

- for measuring 1 core
- for protective relaying 2 cores
- (b) Rated current ratio 800/5 A
- (c) Rated output 30 VA
- (d) Rated short-time thermal current 25 kA for one (1) second
- (e) Accuracy class
 - for measuring 1.0
 - for protective relaying 5P10
- (3) Neutral bushing
 - (a) Quantity
 - for protective relaying 2 cores
 - (b) Rated current ratio 200/5 A
 - (c) Rated output 30 VA
 - (d) Rated short-time thermal current 25 kA for one (1) second
 - (e) Accuracy class
 - for protective relaying 5P10

2.2.19 Control Cabinet

One weather-proof type control cabinet shall be mounted on the transformer tank for control of the cooling system.

Necessary starters, molded case circuit breakers with alarm contacts, auxiliary relays, contacts, control switches, terminals and other equipment shall be mounted and wired in the control cabinet. A "Manual-Off-Auto" selector switch shall be provided for the operation of the oil pumps and cooling fans. Automatic start-stop operation of the cooling system shall be controlled by the winding temperature.

The group fault annunciator shall be provided on the control cabinet for the annunciation of the actuated protective relays and abnormal conditions listed in Clause 2.2.16. The group fault annunciator shall be of target type indicator with a reset switch.

Each item of the protection and alarm specified in Clause 2.2.16 shall be provided with potential-free contact for remote indication.

Potential-free contacts for operation of the oil pumps and the cooling fans and for cabinet door close shall also be provided in the control cabinet.

The control and annunciation system shall be suitable for 220 V DC. The DC power shall be taken from the DC distribution panel to be located in the powerhouse control room.

The control cabinet shall contain the terminals for connections of all alarm contacts and controls. It shall be equipped with removal bottom plate of suitable size to be drilled at the Site as required for conduits and cables. The space below the cabinet shall be kept free of obstructions, which would interface with conduit connections.

Space heaters for 220 V single-phase or 380 V three-phase AC shall be provided inside the cabinet to prevent moisture condensation. A manual switch to control the heaters shall be provided on the cabinet.

The cabinet door shall be provided with suitable handles with locks and equipped with a door switch for remote annunciation of door open.

All control cables between the control cabinet and the powerhouse control room will be supplied by the other contractor.

2.2.20 Accessories

The following accessories shall be provided:

- (a) Rating plate and connection diagrams with full details of rating in English.
- (b) Operating device for tap-changer
- (c) A ladder on the side of the tank to provide access for safe inspection while the transformer is energized. A barrier and locking device shall be equipped on the lower section of the ladder.
- (d) Clamp type grounding pad, two for each lower transformer tank
- (e) Dispatching number plate holder
- (f) Special tools for erection and maