitor function

The sequence monitor function shall monitor the sequential control operation of the unit with checking a processing time of each main step of the start and stop sequences. The sequence monitoring shall be performed by the group status indicator (sequence monitor) provided on both the control board and the visual display unit to be provided under Clause 4.5. In the event of troubles in any sequential step, the trouble step and equipment/devices shall be indicated automatically on the sequence monitor.

4.4.3 System Equipment

(1) System component

Each programmable controller for the generating units shall be composed of the following devices:

(a) Sequence control unit

(b) Sequence monitor

(c) Regulation control unit

(d) Communication interface unit for interfacing with the supervisory computer system

(e) Analog input unit

(f) Analog output unit

(g) Digital input unit

(h) Digital output unit

(i) Power supply unit

(j) System bus

(2) System configuration

The programmable controller shall employ dual redundant (hot standby) control system. The main processors, sequence control unit, power supply unit, system bus and communication interface unit shall be duplicated for the dual (hot standby) control system. Each one is designated prime, the other is backup. In the event of failure in any one of the prime devices, the programmable controller function shall be carried out by its backup device. The system shall continuously monitor its own operation, and shall automatically transfer to the backup device upon the detection of a malfunction. Transfer to backup devices shall be accomplished without any shock and interruption to the control duties of the programmable controller.

Power source for each power supply unit shall be 220 V DC to be taken from the DC distribution panel.

(3) Equipment construction

All programmable controller components shall be housed in the metal-enclosed panel(s) of floor-standing type as specified in Clause 1.6.4 of the General Specifications.

The printed circuit boards shall be of plug-in type and rack mounted. Each printed circuit board shall be clearly marked with its identity, serial number and function. The rack position for each printed circuit board shall be clearly indicated.

Light emitting diodes (LED) shall be provided on all printed circuit boards for indicating the status of power supplies and fault conditions, and shall also be provided for indicating the status of all contact inputs.

All parts liable to failure, including connection and power supplies, shall be readily accessible for the purpose of inspection and repair.

4.4.4 System Requirements

The programmable controller shall withstand the dielectric test voltage of 2,000 V for one minute without any damage.

The programmable controller shall directly interface with the plant without any interface relays to permit non-moving contact system design.

The programmable controller shall have sufficient memory and processing capacity to perform all functions required by this specification. All memories shall be of semiconductor type. Core memory and wire memory will not be acceptable.

The random access memory for data management shall be provided with battery backup exclusively to maintain the contents of all random access memories for eight hour period during power failure.

Each software module shall be secure against faults in other software modules, untypical input data combinations and errors in data. All software associated with safety shall be clearly labelled and located in read only memory (ROM) wherever possible.

In the event of a fault, the programmable controller shall behave so as to ensure no damage to plant. System start-up and re-start facilities shall be automatic. On line self-checking facilities shall be provided to assist with fault diagnosis.

In the event of loss of power supplies, the programmable controller shall shut down in a controlled manner, ensuring that the plant is left in a safe condition. When power is restored, the system shall resume operation in a controlled manner with manual intervention.

The programmable controllers shall be provided with a portable programming unit comprising a visual display unit, a keyboard, a floppy disc unit, printer, controller, interface unit and facilities for connection to a programmable controller. A duplicate set of all software required for each programmable controller shall be provided on floppy discs. All software shall be clearly documented with regard to flow diagrams, program listings and instruction manuals. The language shall comprise a number of different function modules, each with an identifiable graphical symbol, which are programmed by linking the graphical symbols on a display. It shall be possible to ensure protection against changes by unauthorised personnel .

4.5 SUPERVISORY COMPUTER SYSTEM

4.5.1 General

The supervisory computer system shall perform the management of process data for overall control and supervision of the power station in communication with the programmable

controllers.

The computer system shall employ 16 or 32 bits microprocessors and shall be arranged in dual (hot standby) redundant configuration.

All the computer system equipment shall be delivered in the metal-enclosed panels and the man-machine interface equipment shall be arranged to provide the best convenience for easy monitoring and operation management of the power station.

4.5.2 System Function

(1) General

The supervisory computer system shall include the following functions:

(a) Data acquisition

(b) Data exchange

(c) Data processing

(d) Alarm processing

(e) Supervisory control

(f) Data trending

(g) Electrical energy (Wh and varh) accounting

(h) Sequence monitoring

In addition to the above, the following functions shall be provided in the system.

(2) Auxiliary equipment monitor function

The operating counts and the running hour of the auxiliary equipment such as governor pressure oil pumps, air compressors, main water supply pumps and drainage pumps shall be monitored on the visual display unit for the maintenance purpose.

When the operating counts and the integrated running hour exceed the preset value, alarm shall be initiated, and their data shall automatically be displayed on the visual display unit.

(3) Compiling of daily and monthly reports

The supervisory computer system shall be provided with a function to compile the daily and monthly reports for operation management of the power station.

The daily and monthly reports shall include the followings:

(a) Daily report for generator outputs and generated energy

(b) Daily report for 230 kV bus voltage and frequency

(c) Daily report for transmission line sending power and energy, and receiving power and energy

(e) Daily report for consumed power and energy in the house-service supply system

(f) Daily report for 31.5 kV and 6.6 kV feeder sending power and energy

(g) Daily report for operating count and running time for auxiliary equipment

(h) Daily report for temperatures

(i) Monthly report for generator running hours, generator outputs, and generated energy

(j) Monthly report for operating count and running time for auxiliary equipment

(k) Monthly report for temperatures

(l) Monthly report for faults and troubles on power system

(m) Endless record for operating count and running time for auxiliary equipment

The report formats shall be submitted to the Engineer for approval.

The daily and monthly reports shall be saved on the floppy disks by an operator's request. The daily and monthly reports shall be stored in the computer system for at least five days and one month, respectively.

(4) Display on visual display unit

The following items shall be displayed on the visual display unit by the most pertinent manner, such as diagram, barchart, historical trending, curve and table to monitoring and supervision.

(a) Mimic diagrams with measurement display for;

i) Main circuit

ii) Station-service supply circuit

(b) Sequence monitor for;

i) Starting operation

ii) Stopping operation

The sequence monitor shall be displayed automatically on the visual display unit during a period of starting and stopping operation.

(c) Alarm message

In the event of faults and abnormal conditions, the alarm message shall be displayed automatically.

(d) Operating counts of equipment

When the operating counts exceed the preset value, the picture shall be displayed automatically.

(e) Running time of equipment

When the running time exceeds the preset value, the picture shall be displayed automatically.

(f) Daily and monthly reports listed in the above paragraph (3).

The automatic display of the items (b) to (e) shall be available by a selector switch mounted on the keyboard. All above items shall be displayed by an operator's request.

Any display image on the visual display unit shall be possible to be printed on the hard copy unit by an operator's request.

The display formats shall be submitted to the Engineer for approval.

(5) Data and event logging

The supervisory computer system shall perform the data and event logging as follows:

(a) Automatic printing of data log

Voltages, frequency, active powers, reactive powers, electric energies (Wh and varh), temperatures, water levels, water flows, etc. shall be printed out periodically on the logging printer for data logs, in the form of the daily and monthly reports specified in the above paragraph (3).

All daily and monthly reports shall be printed out on the logging printer for data logs.

The data logging function shall be designed to permit manual printing of the data on the logging printer for data logs upon an operator's request.

The printing color shall be black.

(b) Automatic printing of operation record

Whenever the generating units, auxiliary equipment and switchgear are operated, and the operation modes are exchanged, the time (date, hour, minute and second), name of the operated equipment, and operated status shall be printed out automatically on a logging printer for event logs. The listing of operation record shall be made in sequence of operations. The printing color shall be black.

(c) Automatic printing of fault record

Whenever faults or abnormal conditions takes place, the time (date, hour, minute and second), name of the related equipment, and actuated relay or device number shall be printed out automatically on the logging printer for event logs.

The listing of fault records shall be made in sequence of fault occurrence.

The fault record shall be printed out in red color.

The logging formats shall be submitted to the Engineer for approval.

(6) Provision for communication with SCADA system

The supervisory computer system shall be arranged for necessary provision to communicate with the SCADA system to be established in the future. The terminal unit for this purpose will be provided by the Employer. All the necessary informations including communication protocol and data transfer rate for connecting this terminal unit to the supervisory computer system shall be documented with instructions.

4.5.3 System Equipment

(1) System component

The supervisory computer system shall be composed of the following devices:

(a) Two (2) minicomputers in dual (hot standby) redundant configuration

i) CPU processors

ii) Memories, such as

- Random access memory
- Random access memory with battery backup
- Read only memory

iii) File servers

iv) Visual display unit controllers

v) Logging printer controllers

vi) Communication interface units for interfacing with the programmable controllers

vii) Interfaces for peripheral equipment

viii) Process input output interfaces

ix) Automatic switching device between the minicomputers

The file servers shall preferably be the hard discs.

(b) Peripheral equipment

i) Two (2) color visual display units with cursor controllers

ii) Two (2) alphanumeric keyboards

iii) Two (2) dedicated function keyboards

iv) One (1) hard copy unit

v) Three (3) logging printers

vi) One (1) system console

(c) Power distribution panel

All electrical cables for internal connection between the minicom-putters and the peripheral equipment shall be supplied and installed under this Clause.

(2) System configuration

The supervisory computer system shall operate in the hot standby redundant system. One is the designated prime, the other is backup. In the event of failures in the prime system, the system function shall be carried out by the backup system or devices. The system shall continuously monitor its own operation, and shall automatically transfer to the backup system upon a detection of a malfunction by suitable watchdog techniques. Transfer to the backup system shall be accomplished without any shock and interruption to the control duties of the system.

The allocation of peripheral equipment to the minicomputers shall be both automatic and hardware selectable.

It shall be possible to select one minicomputer to be used independently for software development, together with the required peripheral equipment, under normal control execution.

Each minicomputer shall individually and autonomously be capable of carrying out all system functions while still maintaining the specified system response times.

The supervisory computer system shall be connected with each programmable controller by coaxial cable or other suitable means for data transmission between them. The data transmission circuit shall be arranged in dual redundant (hot standby) design for fault-tolerant communication. Protocol for the communication shall conform to the high-level data link control procedures (HDLC) stipulated by the International Organization for Standardization (ISO). The data transmission rate shall be not less than 9,600 bits per second. All the necessary informations for the connection shall be documented with instructions.

(3) Equipment construction

The system equipment shall be housed in the metal-enclosed panels whose construction shall generally conform to the requirements specified in Clause 1.6.4 of the General Specifications as applicable.

The system equipment shall be modular design and each function shall be arranged in one or more printed circuit boards.

The printed circuit boards shall be of plug-in type and rack mounted. Each printed circuit board shall be clearly marked with its identity, serial number and function. The rack position for each printed circuit board shall be clearly indicated.

Light emitting diodes (LED) shall be provided on all printed circuit boards for indicating the status of power supplies and fault conditions, and shall also be provided for indicating the status of all contact inputs.

All parts liable to failure, including connectors and power supplies, shall be readily accessible for the purposes of inspection and removal.

4.5.4 System Requirements

The system equipment shall withstand the dielectric test voltage of 1,500 V for one minute without any damage.

The minicomputer shall have sufficient memory and processing capacity to perform all functions required by this specification. All memories shall be of semiconductor type. Core memory and wire memory will not be acceptable.

The random access memory for data management shall be provided with battery backup exclusively to maintain the contents of all random access memories for eight hour period during failure.

Each software module shall be secure against faults in other software modules, untypical input data combinations and errors in data. All software associated with safety shall be clearly labelled and located in read only memory (ROM) wherever possible.

In the event of a fault, the system shall behave so as to ensure no damage to plant. System start-up and re-start facilities shall be automatic. On-line self-checking facilities shall be provided to assist with fault diagnosis.

In event of loss of power supplies, the system shall shut down in a controlled manner, ensuring that the plant is left in a safe condition. When power is restored, the system shall resume operation in a controller manner with manual intervention.

The computer system shall be provided with a suitable system console comprising a keyboard, a printer and/or a visual display unit, for communication between the maintenance engineer and the computer.

4.5.5 Power Distribution Panel

One (1) set of the power distribution panels shall be provided in the computer room to distribute the electric power to the respective components of the supervisory computer system.

The power distribution system, which may consist of transformers, molded case circuit breakers, electromagnetic contractors and voltage relays, shall be designed that start-up of the system components are made one by one in sequential order so as to prevent overload of the DC-AC inverter due to inrush current.

4.6 DATA LOGGING AND EVENT RECORDING SYSTEM

The data logging and event recording system shall be provided in the control room for the Saigon Substation with a function of data logging and event recording as well as a function of compiling of daily and monthly reports.

The data logging and event recording system shall be basically conform to the requirements for the supervisory computer system specified in Clause 4.5 as applicable.

4.7 MEASURING TRANSDUCERS

Transducers for making measurement of AC electrical quantities, temperatures, etc., shall be provided for indicating the measurements on the main control board and signalling them to the programmable controllers. The output of each transducer shall be 0-5 V DC, 4-20 mA DC or 0 ± 1 mA DC and shall be selected so as to meet the requirements of the programmable controller.

Each transducer shall preferably be of static type. Each transducer shall be enclosed in a metal case of rack mounted type and shall be provided with terminals for its inputs and outputs.

The auxiliary electrical supplies required for the transducers operation shall preferably be derived by internal connections from the voltage input. Should the separate electrical supplies be required for the transducers, suitable power supply unit shall be provided. Its power source shall be 220 V single-phase AC to be taken from the DC-AC inverter or 220 V DC to be taken from the DC distribution panel.

The watt and var transducers shall be suitable for measurement of bi-directional power flow as required.

The temperature transducers shall be suitable for input characteristics from resistance type

temperature detectors of Pt 100 ohm at 0°C.

4.8 AUTOMATIC SYNCHRONIZING DEVICE

One (1) set of automatic synchronizing device shall be provided for automatic synchronizing a generator to the 230 kV power system. The automatic synchronizing device shall consist of an automatic synchronizer, a voltage balance relay and a frequency matching device. Interlocks shall be provided to ensure that only one generator is available for automatic synchronizing operation at a time.

The automatic synchronizing control shall include automatic control of turbine speed, generator voltage and breaker closing for synchronizing operation with a minimum disturbance to the generator and the power system.

The voltage supply to the device shall be fed from the voltage transformers connected to the generator voltage bus and the 230 kV bus as shown on the main single line diagram.

4.9 MANUAL SYNCHRONIZING PANEL

The manual synchronizing panel shall be the metal-enclosed, swing type with hinge and shall be mounted on either one side of the control boards at an appropriate location.

The manual synchronizing panel shall contain one (1) synchronoscope, two (2) voltmeters and two (2) frequency meters complete with necessary wirings.

The voltmeters and frequency meters shall conform to the requirements specified in Clause 1.6.5 of the General Specifications.

The synchronoscope shall be furnished complete with accessories and shall be designed so that the indication pointer shall rotate by the relative phase difference between the generator voltage or 230 kV transmission line voltage and the 230 kV bus voltage for manual synchronizing of each generator an each 230 kV transmission line circuit. The synchronoscope shall operate satisfactorily over a range of 90 to 130 volts, and the pointer shall not rotate if the voltage from either circuit is lost. The synchronoscope shall have full 360 degree scale and shall be marked to show the synchronized point. The synchronoscope shall be provided with suitable measure to protect the driving mechanism against over-rating due to unexpectedly long synchronizing operation.

4.10 FAULT LOCATORS

The fault locators, two (2) sets in total, shall be provided at the Da Nhim Power Station and

the Long Binh Substation for calculation of the distance to the fault point on the 230 kV transmission line. The fault locator shall be of the impedance measuring type using local data from the current transformers and the voltage transformers to be used for the transmission line protective relays. The fault locator shall be modular design, microprocessor-based system to calculate the fault location with high-speed and high degree of precision.

The fault locator shall be suitable for the solidly grounded power system and shall have a measurement accuracy of 1 % or less. Each fault locator shall be designed for application to two or more transmission lines of different direction.

Each fault locator shall be complete with transduce units, setting unit, power supply unit and printer unit.

The fault locator shall preferably be incorporated in the transmission line protective relays specified in Clause 4.3.2 as an optional function of the relays.

4.11 AC AND DC DISTRIBUTION PANELS

A number of AC and DC distribution panels shall be provided in the control room for AC and DC control power supply to the equipment and instruments. The panels shall be of floor-standing, metal-enclosed type of robust construction. The construction for the panel shall generally conform to the requirements specified in Clause 1.6.4 of the General Specifications.

(1) AC circuit

The AC circuit for the inverter loads shall be provided in the AC panel(s) separately from the circuits directly connected with the low voltage bus.

Each AC panel shall consist of the following equipment:

(a) One (1) set of three-phase four-wire bus

(b) Two (2) single transformers having suitable rating for AC control source

(c) One (1) voltage transformer with suitable output for measuring

(d) One (1) AC voltmeter

(e) Molded case circuit breakers

(2) DC circuits

The DC circuits with load voltage compensating device shall be provided in the DC

distribution panel(s) separately from the circuits having no voltage compensating device.

Each DC panel shall consist of the following equipment:

(a) One (1) set of 220 V DC buses

(b) One (1) DC voltmeter

(c) Molded case circuit breakers in total

4.12 STATION BATTERY

4.12.1 Type and Rating

One (1) set of station battery consisting of 190 cells each in sealed plastic transparent container shall be provided for the Da Nhim Power Station and the Saigon Substation to supply 220 V DC power, coordinating with battery chargers specified in Clause 4.13 below. The battery shall be of nickel cadmium alkaline, enclosed type, 220 V and 500 ampere-hour at 5-hours discharge rate.

4.12.2 Construction

The battery shall be of heavy-duty, long life construction shall be provided with the following:

(a) Positive and negative centered plates consisting of highly porous nickel plaques.

(b) Alkaline resistant synthetic separators.

(c) Cells of enclosed alkali-resistant type, consisting of chemical-resistant material, with provisions for measuring the specific gravity of electrolyte from outside.

(d) Cell terminal posts.

(e) Steel battery racks.

Each station battery shall be installed in the battery room and connected to the battery charger as specified in Clause 4.13.

4.13 BATTERY CHARGER

One (1) set of battery charger shall be provided for the Da Nhim Power Station and the Saigon Substation.

(1) Type and requirement

The battery charger shall be of static construction, thyristor type designed for continuous use and shall be suitable for three-phase 380 V AC for the Da Nhim Power Station and 400 V AC for the Saigon Substation. Each battery charger unit shall be housed in a floor-standing, metal-enclosed cubicle having front door to facilitate inspection.

Each battery charger shall be capable of initial charging, floating operation and boost charging for 500 AH station battery supplied under Clause 4.12.

The battery charger shall be provided with a load voltage compensating device (silion dropper) to limit the maximum DC output voltage for DC power supply to the programmable controllers, control source, etc. as required.

The battery charger shall be provided with suitable protection system. All fault items shall be indicated on a group fault indicator to be mounted on the front panel and shall be brought out to the terminal block for remote annunciation.

(2) Characteristics

The battery charger shall be designed to meet the following requirements:

(a)	AC input voltage	
	- Da Nhim Power Station	Three-phase, 380 V
	- Saigon Substation	Three-phase, 400 V
(b)	Rated DC output voltage	Equal to equalizing charge voltage for the station battery.
(c)	Rated DC output current	300 A
(d)	DC output voltage regulation	
	- floating charge voltage	Within ±2%
	- boost charge voltage	Within ±2%
(e)	DC output voltage adjustable range	
	- for floating charge voltage	±3% or more
	- for equalizing charge voltage	±3% or more

(3) Equipment and instruments

The panel-mounted equipment and instruments shall include but not be limited to the

following:

(a) Pilot lamp with auxiliary voltage transformer on AC input voltage side

(b) AC undervoltage relay

(c) DC undervoltage relay

(d) DC ground detecting relay

(e) DC ammeter for rectifier circuit

(f) DC ammeter for battery circuit

(g) DC ammeter for DC-AC inverter

(h) DC voltmeter

(i) Selector switch for DC voltmeter with two positions of "Battery Charger" and "Battery"

(j) DC output voltage adjusters

(k) Molded case circuit breakers

(l) Group fault indicator

(m) Test blocks

(n) Load voltage compensating devices with controls

(o) Other necessary accessories

4.14 DC-AC INVERTER

One (1) set of DC-AC inverter equipment shall be provided for the Da Nhim Power Station and the Saigon Substation.

(1) Type and requirements

The DC-AC inverter shall be of static construction, thyristor type designed for continuous operation. Each DC-AC inverter unit shall be housed in a floor-standing, metal-enclosed cubicle having front door to facilitate inspection.

The inverter unit shall be arranged for automatic transfer to the AC backup source to be

supplied from the AC distribution panel. Automatic transfer shall be done by electric transfer switches (thyristor switches) with a transfer time of not more than 5 milli-seconds, upon a detection of failure in the both inverter units.

Each inverter unit shall be provided with suitable protection system. All fault items shall be indicated on a group fault indicator to be mounted on the front panel and shall be brought out to the terminal block for remote annunciation.

The DC-AC inverter shall be designed for the following requirements:

(a)	DC input voltage	Conform to DC out voltage of the battery charger specified in Clause 4.13
(b)	Rated output	Sufficient for the loads required
(c)	Rated output voltage	AC 230 V of single-phase two-wire system
(d)	AC output voltage regulating	Within ±2%
(e)	AC output voltage adjustable range	±5% of rated voltage
(f)	Rated frequency	50 Hz
(g)	Frequency regulation	Within ±5%
(h)	Transient voltage fluctuation	Within ±10%
(i)	Transient response time	Less than 100 ms
(j)	Wave distortion factor	Less than 5%
(k)	Overload capacity	120% for 10 seconds

The rated output of the DC-AC inverter shall be determined by the Contractor to suit the actual loads requiring AC uninterruptible power. The detailed calculation sheets for the rated output shall be submitted for approval.

(2) Equipment and instruments

The panel-mounted equipment and instruments shall include but not be limited to the followings:

(a) AC ammeter

(b) AC voltmeter

(c) Frequency meter

(d) Group fault indicator

(e) AC output voltage adjuster

(f) Test blocks

(g) Molded case circuit breakers

(h) Electric transfer switches with controls

(i) Other necessary accessories

4.15 ACCESSORIES

The following accessories shall be provided for the control system.

(1) General accessories

(a) Nameplate of each panel

(b) Channel bases

(c) Side (or end) panels

(d) Foundation bolts and nuts

(e) Grounding pads

(f) Nameplates and escutcheon plates for control units, devices, and equipment

(g) Lamp puller

(h) Test plugs for test blocks of each type

(i) Relay testing plugs

(j) Relay tool kit

(k) Maintenance tools

(2) Accessories for programmable controllers

(a) Maintenance tools for the portable type programming unit

(b) Connection cables for the portable type programming unit

(c) Printed circuit board (extension card) for testing and maintenance

(d) Special tools

(e) Other accessories recommended by the manufacturer

(3) Accessories for supervisory computer system and data logging and event recording system

(a) Tools software including:

i) Hardware testing program

ii) Creation and maintenance of database

iii) Creation of mimic diagrams

(b) Programmable-ROM writer

(c) Programmable-ROM eraser

(d) Special tools

(e) Other accessories recommended by the manufacturer

(4) Accessories for station battery

(a) Requisite quantity of potassium hydroxide with 10% extra.

(b) Sufficient quantity of distilled water for first filling up.

(c) One (1) set of mixing tank of adequate capacity, syringe and other special tools.

(d) Two (2) sets of voltmeter, vent mounted hydrometers and vent mounted thermometer.

(e) Intercell connectors having sufficient space between cells and terminal lugs.

(f) Nameplate.

(g) Other necessary accessories.

4.16 SPARE PARTS

The following items shall be supplied for the Da Nhim Power Station and the Saigon Substation as spare parts and quoted separately:

(a) 100% of actual use of LED lamps of each type.

(b) 100% of actual use of lenses of indicating lamps

(c) 100% of actual use of resistors or transformers for indicating lamps

(d) 200% of actual use of fuses of each type and rating

(e) One (1) molded case circuit breaker of each rating

(f) Five (5) status and fault indicator units of each type with LEDs

(g) Two (2) illuminated mimic symbol units of each type with LEDs

(h) Two (2) auxiliary relays of each type

(i) Two (2) timing relays of each type

(j) Two (2) transducers of each type

(k) Two (2) control and selector switches of each type

(l) One (1) protective relay of each type

(m) One (1) printed circuit board of each type for supervisory computer system

(n) Two (2) printed circuit boards of each type for programmable controllers

(o) One (1) power supply unit of each type

(p) Two (2) years' supply backup batteries for RAM

(q) 50% of actual use of erasable and programmable-ROM

(r) Two (2) years' supply of recording chart papers, ink and pens for temperature recorders and voltage and frequency recorder

(s) Two (2) years' supply of printing chart papers, ink ribbons for printers

(t) Two (2) years' supply of hard copy papers

(u) Two (2) years' supply of floppy disc of each type

(v) 10% of installed quantity of marking strips and phase ferrules for wiring

(w) One (1) pair of plug-in type connection accessories of each type

(x) Two (2) years' supply of other expendables

(y) 30% of diluted potassium and two (2) cells in seal for the storage battery

(z) One (1) lot of spares recommended by the manufacturer

4.17 TESTS

(1) Test at works

The following tests shall be carried out at the manufacturer's works before shipment in the presence of the Engineer:

(a) Control and relay boards

i) Construction inspection

ii) Dielectric test, A.C. 2,000 V for one minute

iii) Sequential operation tests

iv) Meter and relay tests

v) Transducer characteristics test

(b) Programmable controller

i) Construction inspection

ii) Dielectric test, A.C. 2,000 V for one minute

iii) Sequential operation test

iv) Hardware check

v) Software check

vi) Tests for power supply unit

(c) Supervisory computer system and data logging and event recording system

i) Construction inspection

ii) Dielectric test, A.C. 1,500 V for one minute

iii) Operation test

iv) Hardware check

v) Software check

vi) Measurement of response time

(d) AC and DC distribution panels

i) Construction inspection

ii) Dielectric test, A.C. 2,500 V for one minute for A.C. circuit, and A.C. 2,000 V for one minute for D.C. circuit

(e) Station battery

i) Construction check

ii) Capacity test for 5 cells

iii) Electrolyte purity measurement

(f) Battery chargers

i) Construction inspection

ii) Dielectric test, A.C. 2,500 V for one minute for A.C. circuit, and A.C. 2,000 V for one minute for D.C. circuit

iii) Characteristics test

(g) DC - AC inverters

i) Construction inspection

ii) Dielectric test

iii) Characteristics test

(2) Tests at Site

The tests as specified in Clause 1.19.2 of the General Specifications shall be carried out by the Contractor at the Site.

SECTION 5

TECHNICAL SPECIFICATIONS FOR POWER LINE CARRIER TELEPHONE SYSTEM EQUIPMENT

5.1 SCOPE

This Section covers the designing, manufacturing, supplying, testing before shipment, finishing, painting, packing for export, insuring, shipping, delivering to the port of Saigon, landing, customs clearance and transport from the port of Saigon to the Site and supervising for the installation work, site testing and commissioning of the following power line carrier telephone system equipment to be installed in the Da Nhim Power Station and the Saigon and Long Binh Substations.

(1) One (1) set of four (4)-channel PLC telephone and protective relaying terminal equipment for the Da Nhim Power Station

(2) Two (2) sets of four (4)-channel PLC telephone and protective relaying terminal equipment for the Long Binh Substation

(3) One (1) set of four (4)-channel PLC telephone and protective relaying terminal equipment for the Saigon Substation

5.2 GENERAL

Two 4-channel PLC terminal equipment will be installed in the section between the Da Nhim Power Station and the Long Binh Substation to replace the existing 1-channel PLC terminal equipment which is made in USSR. Two remaining equipment will be installed newly in the section between the Long Binh Substation and the Saigon substation. In both sections, all high frequency coupling equipment such as coupling capacitors, filters, line traps and power supply equipment will be provided by the Employer.

5.3 POWER LINE CARRIER TELEPHONE AND PROTECTIVE RELAYING TERMINAL EQUIPMENT

5.3.1 Technical Requirement

(1) Transmission system : single side band amplitude modulated type with reducted carrier.

(2) Communication system : Full duplex

(3) Nominal carrier frequency band : 4 kHz

(4) Voice frequency band

(a)	Speech :	300 - 2,300 Hz
(b)	Telephone signalling :	2,550 - 2,650 Hz
(c)	Teleprotection signalling :	Speech band

(5) Carrier - frequency output : 20 W (PEP) or 40 W (PEP
(PEP : Peak envelope power)

(6) Power allocation

(a)	Speech	:	To be recommended by the manufacturer
(b)	Data transmission	:	- ditto -
(c)	Reduced carrier	:	- ditto -
(d)	Telephone signaling	:	- ditto -

(7) Teleprotection signal output : To be recommended by the manufacturer

(8) Speech and signals (data) input/output levels : To be recommended by the manufacturer

(9) Maximum line loss : Within 3 dB with respect to the reference value 800 Hz (without compandor) under adverse weather condition (Tenderer shall submit the detail calculation sheets t show that the proposed equipment will meet this requirement.)

(10) Automatic gain control

(a)	Receiver input gain range	:	50 dB
(b)	Effectiveness	:	10 dB to -30 dB down to ± 0.2 dB typical at audio frequency (AF) output

(11) Transmit/receive frequency difference : Zero difference

(12) Synchronizing system : Pilot-controlled of subcarrier

(13) Commander : Syllabic type with compression radio of 1/2 and expansion ratio of 2.

(14) Nominal impedance:

(a)	Carrier-frequency output circuit	:	75 ohms (unbalanced)
(b)	Speed and signal input and output circuits	:	600 ohms (balanced)

(15)	Noise generated within the PLC equipment	:	Not exceed - 60 dBm Op when measured by a psophometer (Without compandor)
(16)	Audio Distortion factor	:	Less than 30 dB at 800 Hz
(17)	Signing margin	:	More than 12 dB when the 2-wire ends are terminated in 400 ohms not inductive resistance
(18)	Power source	:	D.C. 48 V positive grounded. Allowable voltage variation : 42 to 58 volts. The PLC telephone equipment shall be operated suitable on a floating charging condition of a battery with battery charger.

5.3.2 Alarming Feature

The PLC equipment shall be designed to provide visual alarm on the front panel of the equipment in the event of the following conditions:

(a) Transmitter output level, decreased
(b) Pilot current receive level, decreased
(c) Fuse in power unit, blown

The above abnormal conditions shall be brought out to the terminals for the connection to the fault annunciation system provided on the control board.

5.3.3 Measuring and Testing Facilities

The PLC equipment shall incorporate the following measuring and testing facilities for operational and preventive maintenance purposes:

(a) Measuring circuit for D.C. power source voltage, with voltmeter
(b) Monitoring circuit with a speaker
(c) Service telephone test circuit with telephone set

(d) Light indication for busy condition of each channel

(f) Test oscillator

- Oscillating frequency	:	300 Hz to 3.85 kHz
- Output Level	:	-25 dBm to + 10 dBm

(g) Level meter

- Level range	:	-60 dBm to + 30 dBm
- Frequency range	:	0.3 to 30 kHz (600 ohm)
		50 to 500 kHz (75 ohm)

(h) Others recommended by the manufacturer

Each measuring and testing circuit shall be composed of on one or more printed circuit boards of plug-in insert type and shall be possible to be mounted in the subrack on the equipment.

5.3.4 Equipment Construction

The equipment shall be fully transistorized and constructed on modular basis employing printed-circuit boards of a plug-in insert and rack mounted type and shall be suitable for operation under all weather conditions of the Site.

The equipment shall be housed in a floor-standing, metal-enclosed with a front door. the cubicle construction shall generally conform to the requirements specified in subsection 1.6.4 of the General Specifications and shall be designed suitable for side-by-side alignment.

5.3.5 Teleprotection Equipment

The teleprotection equipment shall be provided to perform the rapid, two-way transmission of a trip command tot he other end of 230 kV transmission line, for the transmission line carrier relaying system specified in subsection 4.3.2.

The teleprotection equipment shall be of static, modular construction with printed circuit boards of plug-in insert and rack mounted type and shall be mounted in the power line carrier panels.

The teleprotection equipment shall operate with D.C. 48 V positive grounded power supply equipment of existing stations.

The teleprotection equipment shall share the speech channel in the power line carrier system. The equipment shall perform the independent transmission of two separate trip signals and shall provide full duplex operation via the speech band of the single side band power line carrier equipment. The equipment shall include a send and receive channel and shall be provided with a line noise monitoring feature which shall function so as to block the trip signal in the event of excessive line noise.

The signalling speed of the channel shall be less than 30 milli-seconds from the receipt of a trip command to output of trip execution signal at the receiving end.

The teleprotection equipment shall be provided with alarming feature to provide visual alarm on the front panel or PLC panel in the event that the input signal level drops. Voltage-free contacts shall be provided for remote alarm purposes suitable for operation at 220-volt D.C.

The teleprotection equipment shall have the testing circuit to enable the maintenance personnel to check equipment under the operating conditions. A suitable test/normal switch shall be provided on the panel with a visual indication to show that the trip output circuitry is disconnected and functional test can be safety performed on the equipment.

Suitable interface between the teleprotection equipment and the transmission line protective relays shall be provided.

5.4 COAXIAL CABLE

5.4.1 General

The coaxial cable shall be supplied and installed for connection between the outdoor coupling equipment and the indoor PLC equipment at each station. Necessary joints and coupling shall also supplied. The coaxial cable shall be of the polyethylene insulated, PVC sheathed annealed copper wire braided.

5.4.2 Ratings

The coaxial cable shall be rated as follows:

(a)	Characteristics impedance at 300 kHz 75 ohms	
(b)	Attenuation loss at 300 kHz	less than 3.7.dB/km
(c)	Insulation strength	
	- Between conductors	AC 3,000 V for one (1) minute
	- Between outer conductor and sheath	AC 6,000 V for one (1) minute

5.5 ACCESSORIES

The following accessories shall be provided for the power line carrier telephone system:

(a) Nameplate of each panel
(b) Rating plates
(c) Nameplates and escutcheon plates for control units, devices and equipment

(d) channel bases
(e) Foundation bolts and nuts
(f) Grounding pads
(g) Lamp pullers, if required
(h) Distant cards for testing
(i) Test cords with connectors
(j) Test plugs
(k) Test telephone handset
(l) Maintenance tools
(m) Other accessories recommended by the manufacturer

5.6 SPARE PARTS

The following items shall be supplied as spare parts:

(a) 500% of actual use of lamps of each type
(b) 100% of actual use of lenses for indicating lamps
(c) 100% of actual use of resistor or transformer s for indicating lamps
(d) 500% of actual use of fuses of each type and rating
(e) 500% of actual use of arresters of each type and rating
(f) One (1) printed circuit board of each type, to be supplied for each station
(g) Two (2) fault indicator units of each type, to be supplied for each station
(h) One (1) joint terminal of coaxial cable to PLC equipment, to be supplied for each station
(i) One (1) joint terminal of coaxial cable to coupling equipment, to be supplied for each station
(j) One (1) telephone set
(k) One (1) lot of spares recommended by the manufacturer

5.7 TESTS

The following test shall be carried out at the Contractor's plant in the Presence of the Engineer:

(1) PLC equipment

(a) Inspection of construction.
(b) High voltage test.
(c) Measurement of insulation resistance.
(d) Carrier frequency characteristics test.

(e) Measurement of output level.
(f) Audio frequency characteristics test.
(g) Impedance characteristics test.
(h) A.G.C. characteristics test.
(i) Measurement of equipment noise.
(j) Measurement of distortion factor.
(k) Ringer characteristics test.
(l) Power consumption test.
(m) Temperature characteristics test.
(n) Combined operation test.

(2) Teleprotection equipment

(a) Construction check.

(b) Operation characteristics test.

The following test shall be carried out on the teleprotection system on the condition that the teleprotection equipment has been equipped on each set of one pair of PLC terminals which are connected with artificial network.

i) Level checking test.
ii) Frequency characteristics test*
iii) Build-up and build-down test.
iv) Switching over test of telephone channel and teleprotection channel*
v) Teleprotection signal check circuit test*

(c) Withstand voltage test*

(d) Interface circuit test*

(e) Power consumption measurement*

Note: For items marked with asterisk *, certificate of type test may be acceptable.

(3) Coaxial cable:

(a) Measurement of insulation resistance.
(b) High voltage test.
(c) Measurement of conductor resistance.
(d) Measurement of attenuation loss.
(e) Impedance characteristics test.

The tests as specified in Section 1.19 of the General Specifications shall be carried out by the Contractor as the Site.

SECTION 6

TECHNICAL SPECIFICATIONS FOR MISCELLANEOUS MATERIALS

6.1 SCOPE

This Section covers the designing, manufacturing, supplying, testing before shipment, finishing, painting, packing for export, insuring, shipping, delivering to the port of Saigon, landing, customs clearance and transport from the port of Saigon to the Site and supervising for the installation work, site testing and commissioning of the following miscellaneous materials to be installed in the Da Nhim Power Station and the Saigon Substation.

(1) Da Nhim Power Station

1) Electrical conductors and fittings
2) Other materials

(2) Saigon Substation

1) Electrical conductors and fittings
2) Other materials

6.2 TESTS

The tests to be carried out before shipment at the manufacturer's plant are as stated in Clause 6 below. The tests as specified in Section 1.19 of the General Specifications, as applicable shall be conducted at the Site.

6.3 ELECTRICAL CONDUCTORS AND FITTINGS

The following electrical conductors and fittings shall be supplied and installed for the respective electrical circuits according to the drawings and the requirements as hereafter specified.

(1) Power cables.
(2) Control cables
(3) Insulated wires.
(4) Bare soft annealed copper conductors.

6.3.1 Power Cables

All power cables shall be of single- or multi- core copper, crosslinked polyethylene (XLPE)

insulated PVC sheathed type with suitable cable ends.

All cable trays and supporting brackets complete with fixing material, required for installation of the power cables shall be supplied by the Contractor as specified in Clause 6.3.5.

The following power cables shall be supplied by the Contractor:

(1) 0.6/1.0 kV, 400 sq.mm, single-core, one cable per phase for line circuit of two (2) house-service transformers; connection between the low voltage switchgear and the 400 kVA house-service transformers in Saigon Substation.

(2) Other power cables required for the equipment to be covered under this Contract shall also be supplied and installed by the Contractor. The minimum size of the power cables shall be 6 sq.mm.

6.3.2 Control Cables

(1) Scope

The following control cables shall be supplied, by the Contractor:

(a) All control cables for renewal of the control system for the water turbines, generators transformers and switchgears in the Da Nhim Power Station.

(b) All control cables for renewal of the control system for the synchronous condensers, transformers and switchgears in the Saigon Substation.

All cable trays and supporting brackets complete with fixing materials required additionally for installation of the control cables shall be supplied by the Contractor.

(2) Type

The control cables shall be of jacket type and classified as follows:

(a) 600 V polyvinyl chloride (PVC) insulated, PVC sheathed cables of single-core or 2, 3, 4, 5, 6, 9 and 12-cores (CVV) for general use.

(b) 600 V polyvinyl chloride (PVC) insulated, PVC sheathed, electrostatic-induction shielded cables of 2, 3, 4, 5, 6, 9 and 12-cores (CVV-S).

(c) 600 V special thermo-resistant polyvinyl chloride (PVC) insulated, thermo-resistant PVC sheathed single-core or 2, 3, 4, 5 and 6-cores (Thermo-resistant VV).

(d) 600 V special thermo-resistant polyvinyl chloride (PVC) insulated, thermo-resistant PVC sheathed, electrostatic-induction shielded cable of 2, 3, 4, 5 and 6-cores (Thermo-resistant VV-S), if any.

Multi-core cables may be used by obtaining the Engineer's approval.

(3) Characteristics

(a) General characteristics;

The characteristics of control cables shall meet all the relevant requirements of Thermoplastic Control Cable.

(b) Electrostatic induction shield;

The electrostatic induction shielded cables shall be wrapped with a soft annealed copper tape with a thickness of 0.1 mm and overlapped for a fourth of the tape.

(c) Thermo-resistant characteristics;

Besides the general requirements specified the above, the thermo-resistant VV and thermo-resistant VV-S cables shall also be provided.

(4) Use

Control cables for search coils, telemetering circuits, speed signal generator circuits, current transformer and voltage transformer circuits, and other circuits liable to interference due to electrical noise shall be shielded against electrostatic and/or electromagnetic induction.

Control cables for fire alarm circuits of generator housing and for emergency stop control circuits shall be of thermo-resistant characteristics.

(5) Requirements

The sectional area of core shall be not less than 4.0 sq.mm and shall comply with the following requirements:

(a) Voltage transformer secondary circuits:

Allowable voltage drop in the cable under the total burden of connected instruments and relays shall be one (1) percent.

(b) Current transformer secondary circuits:

The total burden of instruments and relays plus that of cable shall be less than the rated burden of respective current transformer, and that to be consumed in cable be less than 15 VA.

(c) AC and DC circuits:

i) Allowable AC voltage drop in the cables shall be as follows.

- 10 volt for 400 V circuit
- 5 volt for 230 V circuit
- 2.5 volt for 110 V circuit

ii) Allowable DC voltage drop in the cables shall be 5 volts.

Temperature of cable under continuous current shall be less than 60°C.

(6) Colour

Colours of core insulation shall be as follows:

One-core ----------	Black.
Two-cores ----------	Black and white.
Three-cores ----------	Black, white and red.
Four-cores ----------	Black, white, red and green
Five-cores ----------	Black, white, red, green and yellow.
Six-cores ----------	Black, white, red, green, yellow and brown.

Colour of core insulation of more than six cores shall be in accordance with the Engineer's instruction.

6.3.3 Insulated Wires

600 V grade, PVC insulated wires (IV) may be used for power and space heater circuits for auxiliary equipment. The minimum size shall be 4.0 sq.mm.

6.3.4 Bare Annealed Copper Conductor

Bare annealed copper stranded wires of 95 and 35 sq.mm in size shall be supplied for connecting the equipment and enclosures to the grounding conductors.

6.3.5 Tests

The following test for conductors, as applicable, shall be carried out at the manufacturer's plant:

(1) Construction test
(2) Resistance tests
(3) Withstand voltage test
(4) Insulation resistance test
(5) High temperature insulation resistance test
(6) Tensile strength test
(7) Coiling test
(8) Thermal deformation test
(9) Oil proof test
(10) Non-inflammability test
(11) Shield conductivity test
(12) Thermal shrinkage test
(13) A.C. breakdown voltage test
(14) Impulse breakdown voltage test
(15) Tin plating test
(16) Acid and alkaline proof test
(17) Oxygen index measurement
(18) Chlorine gas measurement
(19) Burning test on vertical tray installation

The appearance and construction check and other check as required shall be carried by the Contractor at the Site under the Engineer's witness.

6.4 OTHER MATERIALS

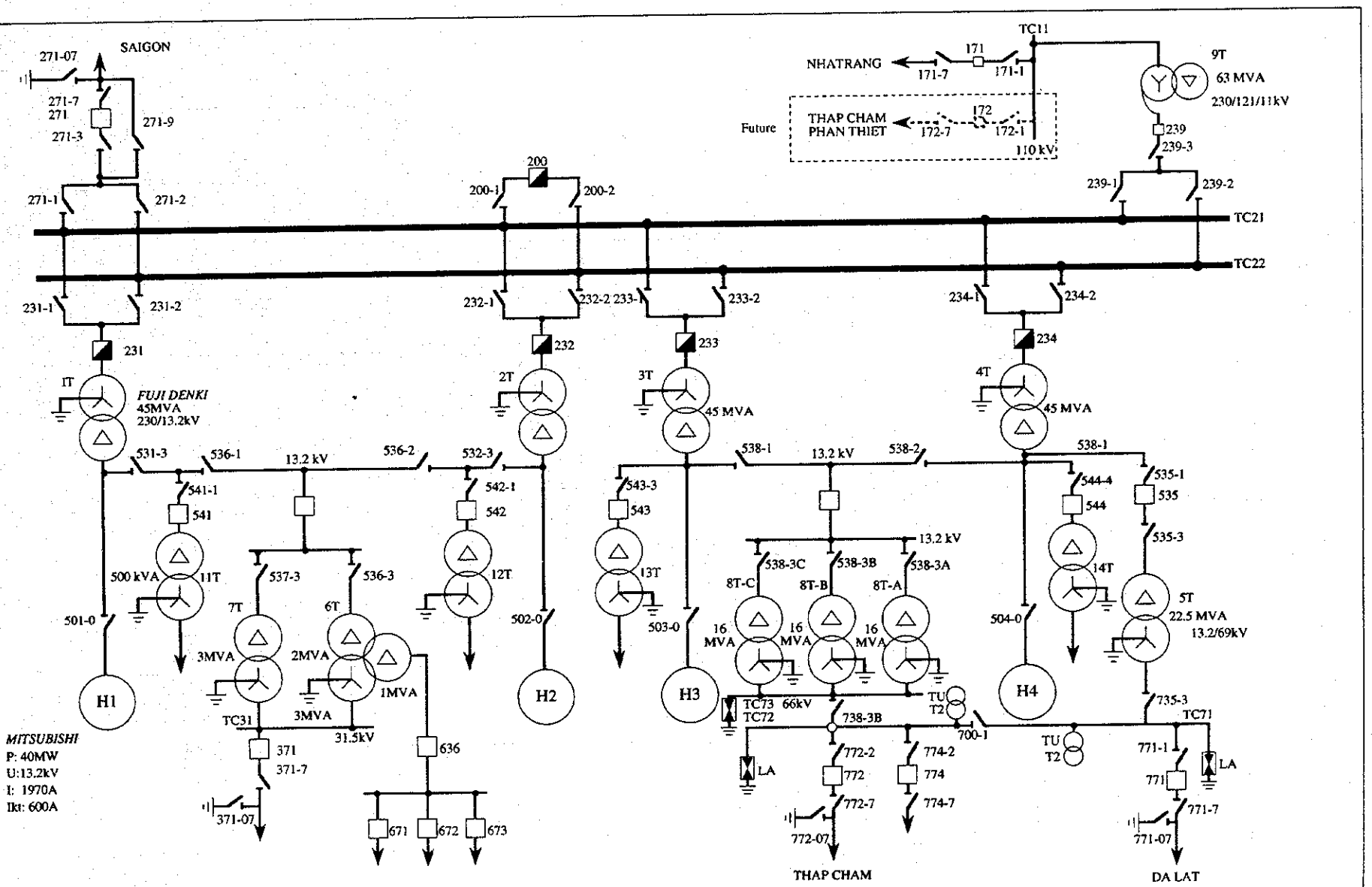
All cable trays and supporting brackets required in addition to the existing ones for the installation of the power cables and control cables to be provided under this Contractor in the powerhouse, the cable culvert and the cable trench in the outdoor switchyard of the Da Nhim Power Station and in the substation control building, the cable culvert and the cable trench in the outdoor switchyard of the Saigon Substation shall be supplied by the Contractor.

All other miscellaneous materials required for this Contract; such as conduit pipes, cable cleats, angle steel, channel steel, steel plate, bolts, nuts and other items required for putting into service the switchgear and control equipment shall be supplied as required according to

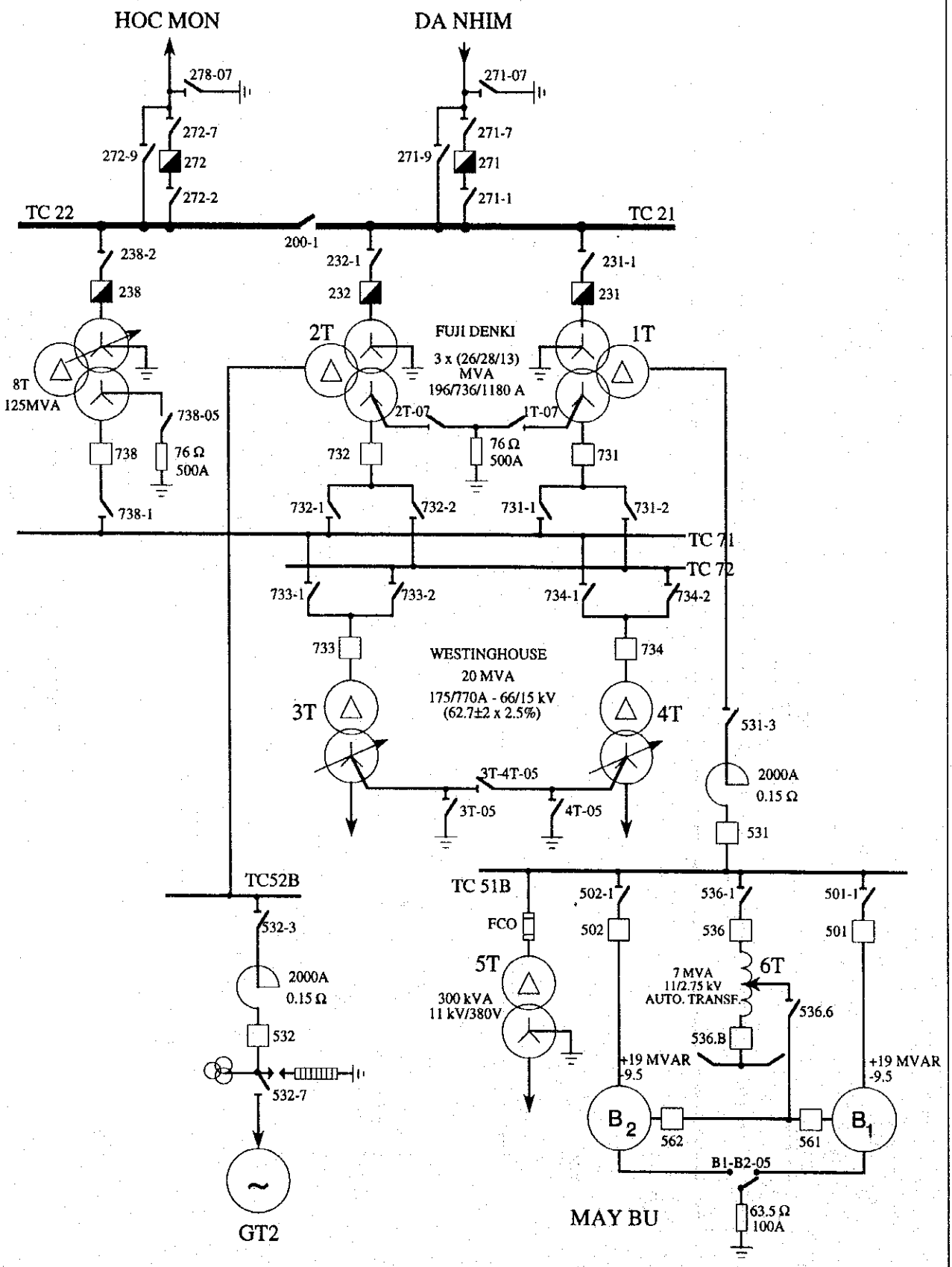
the Engineer's instruction. These materials shall comply with the highest grade specified in the relevant standards.

DRAWINGS FOR CHAPTER 4

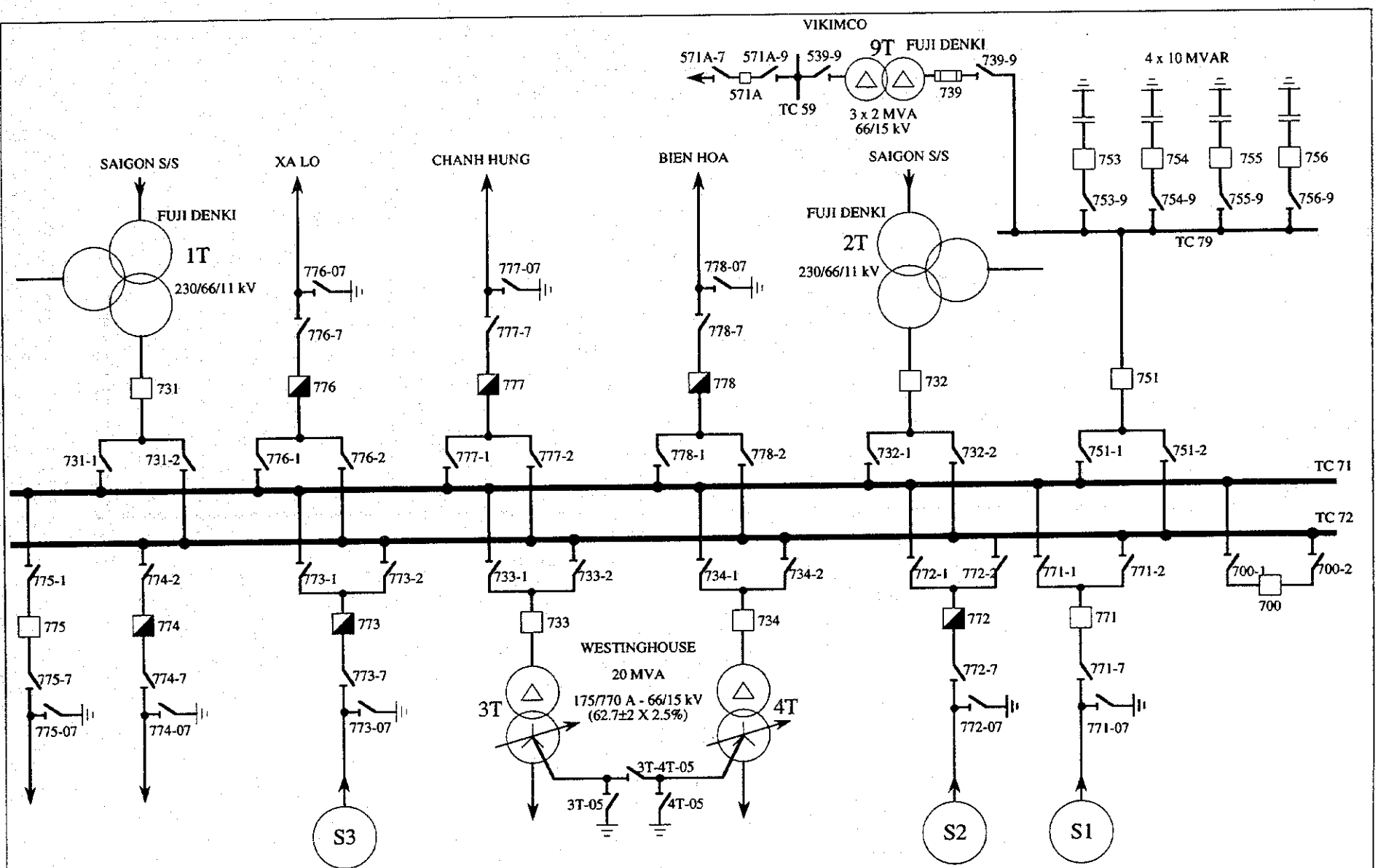
SUBSTATION FACILITIES



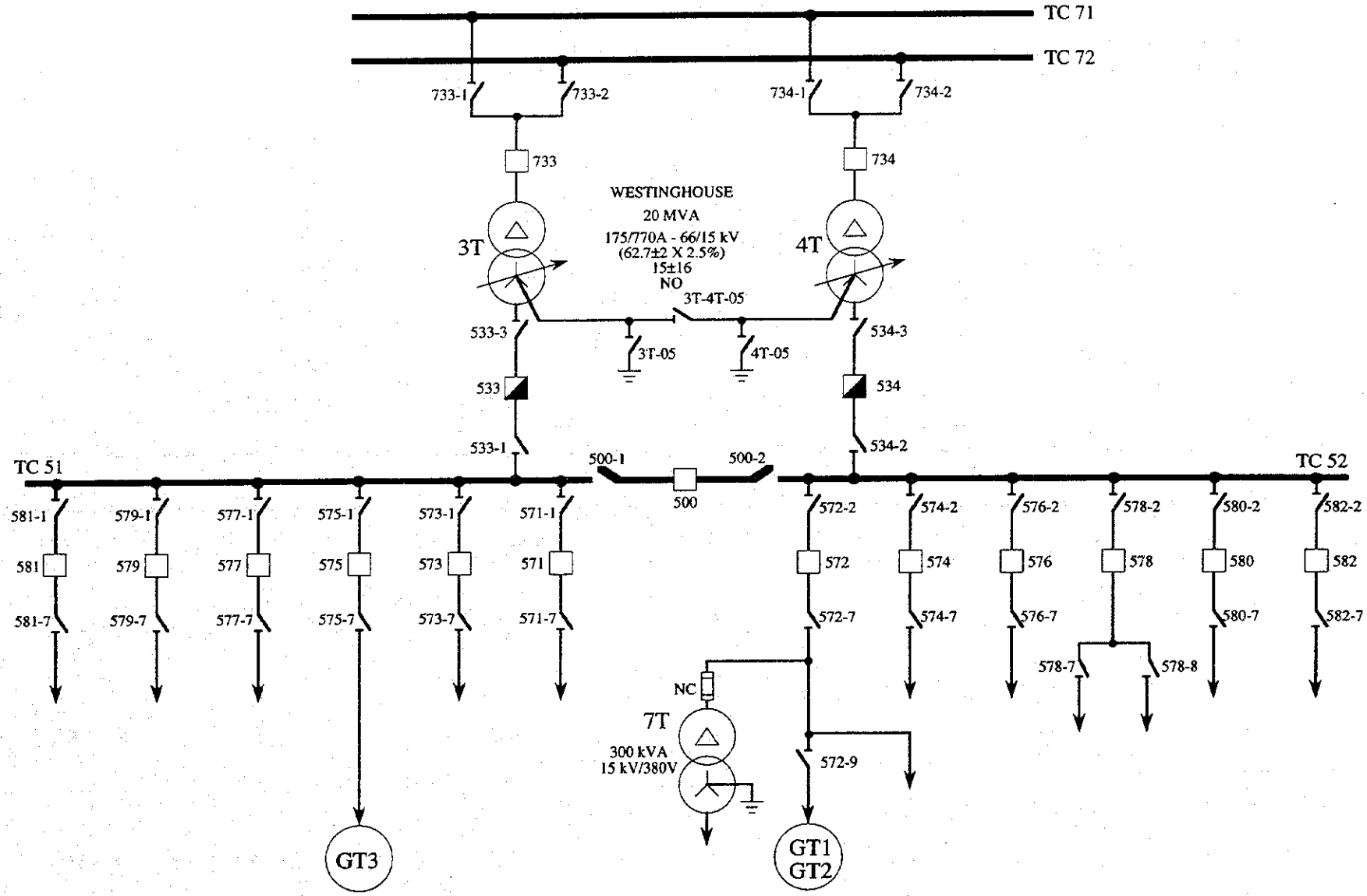
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 4.1 Existing Main Circuit for Da Nhim Power Station



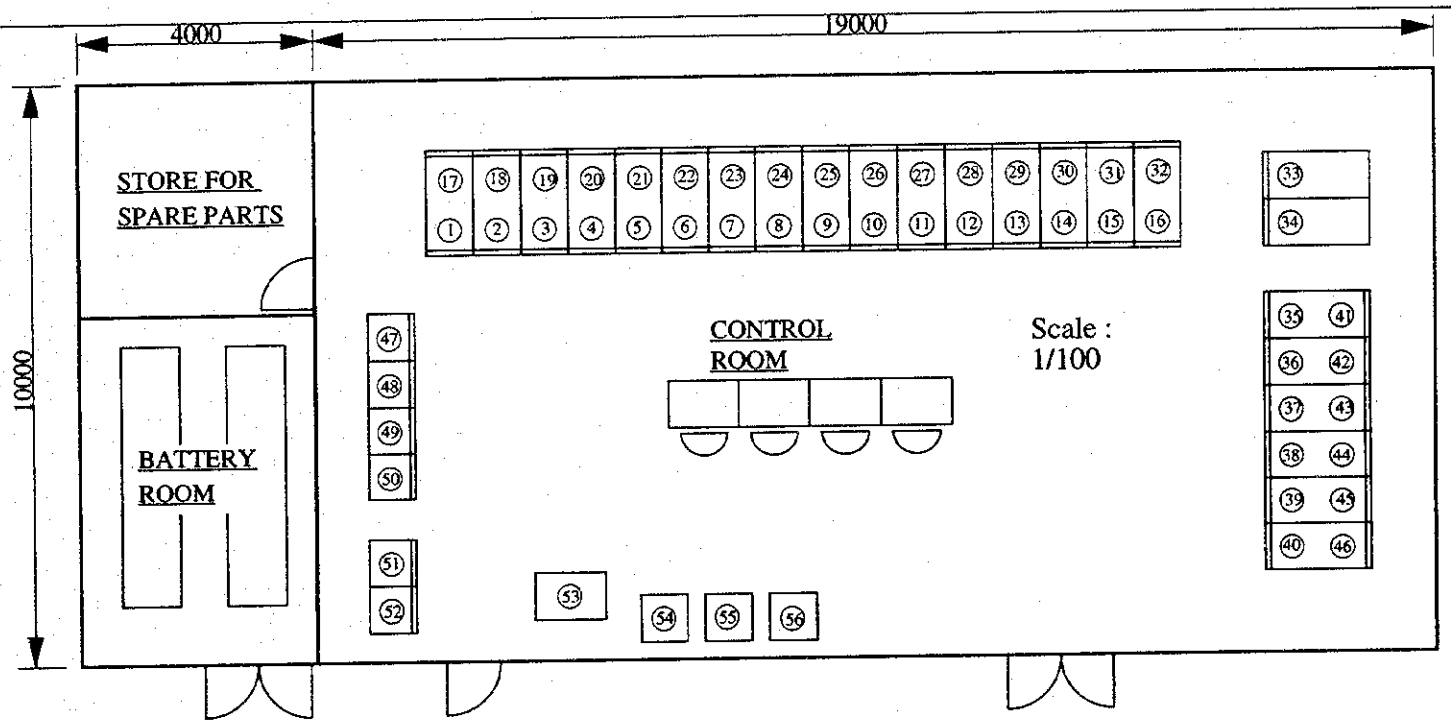
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 4.2 (1) Existing Main Circuit for Saigon Substation



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 4.2 (2) Existing Main Circuit for Saigon Substation



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 4.2 (3) Existing Main Circuit for Saigon Substation



Board Description

①	Control Board for Synchronous Condenser No. 1	⑱	Relay Board for Synchronous Condenser No. 2	㉟ - ㊵	Control Board for 15kV Lines
②	Control Board for Synchronous Condenser No. 2	⑲	Relay Board for Main Transformer "1T"	㊶ - ㊻	Relay Board for 15kV Lines
③	Control Board for Main Transformer "1T"	⑳	Relay Board for Main Transformer "2T"	㊼ - ㊽	AC Distribution Board
④	Control Board for Main Transformer "2T"	㉑	Relay Board for Main Transformer "8T"	㊾ - ㊿	DC Distribution Board
⑤	Control Board for Main Transformer "8T"	㉒	Relay Board for 230kV Transmission Line for Long Binh	51	Battery Charger
⑥	Control Board for 230kV Transmission Line for Long Binh	㉓	Existing Relay Board for 230kV Transmission Line for Hoc Mon	52	DC-AC Inverter
⑦	Control Board for 230kV Transmission Line for Hoc Mon	㉔ - ㉗	Relay Board for 66kV transmission Lines	53	Computer Unit for Data Logging and Event Recording System
⑧ - ⑪	Control Board for 66kV Transmission Lines	㉘	Relay Board for 66kV Bus	54 - 56	Logging Printer
⑫	Control Board for 66kV Buc-Tie	㉙	Relay Board for Transformer "3T"		
⑬	Control Board for Transformer "3T"	㉚	Relay Board for Transformer "4T"		
⑭	Control Board for Transformer "4T"	㉛	Relay Board for Transformer "9T"		
⑮	Control Board for Transformer "9T"	㉜	Relay Board for Static Condenser Banks		
⑯	Control Board for Static Condenser Banks	㉝	Existing Automatic Control Board for Synchronous Condenser No. 1		
⑰	Relay Board for Synchronous Condenser No. 1	㉞	Existing Automatic Control Board for Synchronous Condenser No. 2		

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 4.3 Arrangement Plan of Control Room for Saigon Substation

CHAPTER 5

TECHNICAL SPECIFICATION FOR 110 KV SUBSTATIONS

CHAPTER 5 TECHNICAL SPECIFICATIONS FOR 110 KV SUBSTATIONS

SECTION 1

GENERAL TECHNICAL SPECIFICATIONS

1.1 STANDARDS AND DESIGN BASIS

1.1.1 Standards

The design, materials, manufacture, testing, inspection and performance of all electrical and electromechanical equipment shall, unless otherwise specified in the Technical Specifications, comply with the latest revision of the authorized standards of the International Electrotechnical Commission (IEC).

The equipment, materials and parts thereof to which the IEC standards are not applicable shall comply with the following standards upon written approval of the Engineer:

- International Organization for Standardization (ISO)
- International Telegraph and Telephone Consultative Committee (CCITT)
- Japanese Industrial Standard (JIS)
- Standard of the Japanese Electrical Technical Committee (JEC)
- American National Standard (ANSI, ASME, ASTM)
- British Standard Institution (BS)
- German Standard (DIN)
- Other Standards or Codes approved in writing by the Engineer

If the Technical Specifications conflict in any way with any or all of the above standards or codes, the Technical Specifications, upon confirmation of the Engineer, shall have precedence and shall govern.

Upon request by the Engineer, the Contractor shall submit at his own expense one (1) copy of any of the applied standards translated into English to the Employer and the Engineer.

1.1.2 Units

The International System of Units (SI units) such as "m" as the unit of length, "kg" as the unit of weight, "N" as the unit of force, "Pa" as the unit of pressure, "kW" as the unit of electric power and "J" as the unit of quantity of heat shall be employed as the measurement units in all correspondence, schedules and drawings, and in all scales of the measuring

instruments. In case Non-SI units have been used, the equivalent SI units shall be written in addition.

1.1.3 Language

All documents, correspondence, drawings, reports, schedules and instructions shall be in the English language. Nameplates and rating plates on the equipment, enclosures and structures shall be in the English or Vietnamese language in accordance with the Employer's instruction. Duty labels and instruction plates or labels in/on cubicles and equipment shall be in the Vietnamese language. The Contractor shall propose the entries, sentences and wordings in English for the labels and plates to the Employer. Translation from English to Vietnamese will be made by the Employer.

1.1.4 Service Conditions for Plant Design

All equipment, materials and their arrangements shall be designed to comply with any service conditions stated below.

(1) Ambient Air Temperature

The ambient air temperature does not exceed 40°C and its average value, measured over a period of 24 hours, does not exceed 35°C.

The minimum ambient air temperature is not below 10°C.

(2) Altitude

The altitude for each substation site does not exceed 1,000 m.

(3) Relative Humidity

The average value of the annual relative humidity is 87% and the maximum relative humidity does not exceed 95%.

(4) Wind Pressure

The maximum wind pressure at the Project site is 70 kgf/m^2 corresponding to 25 m/s wind velocity.

(5) Seismic Coefficient

The equipment and their foundations shall be designed to cope with 0.15G acceleration of seismology on the centers of the gravity.

(5) Seismic Coefficient

The equipment and their foundations shall be designed to cope with 0.15G acceleration of seismology on the centers of the gravity.

(6) Atmospheres

The atmospheres in the Project area shall be deemed to be as follows:

(a)	Da Nhim Power Station	:	Lightly polluted atmospheres
(b)	Thap Cham Substation	:	Medium polluted atmospheres
(c)	Phan Ri Substation	:	Very heavily polluted atmospheres
(d)	Phan Thiet Substation	:	Medium polluted atmospheres
(e)	Cam Ranh Substation	:	Very heavily polluted atmospheres
(f)	Dien Khanh Substation	:	Medium polluted atmospheres

1.1.5 Tropicalization

Unless otherwise specified, all Plants furnished under this Contract shall be suitable for and where necessary specifically treated and processed for delivery, storage and service under tropical conditions of high temperature, high humidity, heavy rainfall, mildew, and white ants and fungus conductive environment. Tropicalizing materials and processes shall be in accordance with the best commercial and industrial practice which have been proven satisfactory and shall be subject to the Engineer's approval. All switchgear and control cubicles shall also be rodent and vermin proof construction.

1.1.6 Lubricating Oil and Insulating Oil

Oil and grease used throughout the Works shall be of a same make and grade readily and commercially available in Vietnam.

Insulating oil for the transformers and switchgear shall be non-sludging and of medium viscosity and shall comply with IEC 296 Class I. The insulating oil shall be "Shell Diala-B" or equivalent mixable with Shell Diala-B.

The Contractor shall assure himself by testing samples of the oil on suitability for the use intended. The test specification and results shall be submitted to the Engineer.

The first filling of oil for all the equipment supplied plus 10 percent extra oil of the overall net amount required shall be included in the Contractor's scope of supply.

Care shall be taken to prevent contamination of oil during transport, handling and storage.

The Contractor shall state the make and grade of oil proposed in his Bid.

1.1.7 Labels, Plates and Tags

(1) General

All transformers, switchgear, cubicles, instruments, switches, relays, valves, pipelines, cables, etc., shall be clearly identified by nameplates, escutcheon plates, labels, tags and/or other approved means showing the function and proper use of each item. Such identification shall be in English or Vietnamese language in accordance with the instruction of the Employer and must be intelligently and carefully designed to minimize errors and to avoid maloperation in operation or maintenance.

All labels, plates and tags shall be permanently legible, clearly worded, weather proof and corrosion proof where damp areas and outdoors, and shall not be deformed under any service conditions at the Site. The entries on the plates and tags shall be indelibly marked by engraving to black letter.

All labels, plates and tags shall be securely mounted in conspicuous and logical locations.

(2) Rating Plates

Every machine, transformer, switchgear and controlgear shall be provided with a rating plate containing the necessary information specified in the relevant IEC standards.

(3) Warning Notices

The Contractor shall provide warning notices and signs associated with the Plant in his supply, of a form and wording determined by the Engineer to suite the Employer's rules. Such notices and signs will be required to be in the Vietnamese language.

(4) Device Numbers

A device number shall be allocated for every electrical control switch, relay and other device and shall be shown on the Contractor's comprehensive circuit diagrams. The Contractor shall apply a label of approved form to every electrical device, showing the device number in a legible and permanent manner.

1.2 MATERIALS AND WORKMANSHIP

All materials incorporated in the Plant supplied shall be new, first-class commercial quality and free from defects and imperfections of classifications and grades designated. All materials shall comply with the latest issues of the specified or approved standard.

Workmanship shall be of the highest class throughout to ensure reliable and vibration free operation under all possible operating conditions. The design, dimensions and materials of all parts shall be such that the stresses to which they may be subjected shall not cause distortion, undue wear, or damage under the most severe conditions encountered in service.

All parts shall conform to the dimensions shown on and shall be built in accordance with approved drawings. All screws, bolts, studs and nuts and threads for pipe shall conform to the latest standards of the International Organization for Standardization (ISO) covering these components and shall all conform to the standards for metric sizes. The Contractor shall never incorporate any standards or size system by his own account, regardless of that accepted and incorporated in this Contract.

All materials and works which have cracks, flaws or other defects or inferior workmanship will be rejected by the Engineer. All defective materials shall be promptly removed from the Site by the Contractor, and inferior workmanship shall be cut out and replaced.

The Plant shall be complete in all respects, including all materials, equipment, parts, etc., so as to provide a complete and satisfactory installation. If the Specifications do not contain particulars of materials that are obviously essetial for the proper completion of the Works, all such materials shall be supplied by the Contractor without any extra charge.

1.3 FOUNDATION OF EQUIPMENT

Unless otherwise specified, all concrete foundations, block-outs and openings on the floors, walls and roofs, and trenches with cover plates for cables and pipes will be provided by the Employer.

The Contractor shall supply all anchors, foundation bolts, braces, posts, supports, shims, fasteners and other metalworks as may be required to be embedded and installed in the concrete for temporary or permanent support and anchorage of the Contractor's Plant. All embedded pipes, conduits and sleeves associated with installation of the Contractor's Plant shall also be supplied by the Contractor.

Dimensioned arrangement drawings for foundation details, block-outs, openings, cable trenches and the like required for installation of the Contractor's Plant shall be prepared by the

Contractor and submitted to the Engineer for approval. Details and locations of such foundations and all embedded parts to be supplied by the Contractor shall be fully indicated on the drawings. The Contractor shall be responsible for the completeness and accuracy of his drawings.

The foundation drawings shall be provided with the following design data for the foundations.

(a) Transformer
   i) Location of center of gravity
   ii) Total weight of transformer with oil
   iii) Moment on foundation around X-axis and Y-axis

(b) Switchgear and Structures
   i) Location of center of gravity
   ii) Vertical load; weight of equipment with bushing and supporting structure
   iii) Horizontal load; wind load, working tension of conductor and seismic load, for X-axis and Y-axis directions
   iv) Uplifting load
   v) Moment on foundation around X-axis and Y-axis

Safety factor of concrete for uplifting force shall not be less than 2. The allowable bearing strength of earth shall be assumed as 20 ton/m^2. The weight of earth shall be assumed as 2.0 ton/m^3 and weight of concrete as 2.4 ton/m^3.

1.4 WORKING STRESSES AND DESIGN

The transformer, switchgear, power cables and other elecctrical plants shall electrically be designed to avoid local corona formation and discharge likely to cause radio interference, and shall be designed to mechanically endure short-circuit current without thermal and mechanical failure for three seconds. The design, dimensions and materials of all parts shall be such that they will not suffer damage under the most adverse conditions nor results in deflections and vibrations which might adversely affect the operation of the equipment. Mechanisms shall be constructed to avoid sticking due to rest or corrosion.

Whenever possible, all similar parts, including spare parts, shall be made interchangeable. Such parts shall be of the same materials and workmanship and shall be constructed to such tolerances as to enable substitution or replacement by spare parts easily and quickly.

Suitable structural steel bases or frames shall be provided where necessary to transmit to the concrete foundations all loads imposed by the various parts of the equipment. Such bases or

frames shall be supplied complete with suitable anchor bolts and shall be so proportioned that the bearing loads imposed on the concrete foundations will not exceed 4.9 MPa.

The Plant shall be designed to minimize the risk of fire and consequential damage, to prevent ingress of vermin, dust and dirt, and accidental contact with electrically energized or moving parts. The Plant shall be capable of continuous operation with minimum attention and maintenance in the exceptionally severe conditions likely to be obtained in a tropical climate.

Each part of the Plant shall be of such construction and design as to give long and continuous service with low maintenance costs.

Upon request by the Engineer complete information regarding the design assumptions, loading and operating conditions, deflections and unit stresses used in the design shall be provided by the Contractor.

The Contractor shall be deemed to have examined the specification and drawings herewith, and unless stated specifically to the contrary in the schedule of proposed conditions and/or deviations from the specification to have concurred with the design and layout of the applicable project features as being sufficient to ensure reliability and safety in operation, freedom from undue stresses, adequate drainage and other essentials for a satisfactory working plant.

1.5 CORROSION PROTECTION AND FINAL PAINTING

All machined parts or bearing surfaces shall be cleaned and protected from corrosion before leaving the manufacturer's works by the application of an approved rust preventive coating, or a peelable plastic film. Where the latter is impracticable, such parts shall be heavily covered with high melting point grease. After erection such parts will be cleaned with solvent and lapped or polished bright.

All exposed steel parts, unless otherwise specified in the Specifications, shall be given with two coats of best quality approved primer and one coat of best quality approved finish paint before leaving the manufacturer's works. A further one coat of paint of an approved quality and color shall be given after erection and touching up on the Site.

Primer shall be applied to surfaces prepared in accordance with the plant manufacturer's instructions. The surface shall be wiped clean immediately prior to applying the paint. The primer and finish coats of paint shall be applied using the methods and equipment recommended by the manufacturer.

Contractor shall propose a color scheme for the steelworks and shall submit color chips or paint samples. A color chip shall be included with the approved color schedule for each type of finish to be applied at the Site. The color of all undercoats shall match the color of the finish coat.

Paint shall be a product of reputable manufacturer and be available in Vietnam. Paint shall be delivered in the manufacturer's sealed cans, stored under cover and used within the guaranteed term of validity and by the method recommended by the manufacturer. The Contractor shall select the type of paints which shall endure five (5) years after application.

The Contractor shall prepare and submit the painting specifications for approval of the Engineer. The painting specifications shall cover paint schedule, manufacturer's statement of the physical and performance characteristics for paint materials to be selected, and manufacturer's recommended procedures for the surface preparation, application, handling instructions, equipment, ambient conditions, mixing instructions, safety and storage instructions, etc. The procedures shall also include any special requirements for field repairs to the damaged coating and for the coating of field joints.

The humid and tropical conditions shall be taken into account on selection of the paints and painting procedure.

1.6 COMMON CLAUSES FOR ELECTRICAL PLANT

1.6.1 Electric Power Systems

The electric power for the Project shall be as follows:

(1) 230 kV, 50 Hz, three-phase system with directly grounded neutral only for the Da Nhim Power Station.

(2) 110 kV, 50 Hz, three-phase system with directly grounded neutral.

(3) 22 kV, 50 Hz, three-phase system with directly grounded neutral. 22 kV is the future operational voltage of the distribution lines.

(4) 15 kV, 50 Hz, three-phase system with directly grounded neutral. 15 kV is the present operational voltage of the distribution lines.

(5) 400/230 V, 50 Hz, three-phase, four-wire system with directly grounded neutral, for house-service power supply to feed three-phase and single-phase equipment for the Substations of Thap Cham, Phan Ri, Phan Thiet, Cam Ranh and Dien Khanh.

(4) 15 kV, 50 Hz, three-phase system with directly grounded neutral. 15 kV is the present operational voltage of the distribution lines.

(5) 400/230 V, 50 Hz, three-phase, four-wire system with directly grounded neutral, for house-service power supply to feed three-phase and single-phase equipment for the Substations of Thap Cham, Phan Ri, Phan Thiet, Cam Ranh and Dien Khanh.

If the A.C. control voltage other than 400/230 V is required, the Contractor shall provide control transformers where necessary.

(6) 380/220 V, 50 Hz, three-phase, four-wire system with directly grounded neutral, for house-service power supply to feed three-phase and single-phase equipment only for the Da Nhim Power Station.

(7) 220 V D.C. system, isolated from ground, for main and auxiliary control circuits, protective relays, lamp indications and closing source of the circuit breakers only for the Da Nhim Power Station.

(8) 110 V D.C. system, isolated from ground, for main and auxiliary control circuits, protective relays, lamp indications and closing source of the circuit breakers for the Thap Cham, Phan Ri, Phan Thiet, Cam Ranh and Dien Khanh Substation.

All D.C. equipment and apparatus, except the electrical protective relays and electronics equipment, shall be capable of satisfactory operation at 80 % to 125 % of the rated D.C. supply voltage. The electrical protective relays and electronics equipment shall be capable of satisfactory operation at 85 % to 110 % of the rated supply voltage. All devices on D.C. operating circuit for the circuit breakers shall also be capable of satisfactory operation even at 130% of the rated working voltage, considering boost charging voltage of storage battery.

D.C. loads to be supplied from the station battery and/or battery charger shall be estimated by the Contractor and lists of those loads shall be submitted to the Engineer for approval.

(9) 48 V D.C. system, positive pole grounded, to be supplied from the power supply unit for the power line carrier telephone system.

1.6.2 Insulation Requirements

All transformers, switchgear, controlgear, other electrical equipment and power cables shall withstand the following dielectric test voltages for the rated voltages at the standard

atmospheric conditions (Ambient temperature of 20°C, atmospheric pressure of 1,013 millibars and humidity of 11 g/m^3):

Rated voltage	245 kV	123 kV	24 kV	600 V
Full-wave lightning impulse of 1.2 x 50 micro-second	950 kV	550 kV	125 kV	–
Power frequency for one minute	395 kV	230 kV	50 kV	2.5 kV (3 kV)

Note : The value in the parenthesis is applied to the power transformers.

Their insulations shall be verified by the voltage tests at the manufacturer's works.

They shall also be subject to the voltage tests at ambient temperature at site. Values of single-phase test voltage for the rated voltage shall be as follows:

	230 kV	110 kV	22 kV	400 V
Power frequency for ten minutes	156.8 kV	78.7 kV	28.8 kV	600 V

When direct voltage is used for the voltage test at site, the voltage of two times the power frequency test voltage shall be applied for ten minutes.

Attention shall be drawn to the service conditions at the site described in Clause 1.1.4.

1.6.3 Insulators and Bushings

All insulators and bushings to be used in outdoors shall be brown glazed porcelain type and those for indoors shall be white glazed porcelain or resin type. The resin insulators will be of inherent color of the resin. All fittings for insulators shall be malleable iron hot-dipped galvanized alloy.

The minimum creepage distance of the indoor and outdoor bushings shall be 20 mm/kV for the rated voltage of the equipment unless otherwise specified in the Technical Specifications.

All insulators and bushings shall be impressed thereon, before firing the glaze, the supplier's name or trade mark, the year of manufacture and mechanical strength as applicable. Each bushing for voltages equal to or above 72.5 kV shall have a rating plate with marking in compliance with IEC 137.

1.6.4 Enclosures

The enclosures for switchgear and controlgear assemblies shall be dead-front, free-standing, rigid, welded steel frames, completely enclosed by metal sheets not less than 2.3 mm thick and suitable for indoor or outdoor installation.

The completed sections shall have provisions for lifting and ample strength to withstand all stresses incidental to shipping, installation and operation without distortion or other damage.

The enclosure shall be fastened at the bottom to suitable steel floor sill for proper installation of the enclosure. The floor sills shall be provided in advance of the enclosures to allow setting and grouting into place in the floor and shall have slotted holes to provide necessary enclosure alignment.

The enclosure shall be so constructed that all components are easily accessible for installation and maintenance, and so that it ensure the vermin-proof construction.

All measuring instruments, indicating lights, pushbuttons and control and selector switches shall be mounted on the front panel of the enclosure.

The enclosure shall be provided with suitable cable terminal compartments for power cable connections where necessary. Ample space for stress-cones shall be provided. Suitable terminal blocks shall be provided for all outgoing power and control cables. All cable terminals shall generally be located for cable entry from the bottom. A cover plate with suitable cable glands shall be provided on each cable entrance at the bottom of the enclosure.

Interior illumination lamps operated by door switches shall be provided for each enclosure as much as applicable. At least one 230 V socket outlet shall be provided for each assembly unit of switchgear and controlgear at convenient location.

Space heaters for 230 V or 400 V, 50 Hz shall be provided inside the enclosures to prevent moisture condensation. A manual switch to control the heaters shall be provided in the enclosures.

The enclosure shall be cleaned off rust and excess weld, and given a minimum one coat of phosphate or rust prevention treatment. All outside panel surfaces shall be primed, filed where necessary, and given not less than two coats of synthetic undercoat. The finishing coat for the outdoor installations shall be a gloss paint and for the indoor installations shall be a semigloss paint. The inside surface of the enclosures shall have two prime coats and one finishing coat. The floor sills shall be painted with the same as the enclosures.

The finished painting color of the enclosures and mounting instruments shall be as follows, unless otherwise specified in the Technical Specifications.(All colors are shown in Munsell Notation)

(a)	Exterior surface of enclosure	
	- for indoor installation:	5Y7/1
	- for outdoor installation:	N7
(b)	Frame of measuring instrument:	N1.5
(c)	Frame of protective relay:	N1.5
(d)	Handle of control switch	
	- for ordinary use:	N1.5
	- for emergency use:	7.5R4.5/14

The degree of protection for the enclosures shall be IP 41 for indoor switchgear, IP 54 for outdoor switchgear and IP 51 for indoor controlgear conforming to IEC 529 and IEC 144.

1.6.5 Measuring Instruments

All electrical measuring instruments, speed meters, guide vane opening and load limiter position indicators, pressure gauges and thermometers to be mounted on the enclosures shall be of flush-mounted, back-connected, dust-proof and heavy duty switchboard type. Each instrument shall have a removable cover, either transparent or with a transparent window. Each electrical measuring instrument shall be suitable for operation with the current and/or voltage transformers shown on the drawings under both normal and short-circuit conditions.

All analog type instruments shall preferably be of 240 degrees scale calibration, 110 mm square enclosures with clearly readable long scale. The maximum error shall be not more than one and a half (1.5) percent of full scale range. Scale plates of analog type instruments shall be of a permanent white circular or rectangular finish with black pointer and markings. The scale range shall be suitable for the measuring purpose intended and those for the electrical measuring instruments shall be determined from the current transformer and voltage transformer ratios.

Digital type measuring and indicating instruments shall be suitable for operation with D.C. output of the related transducers. The number of digits of each digital instrument shall be selected to suit the indicating purpose intended. The indicating elements for each digital

indicator shall be of seven-segment LED illumination type. The digital type instruments required to indicate flow direction shall be provided with "+" and "-" signs.

Each watthour meter and varhour meter shall be fitted with a reverse running stop, and shall be provided with a pulse transmitter suitable for signalling the watthour and varhour value as required.

1.6.6 Selector and Control Switches

The selector and control switches shall be heavy duty, rotary type with suitable handle or pushbutton type. Their operating contact mechanisms shall be on the rear of the panel.

All contacts shall be enclosed in a cover or covers which can be easily removed when installed on the switchboards to afford complete accessibility to contacts and terminals. Each contact shall be readily renewable, and shall have adequate insulation and contact surface.

Each selector and control switch shall be provided with an escutcheon plate or a marking plate to show each operating position. The switch identifications shall be engraved on the escutcheon plates, marking plates or separate nameplates. The entries on the plates shall be subject to the Engineer's approval.

In case the illuminated type switch is used, illumination shall be made by the light-emitting diode (LED) to be integrated in the switches.

1.6.7 Indicating Light Units

The indicating light units for the switchgear and controlgear cubicles shall be the light-emitting diode (LED) illumination, flush mounted, dust-proof, heavy duty type indicators suitable for operation with 110 V D.C. service.

Each indicating light shall have a marking plate or appropriately colored lens with an escutcheon plate or a separate nameplate to indicate the purpose intended. Entries for each indicator shall be engraved with black letters on the marking plates. The marking plates and lenses shall be made of a material which will not be softened by the heat by the lamps.

For indication of switching position or operating condition, red light shall be used for "Close" or "Operation" and green light for "Open" or "Stop".

1.6.8 Printed Circuit Boards

The printed circuit boards shall be of plug-in type and rack mounted. Each printed circuit board shall be clearly marked with its identity, serial number and function. The rack position for each printed circuit board shall be clearly indicated.

1.6.9 Molded Case Circuit Breakers and Miniature Circuit Breakers

The molded case circuit breakers and miniature circuit breakers shall be of one-, two-, three- or four-pole for A.C.circuits and two-pole for D.C.circuit, manual operated, fixed type with inverse time-delay overcurrent release and instantaneous overcurrent release.

Each circuit breaker shall be provided with a trip alarm switch for remote annunciation and auxiliary switches as required.

The circuit breakers shall be rated as follows:

		A.C. circuit	D.C. circuit
(a)	Rated insulation voltage	600 V	250 V
(b)	Rated operational voltage	400 V or 230 V	110 V

The rated short-circuit breaking current and the rated trip current shall be selected by the Contractor on the basis of the prospective short-circuit fault current and the rated normal current of the circuit, unless otherwise specified in the Technical Specifications.

1.6.10 Electric Motors

All electric.motors shall be of the totally enclosed fan-cooled type with degree of protection of IP44 or better.and shall generally comply with IEC 34. The windings of the motors shall be insulated with class E, B or F materials.

All A.C.motors shall be capable of operating continuously and successfully with their rated output when they are supplied by a voltage that may vary between 90% and 110% of their rated voltage under their rated frequency or when the supplied frequency varies between 95% and 105% of their rated frequency under their rated voltage or when the sum of the absolute percentage of both voltage and frequency variations is not more than 10% under the variation in voltage being within 10% and that in frequency being within 5%. All A.C.motors connected to the station service transformer secondary circuit shall be designed to withstand the temporary frequency rise of 60 % which may arise during full load rejection of the generators.

All D.C. motors shall be capable of operating continuously and successfully with rated output at any voltage between 85% and 110% of their rated voltage.

the temporary frequency rise of 60 % which may arise during full load rejection of the generators.

All D.C. motors shall be capable of operating continuously and successfully with rated output at any voltage between 85% and 110% of their rated voltage.

Starting of all motors will generally be direct on line. In this connection, the Contractor shall submit the list of starting kVA of each A.C.motors for the Engineer's approval.

All motors shall be provided with terminal boxes of totally enclosed type, grounding terminals and suitable lifting facilities.

1.6.11 Power and Control Cables

(1) Power Cables

All power cables shall be of single-core or multi-core, crosslinked polyethylene (XLPE) insulated PVC sheathed cables with stranded copper conductors. Power cable shall have an ample current carrying capacity and shall duly withstand the maximum prospective fault current for at least one second for medium and high voltage circuits and for a duration time approved by the Engineer for low voltage circuits.

Each power cable shall be provided with suitable cable terminals at both ends.

(2) Control Cables

All control cables for instrument transformer secondaries, control and auxiliary wirings in the switchgear and controlgear cubicles and for interconnecting wirings between cubicles shall be of single-core or multi-core, 300/500 V or 450/750 V, PVC insulated and PVC sheathed cables with stranded copper conductors. Unless otherwise specified in this Specifications, construction and requirements for the control cables shall generally comply with IEC-227.

Control cables employed for the circuits for embedded thermometers, telemetering, speed signal generators, current transformers and voltage transformers and for other circuits liable to interference due to electrical noise shall be the screened cables with suitable metallic shielding against electrostatic induction and if necessary against electromagnetic induction too.

Control cables for the circuits for generator fire alarming, transformer fire alarming and emergency and quick stop controls of the generating unit shall be provided with approved thermo-resistant characteristics

Sectional area of each core shall be not less than 2.5 mm^2 for control and auxiliary wiring and not less than 4 mm^2 for current transformer and voltage transformer circuits. In selection of sectional area of the cables, the following shall also be considered.

(a) For current transformer secondary circuit

The total burden of measuring instruments, protective relays, transducers and connected cables shall be less than the rated output of the related current transformer. The burden to be consumed in the cables shall preferably be less than 15 VA.

(b) For voltage transformer secondary circuit

The total burden of measuring instruments, protective relays, transducers and connected cables shall be less than the rated output of the related voltage transformer. Allowable voltage drop in the cables shall be one percent.

(c) For AC control and indication circuits

Allowable voltage drop in the cables shall be as follows:

i) 10 V for 400 V circuit
ii) 5 V for 230 V circuit
iii) 2.5 V for 110 V circuit

(d) For DC control and indication circuits

Allowable voltage drop in the cables shall be 5 V.

1.6.12 Wiring and Terminals

(1) General

Wiring shall be suitably grouped, neatly and securely bunched or cleated, and shall be installed as applicable in the wiring ducts. A suitable wiring duct system shall be provided for interpanel and front-to-rear panel wiring to provide easy access for inspection and maintenance. All wiring from hinged door panel to the fixed panel shall be done by using of flexible conductors. Exposed wiring shall be kept to minimum, but where used they shall be bunched and protected properly.

The bunching of wiring shall be kept in bunched condition by means of strips of special plastic ribbon material at suitable intervals. Lacing of wire bunched with textile or

plastic cord or metal buckle type clips will not be accepted. Wherever wiring is cleated to metalwork, it shall be insulated from the metal surface and shall be cleated by means of insulated straps in an approved manner. All wiring shall be left sufficiently long and neatly looped to allow a fresh termination to be made.

Wiring between terminals of the various devices shall be point to point. Splices or tee connection will not be acceptable.

Current and voltage transformer secondary circuits shall be grounded only at the first panel entered, and shall not be grounded at any point or outside of the enclosures.

All wiring shall be brought to terminal blocks. Terminal blocks shall be complete with clamp type molded plastic terminals, barriers and covers and shall be mounted vertically. All wiring to those blocks shall be arranged to run in numerical order from top to bottom. At least 10 percent spare terminals shall be provided in the terminal blocks.

White or other light-colored marking strips, fastened by screws to the molded sections at each block, shall be provided for circuit designation. Spare marking strips shall be furnished with each block.

Each end of each wire shall be provided with a clamp or pressure type terminal lug and with a vinyl marker fixed permanently to the wire, and imprinted with the wire number and identification letter or symbol corresponding to the Contractor's final circuit diagrams forwarded for approval.

(2) Phase Arrangement

The standard phase arrangement when facing the front of the panel shall be R-S-T-N, and R-N-S from left to right, from top to bottom, and front to back for A.C. three-phase and single-phase circuits and N-P from left to right, P-N from top to bottom and front to back for D.C. polarity. All relays, instruments, other devices, buses and equipment involving three-phase circuit shall be arranged and connected in accordance with the standard phase arrangement where possible.

(3) Wiring Color Code

All wires shall be colored as follows:

Circuit	Color
Voltage transformers	Red
Current transformers	Black

A.C. circuit	Yellow
D.C. circuit	Blue
Grounding circuit	Green with yellow stripe

(4) Phase and Polarity Color Code

Following colored ferrules shall be provided on each wire in order to identify phase and polarity.

Phase and Polarity		Color
A.C., three-phase,	first phase	Red
	second phase	Yellow
	third phase	Blue
A.C., single-phase	first line	Red
	second line	Yellow
Neutral		Black
Grounded		Black
D.C., positive		Red
negative		Blue

1.6.13 Cabling Works

(1) General

Cables and wires will be neatly and securely bunched or cleated, and installed in cable trenches, culverts or conduits. Where cables and wires are installed in the cable trenches or culverts, they will be laid by means of cable trays with suitable supporting brackets.

All cable trays, supporting brackets, cleats and conduits complete with their fixing materials required for installation of cables shall be provided by the Contractor.

Cable trenches, openings and block-outs necessary for the cabling works will be provided by the Employer at the places designated by the Contractor upon approval of the Engineer. The Contractor shall provide all the necessary information and drawings for this purpose in due time. In the event of the absence or misplacement of cable trenches, openings, block-outs or inserts due to lack of such information, the Contractor shall arrange alternative routes or curing of openings at his own expense. Any cutting of concrete shall be only with the prior approval of the Engineer.

At the portion where the cables are passing through the openings on the building walls and floors and at inlet and outlet of cable conduits, suitable sealing materials shall be supplied by the Contractor to seal spaces between the cables and the openings for complete rain and moisture tightness, for vermin-proof and for pretension of fire spreading. Sealing materials shall be non-inflammable type approved by the Engineer.

The Contractor shall design and prepare the cable schedules showing all power and control cabling between the Plants related to the Works and shall submit them to the Engineer for reference. The cable schedules shall include the following information:

(a) Cable identification

(b) Termination points (e.g., cubicle designations).

(c) Cable construction, number of cores and rated voltage.

(d) Route length.

Each cable shall be fitted with a cable identification label at each end.

Construction method for each type of cable and for each condition for the service shall be submitted to the Engineer for approval.

(2) Cabling and Wiring

The power and control cables shall be continuous between terminals, and no junction shall be made in the cable ducts, trenches and conduits. The power and control cables shall be laid in the cable ducts, trenches or conduits after they have been cleaned.

Grounding conductor, where required to run with other conductors in the cable ducts, trenches or conduits shall be of 600 V PVC insulated wire.

(3) Conduits

Rigid steel conduit shall be galvanized inside and outside, or enamelled inside. It shall be of a minimum thickness of 2.3 mm and have a minimum inside diameter of 16 mm.

The sectional area of the conduits shall be selected so that the accumulated sectional area of the conductors installed shall not exceed 40 percent of the sectional area of the conduit bores.

(4) Conduits Installation

Steel conduit systems shall be electrically and mechanically continuous.

Where the conduit installation is wholly or partly of a non-metallic material, then a separate ground continuity conductor shall be supplied to ensure complete electrical continuity of the conduit system.

An adequate number of pull boxes shall be included in the conduit installation to facilitate wiring without undue strain or damage to the cables. On straight runs, pull boxes shall be provided at distances not exceeding 15 m.

Conduit threads shall be cleanly cut to a finished length which leaves the minimum amount of thread exposed when the conduit installation is completed.

All edges of conduits shall be smoothed and internal bores of steel conduit edges shall be taper reamed to prevent damage to wires and insulation.

All exposed metals shall be cleaned and protected against corrosion by the use of materials compatible to the original protective coating.

Any bends in the conduit run shall be made in a manner that does not cause any damage or indents in the conduit section. The radius of bends shall not be less than the minimum values provided in relevant codes of practice and wiring regulations. Not more than two right angle bends shall be installed between pull boxes.

Concealed conduits shall be located in the walls, ceilings and floors to a sufficient depth which will enable a minimum required depth of the concrete covering over the conduit to be installed.

Exposed conduit shall be routed on walls, ceilings and other concrete structure either horizontally or vertically and shall be supported every 1,200 mm by saddles or suitable means, and 250 mm on either side of any box or bend. Exposed conduits shall be finished with the same color paints as the finished color of the wall or ceiling against which the conduits are placed.

Where conduits cross expansion joints of buildings, expansion couplers shall be fitted across the joint and at right angles to it. A 4 mm^2 insulated wire for grounding purpose shall be installed between the two conduit boxes either side of the expansion joint.

Conduits to be directly buried in the ground will be installed not less than 600 mm below the ground surface with suitable protection against the heavy load imposed on the conduits. The buried conduit system will be provided with suitable hand holes where required.

Conduit run to motors shall terminate 250 mm short of the terminal boxes and the final connections shall be completed by the use of flexible conduit with PVC sheathing.

Where conduits terminate in the cable trenches or openings not provided with the tapped holes or threaded spouts, the end of conduits shall be provided with suitable bushings and locknuts.

Only threaded joints shall be used. Conduit which were crushed or deformed shall not be used in the Works.

All joints and terminations shall comply with the weatherproof or explosion proof requirements as applicable.

All exposed threads will be given two coats of zinc based paint of approved type after installation.

1.6.14 Grounding of Equipment and Cables

(1) General

All exposed metal parts of transformer tanks, switchgear, switchboards, instrument-transformer secondaries, steel structures, motors, etc. shall be grounded securely by connecting to the station ground grid as well as ground connection for the grounded neutral of transformers and for surge arresters. Metal sheaths and shields of power and control cables shall also be grounded.

(2) Ground Connection to Station Ground Grid

The station ground grid comprising horizontally buried bare copper conductors will be installed by the Employer. For ground connection to any of the equipment supplied under the Contract, ground leads will be tapped from the main station grid by bare or insulated copper conductors of 95 mm^2 or 35 mm^2 at some locations which shall be proposed by the Contractor. The tapped ground leads will be provided by the Employer up to about one meter from the floor or ground level. The Contractor shall supply the grounding conductors required for ground connection between all electrical equipment to be installed under the Contract and the tapped ground leads. These grounding conductors shall be the insulated copper wires with suitable size which shall be determined from the maximum available line-to-ground fault current. The grounding conductors shall be connected to the tapped ground leads by compression type clamps.

(3) Grounding of Cubicles

A continuous copper grounding busbar shall run through the assembled switchgear and controlgear cubicles and all non-current carrying metal parts shall be effectively connected to it. The ground busbar shall be not less than 50 mm by 6 mm in size. Connections shall be made by welds or by approved clamp type fittings and no soldered connections shall be used. The grounding busbar shall be effectively and electrically connected to the station grounding grid of each 110 kV substation.

If the operating mechanism of removable units is not permanently grounded, ground contacts shall be provided to connect the movable element to the grounding busbars whenever the mechanism is in use. These connections shall make before the main disconnecting devices upon insertion and break after the main disconnecting devices upon withdrawal.

Copper busbar splices between shipping sections shall be provided with bolted connections having silver-plated contact surfaces and means for adequate clamping.

(4) Grounding of Cables

Metal-sheath and shield for the multi-core power cable shall generally be grounded at both ends and those for single-core power cable at either one end.

In case of the shielded control cable, electrostatic shield like copper tape or wire shall be grounded at either one end and electromagnetic shield like copper tape plus steel tape at both ends.

1.7 PARTICULAR REQUIREMENTS FOR OUTDOOR ELECTRICAL PLANT

1.7.1 General Requirements

All outdoor electrical plants shall operate without undue vibration and excessive corona and shall be designed to ensure satisfactory operation under the atmospheric conditions at the site where the switchgear and transmission lines are to be installed. The design of all steel structures, towers, conductors, groundwires, and insulator and groundwire fittings shall be such as to minimize the risk of damage due to deterioration or damage in service of any part of the outdoor switchgear and transmission line.

The design of all line conductor fittings, vibration dampers, insulator sets, etc., shall avoid sharp corners or projections which would produce high electromechanical stress under

normal working conditions. The design of adjacent metal parts and melting surfaces shall be such as to prevent corrosion of the contact surfaces and to maintain good electrical contact under any service conditions. Particular care shall be taken during manufacture of conductors and fittings and during subsequent handling to ensure smooth surfaces free from abrasion.

1.7.2 Marking

(1) Members of Towers and Outdoor Steel Structures

All members and plates of towers and outdoor steel structures shall bear punch marks corresponding to the Approved Drawings for erection and the member lists to be used for assorting work.

The erection marks shall be punched before galvanizing and shall be clearly readable afterwards.

Bolts shall bear marks corresponding to their sizes, lengths and material qualities to facilitate assembly at the Site.

(2) Insulator Units and Bushings

Each insulator unit and bushings shall be marked with the supplier's name or trade mark, the year of manufacture and the mechanical strength.

The marks shall be impressed before firing the glaze.

(3) Others

Fittings for insulator and ground wire, clamps, joints, vibration dampers, etc., shall preferably bear the identification marks to facilitate assembly and assorting at the Site.

1.7.3 Bolts and Nuts

All structural members shall be secured by means of bolts and nuts with flat and spring washers.

Bolts for all structural connections shall be of hexagonal head and shall be of M16 in the minimum size, except those for fixing the number and danger plates.

All bolts, nuts and washers shall be hot-dipped galvanized. Other plating method and stainless made will not be acceptable.

The nuts of all bolts for attaching insulator sets and groundwire fittings to the towers and outdoor steel structures shall be locked in an approved manner. These nuts shall be finger

tight on the bolt and will be rejected if, in the opinion of the Engineer, they are considered to have an excessively loose or tight fit.

The screwed thread of any bolts or studs shall not form part of a shearing plane between members. When in position, all bolts or studs shall project through the corresponding nuts for at least three (3) full turns.

Five (5) percent of spare of bolts, nuts, washers, fillers etc. shall be supplied for all tower and outdoor steel structure materials under the Contract.

1.7.4 Galvanizing

(1) General

Unless specifically mentioned in the Technical Specifications, all iron and steel used for towers and outdoor steel structures shall be hot-dipped galvanized after all fabrication are completed. The zinc coating shall be uniform, clean, smooth and as free from spangle as possible.

All iron and steel articles other than wires shall be hot-dipped galvanized and shall have the minimum average coating weight of 600 g/m^2 on structural steel members and 400 g/m^2 on bolts and nuts, and shall withstand the tests set out in ISO 1460 or equivalent.

After galvanizing, holes shall be free from nodules or spelter.

All iron and steel wires shall be galvanized by an approved process before stranding. The zinc shall be smooth, clean, or uniform thickness and free from defects, and shall withstand the tests set out in ISO 1460 or equivalent.

The preparation for galvanizing and the galvanizing itself shall not distort or adversely affect the mechanical properties of the materials.

If any galvanized part is found to be imperfect, such part must be replaced. The whole of the expense involved in the replacement of the imperfect part shall be borne by the Contractor.

If, in the opinion of the Engineer, the extent of damage found on Site to a galvanized part appears capable of repair, the Contractor may, after receiving such agreement, attempt to effect repair by approved methods. The agreement to attempt repair shall not bind the Engineer to accept the repaired part when such is offered for re-inspection.

(2) White Rust

In order to avoid the formation of white rust on the galvanized surface of iron and steel articles for structural members, the galvanized surface shall be treated with chromate process or other approved processes.

If it is found that galvanized surfaces are subject to the formation of white rust in transit or storage on Site, the Engineer shall either approve a method of scrubbing and protective painting on the Site or order to replace with new materials.

Either of the above measures shall not cause extra charge to the Employer nor extension of Time for Completion.

1.7.5 General Requirements on Arrangement of Outdoor Switchyard

Basic requirements in designing the arrangement of equipment in the outdoor switchyard shall be as follows:

(a)	Minimum clearance from the ground level to the bottom level of the bushings or supporting insulators:	2.5 m
(b)	Minimum clearance from the ground level to the nearest unscreened live conductors in air	
	i) 230 kV circuit:	4.5 m
	ii) 110 kV circuit:	3.4 m
	iii) 20 kV circuit:	2.6 m
(c)	Height of supporting structures for equipment from the ground level:	To be adjusted according to the height of equipment and bushings

1.8 SPARE PARTS

The Contractor shall supply the spare parts as listed in the Schedules of "Form of Bid and Schedules".

Spare parts shall be brand-new. The broken or damaged or troubled or repaired parts will not be acceptable as spare parts. All spare machines, relays, measuring instruments and printed circuit boards shall be subject to the operation test at site before delivery to the Employer.

Details of the contractual spare parts shall be subject to the Engineer's approval. Those lists shall include the following items and shall be submitted to the Engineer.

(a) Outlined sketch of each type and kind of spare part
(b) Actually used quantity of the part
(c) Supplied quantity as spare

Any spare parts supplied shall be packed or treated in such a manner as to be suitably stored in the climate at the Site for a period of not less than two (2) years, and each part shall be clearly marked with its description and purpose on the outside of the packing.

Spare parts shall be delivered into the stores designated by the Employer. Delivery of spare parts will not be deemed to be complete until the packages have been opened by the Contractor, their contents and operating performance have been checked by a representative of the Employer and then the parts have been reprotected and repacked by the Contractor to the satisfaction of the Employer or assembled into units at the Employer's option. The method of package and package materials shall be suitable for the satisfactorily re-package.

1.19 Tests

1.19.1 Tests at Manufacturer's Works

(1) General

Before any Plant will be packed or delivered from the Manufacturer's Works, all tests itemized in the relevant Clauses of the Technical Specifications shall be carried out by the Contractor as far as practicable to prove compliance with the requirements of the Specifications.

All tests shall be performed in accordance with the approved test procedures.

All tests results shall be approved by the Engineer. Approval of tests, acceptance of test certificates or waiving of tests shall in no way relieve the Contractor from his contractual obligations for furnishing the Works in accordance with the provisions of the Specifications.

If two or more auxiliary equipment of identical design are supplied under the Contract, a complete performance test shall be carried out on the first unit of each kind of auxiliary equipment. As for the Plants identically designed with those well tested and proven for the other projects, submission of the previous type test certificates and test reports may be acceptable instead of further complete performance tests upon the written approval of the Engineer.

The Contractor's expense associated with all such tests and inspections shall be borne by the Contractor.

The Contractor shall arrange for the Employer's personnel and the Engineer to attend tests of major Plant in the Manufacturer's Works.

(2) Dates for Inspection and Testing

Written notice of the exact date, time and place of test to be attended by the Employer and the Engineer, as well as all other necessary information shall be given to the Employer and the Engineer in writing not later than thirty (30) days prior to the date of any such test. It shall also be understood that the Contractor will provide the Engineer with all facilities for a proper and timely execution of the tests.

Free and unrestricted access to the Manufacturer's Works shall be granted to the Employer and the Engineer.

Should an agreed test not be carried out as proposed because of lack of preparation, obvious negligence or material and/or equipment being presented in a state which is clearly not acceptable, the cost for repeated tests shall be fully borne by the Contractor upon invoicing by the Engineer.

If the Engineer does not attend on the date agreed, the Contractor may, unless the Engineer instructs the Contractor not to do so, proceed with the tests, which shall be deemed to have been made in the Engineer's presence.

(3) Test Reports

Seven (7) sets of all test records, test certificates, performance curves, tables, etc., of all tests, whether or not attended by the Engineer shall be submitted soonest after execution of each test. After completion of all testing, two (2) sets of the above mentioned documents shall be submitted properly bound in books.

All test certificates shall be endorsed with sufficient information for identification of the equipment and material to which the certificates refer and shall clearly indicate the reference such as Employer's name, project name, plant name, document No. and tested date.

(4) Rectification of Deficiencies

All deficiencies revealed by testing shall be rectified by the Contractor at his own expense and to the approval of the Engineer. Rectified components shall be subject to retesting.

If the Works or any section fails to pass the tests, the Employer or the Engineer may require such tests to be repeated on the same terms and conditions. All costs to which the Employer may be put by the repetition of the tests under this Clause or under Clause 2.73 "Defects" of the General Conditions shall be deducted from the Contract Price.

(5) Inspection Certificates

After the test has been satisfactorily completed and the corresponding reports have been accepted by the Engineer, the Engineer will issue an "Inspection Certificate" per every shipment/delivery in which he shall certify the date on which the said test has been completed and the particulars of the Plant inspected and tested. Issuance of such Inspection Certificate shall not release the Contractor from any of his contractual obligations.

1.19.2 Tests at Site

All site tests shall be carried out by the Contractor himself in accordance with the approved test procedures. All test forms to record the test results and data shall be prepared by the Contractor and shall be approved by the Engineer prior to starting the tests. All test results and data shall be recorded by the Contractor himself and shall be subject to approval of the Engineer. The test results and data relating to performance of the turbine and generator shall be analyzed by the Engineer.

During the erection and after the installation of each plant or each part of thereof, the Contractor shall execute all tests listed below as far as applicable to establish the accuracy of the assembly and to ensure that the Plant has been correctly installed, all necessary adjustments and settings made, and that each Plant is in sound condition to operate under loading conditions.

(1) Preliminary test during erection of equipment

(a) Appearance check of all equipment
(b) Check and adjustment of setting level
(c) Insulating oil test, before filling oil into transformer tank
(d) Calibration check of dial type thermometers
(e) Calibration check of pressure gauges

(f) Oil tightness check and gas leakage tests

(g) Measurement of the resistance of the main circuit

(2) Performance test

(a) Transformers

i) Measurement of winding resistance
ii) Ratio check
iii) Polarity and phase relation check
iv) Measurement of insulation resistance
v) Withstand voltage test
vi) Tests of cooling equipment
vii) Operation test of tap-changer
viii) Measurement of noise

(b) Circuit breakers

i) Closing and opening operation test
ii) Trip-free operation test
iii) Manual operation test
iv) Remote operation test
v) Minimum coil operation voltage test
vi) Measurement of operating coil resistance
vii) Measurement of insulation resistance
viii) Withstand voltage test
ix) Tests of pneumatical or hydraulic equipment

(c) Disconnecting switches and earthing switches

i) Manual operation test
ii) Remote operation test
iii) Check of interlock mechanism
iv) Measurement of insulation resistance
v) Withstand voltage test

(d) Current transformers and voltage transformers

i) Measurement of insulation resistance
ii) Check of polarity
iii) Measurement of ratio

iv) Measurement of actual burden of current transformer and voltage transformer circuits

(e) Lightning arresters

i) Measurement of insulation resistance

(f) Busbars in switchgear cubicles

i) Measurement of insulation resistance
ii) Withstand voltage test

(g) Control and measuring equipment

i) Measurement of insulation resistance
ii) Check of status and fault indications
ii) Check of control sequences
iii) Calibration check of measuring instruments and transducers

(h) Protective relaying equipment

i) Individual relay tests
- Appearance and construction check
- Operating characteristics tests
- Operating time characteristics tests
- Setting of protective relays
ii) Residual voltage (current) measurement
iii) Measurement of actual burden
iv) Grounding point check of current and voltage transformer circuits
v) Sequential operation test at each station by primary and secondary injection to check sensitivity and stability
vi) Station to station operation performance tests (transmission line protective relaying equipment only)

(i) Storage battery

i) Measurement of voltage, specific gravity and temperature of all cells before and after initial charge
ii) Measurement of voltage, specific gravity and temperature of pilot cells during initial charge
iii) Capacity test

(j) Battery charger

i) Calibration of measuring instruments
ii) Measurement of insulation resistance
iii) Operation check and setting of protective relays
iv) Operation and load test

(k) Power Line Carrier Equipment

i) Test of PLC terminal equipment
- Performance test
- Measurement of output power
- Carrier frequency stability test
- Carrier frequency output level test
- Automatic gain control test
- Measurement of noise generated within the equipment
- Crosstalk test
- Ringer signal distortion test

ii) Test of coupling capacitor voltage transformers

- Measurement of insulation resistance
- Check of polarity
- Measurement of voltage ratio
- Measurement of actual burden of voltage transformer circuit

iii) Power supply equipment

- Measurement of voltage, specific gravity and temperature of all cells before and after initial charge
- Capacity test
- Battery charger test

(l) Power cables

i) Withstand voltage test
ii) Insulation resistance measurement

(m) Control cables

i) Insulation resistance measurement

(3) Testing Personnels and Facilities

The Contractor shall provide all man power, testing instruments, equipment, tools and materials necessary for performing all thetests.

All testing instruments shall be calibrated prior to the commencement of the tests.

The Contractor's expenses associated with all such tests shall be borne by the Contractor.

(4) Maintenance during Site Tests

The Contractor shall be responsible for all routine maintenance, that is, lubricating, inspection and adjustment of all equipment in the Contract until the Taking-Over Certificate is issued.

(5) Test Reports

Three (3) copies of all test records and test data of all tests, whether or not attended by the Engineer, shall be submitted to the Engineer soonest after completion of each test.

After completion of all tests, ten (10) complete sets of the above mentioned documents shall be submitted to the Employer as well as to the Engineer by binding them properly in books.

(6) Rectification of Deficiencies

If the test results are not satisfied with the performance given in the performance guarantees and the technical particulars, the Contractor shall carry out at his own expense such measures as may be approved by the Engineer to rectify the deficiency. The Employer shall have the option of making a reasonable reduction in the Contract Price, for any residual deficiency in performance at the time of acceptance of the equipment.

SECTION 2

TECHNICAL SPECIFICATIONS FOR TRANSFORMERS

2.1 SCOPE

This Section covers the designing, manufacturing, supplying, testing before shipment, finishing, painting, packing for export, insuring, shipping, delivering to the port of Saigon, landing, customs clearance and transport from the port of Saigon to the Site and supervising for the installation work, site testing and commissioning of the following transformers:

(1) One (1) bank of three-phase, 125,000 kVA, 230/121 kV auto-transformer with an on-load tap-changer for the Da Nhim Power Station

(2) One (1) bank of three-phase, 25,000 kVA, 115/22 (15) kV main transformer with an on-load tap-changer for the Phan Thiet Substation

(3) Four (4) banks of three-phase, 16,000 kVA, 115/22 (15) kV main transformers with an on-load tap-changer for the Thap Cham, Phan Ri, Cam Ranh and Dien Khanh Substations

(4) Five (5) banks of three-phase, 200 kVA, 22/0.4 kV house-service transformers with an off-circuit tap-changer for the Thap Cham, Phan Ri, Phan Thiet, Cam Ranh and Dien Khanh Substations

(5) One (1) set of oil handling and purifying equipment

2.2 230/121 kV AUTO-TRANSFORMER

2.2.1 Type and Ratio

The 230/121 kV auto-transformer shall be of three-phase, oil immersed, two auto-connected windings, sealed, on-load tap-changing, outdoor use type auto-transformer with a stabilizing delta-connected winding. The auto-transformer shall be provided with a tapped 121 kV winding having altogether 17 tappings, symmetrically placed, and the no-load ratio between the primary and secondary windings shall be 230 kV/(121 kV $\pm$ 8 x 1.5 %).

The transformer connection of the auto-transformer shall be YNad1 of IEC 76-1 (1993) and the neutral of the star connected winding shall be brought out for grounding.

2.2.2 Rated Power

The rated power of the auto-connected windings shall be 125,000 kVA, under forced-oil-circulation and forced-air-cooled operation, on any of the taps. The rated power of the delta-connected tertiary winding shall be sufficient for the stabilizing purpose to decrease the zero-phase impedance of the auto-transformer.

2.2.3 Temperature-Rise Limit

The maximum temperature rise of the transformer shall not exceed the following values under the continuous rated power on condition that the maximum ambient air temperature at the site should not exceed 40 °C.

(a)	Top oil:	60 K by thermometer
(b)	Winding	
	- For forced oil circulation (OF)	65 K by resistance method
	- For forced directed oil circulation (OD)	70 K by resistance method

2.2.4 Insulating Oil

The insulating oil shall be non-sludging and of medium viscosity. The characteristics of the insulating oil shall comply with IEC 296 Class I and shall be "Shell Diala - B" or equivalent mixable with Shell Diala-B.

The transformer shall be supplied with the first filling of oil and ten (10) percent extra oil in sealed non-returnable drums.

The manufacturer's name and characteristic of oil shall be stated in the Tender.

2.2.5 Insulation Levels

The transformers shall withstand the following voltages:

(1) 230 kV side:

- Full-wave lightning impulse	
1.2 x 50 micro-second	950 kV
- Power-frequency for one minute	395 kV

(2) Neutral terminal to be directly grounded:

- Power-frequency for one minute	at least 38 kV

(3) 121 kV side:

- Full-wave lightning impulse
  1.2 x 50 micro-second 550 kV
- Power-frequency for one minute 230 kV

2.2.6 Impedance Voltage

Impedance voltage between the primary (230 kV side) and secondary (121 kV side) windings shall be about 10 % or less on the basis of the rated power on the rated tap and shall be guaranteed by the Contractor, and the variation on other tappings shall be within the limits plus and minus 10 percent of the value as measured on the rated tap.

2.2.7 Sound Level

The acoustic sound level of transformers measured by the measurement method complying with IEC 551 (1976) shall be not more than 86 dB at any operating conditions.

2.2.8 Core

The transformer cores shall be built up of thin laminations of the best quality non-aging silicon steel. Lamination shall be coated with an insulating material.

The design of the core and the method of clamping shall be such as to ensure it free from excessive noise and vibration. The clamping framework shall be built up of structural steel members.

To ensure efficient cooling, each core shall be provided with oil ducts.

Suitable means shall be adopted to prevent circulating current being set up within the core.

The core and windings shall be so located within the tank as to prevent movement.

The core shall be electrically connected to the transformer tank.

2.2.9 Windings and Insulation

Graded insulation shall be applied to both the primary (230 kV) and the secondary (121 kV) windings where the neutral point of the auto-connected windings shall be directly grounded. The tertiary winding shall be fully insulated.

The windings shall be of high conductivity copper.

The amount of insulation shall be determined not only by normal voltage per turn, but also by

due consideration of the line voltage and the service conditions, including impulse phenomena caused by lightning strokes on the transmission line and surges during switching operation of circuit breakers and other associated fault conditions.

The insulation of the end turns of the graded insulation windings shall be reinforced between turns or provided with suitable means to protect the winding against surges and transients.

The primary and secondary windings shall be so placed that they remain electrically balanced with their magnetic centers coincident under all conditions of operation. The windings shall be so arranged and so firmly clamped in position that they will withstand the mechanical stresses to which they might be subject on short circuit.

Provision shall be made for taking up any contraction of windings due to shrinkage of insulation materials in order to eliminate movement of any coil due to short circuit, vibration or other sources of disturbance.

All windings, after being wound, and all fibrous and hygroscopic material used in the construction of the transformer shall be dried under vacuum and impregnated with purified and degassed oil under vacuum.

Adequate provision shall be made for the circulation of the oil around and between the windings, so that a very low temperature gradient between the conductors and the oil is assured and any danger of excessive local heating is eliminated. Spacing blocks shall be provided between section of the windings to ensure circulation of the oil and to ensure that the windings present a sufficient contact surface to the oil.

The general design and construction of the transformer and the bracing of the windings shall be such that no mechanical movement of the coil is possible as a result of the dead short circuit on any side of the transformer. The transformer shall withstand, without injury, the dead short circuit for a duration of at least three (3) seconds.

2.2.10 Bushing

The bushings for the line terminals of both 230 kV and 121 kV sides shall be of oil impregnated paper condenser type outdoor-oil bushings. The bushing for the neutral terminal shall be of oil filled type. The porcelain of each bushing shall be brown-glazed and the glaze shall be uniform throughout the surface.

The neutral terminal of the auto-connected winding shall be connected with a copper conductor of bar or rod or pipe, which shall run down to ground, supported by insulators on the transformer tank. The neutral conductor shall be fitted with a terminal for the grounding wires of two 95 sq. mm stranded copper.

Each bushing shall be provided with suitable type terminals for connecting the following conductors:

230 kV side:	Hard-drawn copper conductor (HDCC) of 400 mm^2
121 kV side:	Hard-drawn copper conductor (HDCC) of 240 mm^2

2.2.11 Tank

The construction of the transformer tank; three-phase or three-subdivided three-phase type, shall be determined by the Contractor on the basis of physical size and weight limitations imposed by shipping and transporting restrictions as specified.

Three-subdivided three-phase type transformer may be so constructed that the lower tank is separated to each phase and the upper tank is common for all three phases, which are connected internally. Three single-phase transformers will not be acceptable.

The core and winding assembly shall be completely enclosed and securely held in a tank made of stout steel plates. The tank(s) shall be of welded construction suitably stiffened by means of channel or angle section, and shall be absolutely water and hot oil tight and suitable for vacuum drying.

The tank shall be provided with oil sampling valve, oil drain valve, oil fill valve, air vent plug and explosion vent. The valves shall have fittings suitable for connecting the existing oil purifier. An oil discharge pipe shall be provided to lead the oil gushed out from the explosion vent to the ground level.

A pressure relief device with alarm contacts shall be provided on the explosion vent and shall be connected to the discharge pipe.

The tank shall also be provided with jacking bosses or recesses to permit the use of jacks and shall be provided with pulling lugs to facilitate transferring it in the longitudinal and transverse directions.

Necessary lugs and shackles shall be provided to enable each tank to be handled by a crane or other means, and shall be so located that safe clearance is obtained between the slings and transformer bushing without use of a spreader.

The top cover of the tank shall be designed to remove the bushing easily and to make the winding connection easily.

The inside of the tank and all steel connections shall be sand or shot blasted. The tank internal surface and the metallic part of the core and winding assembly shall be coated with

white paint so as to observe dust accumulation.

One or more manholes or handholes shall be provided to permit easy access to the bushings and the terminals.

Two suitable grounding pads for two 95 mm^2 stranded copper conductors shall be welded to the bottom of each tank.

2.2.12 Cooling System

The cooling method of the auto-transformer shall be forced oil circulation and forced air cooled system (OFAF). The forced directed oil circulation system (OD) will also be acceptable. The cooling equipment shall consist of finned-tube radiators, oil pumps and cooling fans. The cooling equipment shall be divided into several units including one stand-by unit and shall have sufficient capacity, without the stand-by unit, not only to maintain the insulating oil at proper temperature under the specified service condition but also to prevent overheating the transformer when operating continuously with the rated power.

The radiator units shall be fitted directly to the tank of the transformer and shall be arranged so as to provide uniform and effective circulation of the oil through the transformer windings. Each radiator unit shall be provided with radiator valves at the oil inlet and outlet connections so as to permit its removal without draining the oil from the tank. Each radiator unit shall be equipped with suitable lifting lugs or shackles to facilitate handling.

The radiators shall be designed for safe operation at an oil pressure of 2.0 kg/cm^2. The finned-tube type radiators shall be made of corrosion resistant materials.

An oil pump shall be provided on each radiator unit and located below the unit. The oil pump shall be designed to prevent cavitation pitting. An oil-immersed motor shall be incorporated with the oil pump integrally in a totally enclosed casing to prevent oil leakage. Suitable stop valves shall be provided on both sides of each pump for easy maintenance. The oil pumps shall be provided with suitable oil filters at the oil inlet to prevent foreign materials such as the transformer insulation materials and spaces from entering into the oil pump.

The oil pumps, the cooling fans and their motors shall be of an approved design, suitably rated for continuous service under the site conditions, and their operating noise and vibration shall be kept to a minimum level. Each motor for the oil pumps and the cooling fans shall be equipped with an individual overload protective measure with alarm contacts.

An oil flow indicator with low-flow alarm contact shall be provided for each radiator unit and located between radiator and oil pump.

The power source for the oil pumps and the cooling fans shall be 380 V three-phase or 220 V single-phase, 50 Hz and shall be taken from the AC distribution panel in the powerhouse. The power cables for the pumps and fans shall be supplied by the Contractor.

2.2.13 Oil Preservation System

The transformer shall be provided with diaphragm type oil preservation system with an oil-resistant synthetic rubber air cell in the conservator to completely isolate the insulating oil from atmospheric air.

The system shall be provided with a dehydrating breather having sufficient size to prevent moisture condensation of air in the air cell of conservator. The dehydrating breather shall consist of moisture absorbent and its container of transparent materials to enable the extent of the moisture absorption of the moisture absorbent from the outside.

A dial-type oil level gauge with low-level alarm contact shall be mounted on the conservator at easily visible position from the ground level.

2.2.14 Tap-Changer

An on-load tap-changer shall be provided on the auto-transformer to maintain the secondary voltage (121 kV side) at the predetermined value by changing the tapping connection of the winding while the transformer is energized or on load.

The on-load tap-changer shall preferably be of resistor type consisting of diverter switch, transition resistor, tap selector and change-over switch.

The diverter switch and the transition resistor shall be provided in a separate oil chamber to be attached with the transformer main tank, so that the oil in the separate chamber should completely be isolated from the oil in the main tank. The diverter switch and the transition resistor shall be arranged to provide ready access for inspection and maintenance without draining the oil of the main tank.

The separate oil chamber shall be provided with the following equipment:

(a) An own oil preservation system of similar design to the oil preservation system specified in Clause 2.2.13.

(b) An explosion vent having a pressure relief device with alarm contacts.

(c) A sudden oil flow relay with alarm contacts.

(d) An on-load oil purifier on the transformer tank to always keep the oil clean.

The selector switch and the change-over switch shall be incorporated in the transformer tank.

All arcing contacts shall be made of special arc resisting alloy to ensure long contact life with minimum maintenance.

The driving mechanism of the on-load tap-changer shall be so designed that once the tap-changer is actuated, it must proceed until the tap changing operation is completed without interruption even when the power supply to the mechanism is failure. Necessary provisions shall be made on the mechanism to prevent over-running and consequent damage to it. The driving mechanism and motor shall be provided with suitable protection measures. The power source for the driving motor shall be 380 V three-phase or 220 V single-phase, 50 Hz to be taken from the AC distribution panel in the powerhouse control room.

Besides the motor-driven mechanism, a hand operating measure shall be provided in the mechanism for manual operation. The hand operating mechanism shall be so designed that when the manual operating handle is inserted, the motor circuits should automatically be disconnected and the motor gearing should be disengaged to ensure safety of the operator, and all the motor circuits and gearing should automatically be restored to their ready-to-operate condition when the manual operating handle is removed.

The control system of the on-load tap-changer shall be designed to permit automatic control, remote electrical control, local manual control and hand operation. The automatic control shall be made by action of an adequate voltage regulating relay to be connected to the 110 kV voltage transformer. The remote electrical control shall be made remotely from the main control board to be provided by the other contractor in the control room of the powerhouse. The local manual control shall be made on the front of a driving mechanism panel to be mounted on the transformer.

The driving mechanism panel shall be provided with push-buttons for local tap-changing control, a selector switch with "Remote" and "Local" for selection of control place, tap position indicators, and a mechanical operation counter.

The automatic control shall be available only when the selector switch on the driving mechanism panel is set to "Remote" position. While the on-load tap-changer is operating under the automatic control mode, all the other control modes and hand operation shall be disengaged.

2.2.15 Base

The transformer shall be provided with skid base of fabricated structural steel to be embedded in the concrete foundation for installation of the transformer.

Setting of the skid base will be done by the Employer under supervision of the Contractor.

2.2.16 Protection and Alarm

The following protection and alarm shall be provided on the auto-transformer:

(a) Buchholtz relay (first stage and second stage); for alarm at first stage relay operating and trip at second stage relay operating

(b) Sudden oil flow relay for on-load tap changer; for trip

(c) High oil temperature for top-oil and windings; for alarm

(d) Low oil level; for alarm

(e) Pressure relief device on either main tank or separate oil chamber for on-load tap-changer; for alarm

(f) Low oil flow; for alarm

(g) Oil pumps or cooling fans troubled; for alarm

(h) Cooling system circuit low voltage; for alarm

A Buchholtz relay shall be fitted on connecting pipe between the conservator and the tank with alarm and trip contacts suitable for 220 V DC, and isolating valves shall be inserted on the both sides of the Buchholtz relay. The Buchholtz relay shall be equipped with a testing cock and a gas release cock.

The control source for the relays shall be 220 V DC to be taken from the DC distribution panel in the powerhouse control room.

Electrical protective relays for the auto-transformer protection will be provided by the other contractor.

2.2.17 Thermometer and Temperature Detector

The dial type indicating thermometers with maximum temperature pointer, calibrated in centigrade, and equipped with alarm contacts suitable for 220 V DC, shall be provided to indicate both the top oil and winding temperatures.

The thermometer shall be of vapor pressure type or mercury filled type and variation of the volume or pressure arising from temperature change shall be transmitted to a Bourdon tube fitted to the indicator through the capillary tube of the flexible interconnecting pipe. The

sensing bulb of the thermometer shall be installed at the hottest oil near the top of the tank. The dial type indicators shall be mounted on the tank or the control cabinet specified in Clause 2.2.19 below.

The current proportional to the load of the transformer; which is necessary for the winding temperature measurement, shall be supplied from the built-in current transformer specified in Clause 2.2.18 below.

Each transformer shall be provided with resistance type temperature detectors of 100 ohm at 0 °C of platinum element for temperature measurements of the top oil and winding. These oil and winding temperatures will be indicated on the control boards to be provided by the other contractor in the powerhouse control room. The resistance type temperature detectors shall be wired to the terminals of the control cabinet for connection to the control boards. Control cables between the detector and the control boards and necessary transducers will be supplied by the other contractor.

2.2.18 Built-in Current Transformers

The auto-transformer shall be equipped with single-ratio ring-core type current transformers in each bushing. The current transformers shall be rated as follows:

(1) 230 kV line bushing

(a)	Quantity - for protective relaying	 3 cores
(b)	Rated current ratio	400/5 A
(c)	Rated output	30 VA
(d)	Rated short-time thermal current	20 kA for one (1) second
(e)	Accuracy class - for protective relaying	 5P10

I addition, one ring-core type current transformer with suitable current ratio shall be provided in the 230 kV line bushing for the thermal image type winding thermometer of the 230 kV winding. The rating of this current transformer shall be determined by the Contractor and shall be subject to the Engineer's approval.

(2) 121 kV line bushing

(a) Quantity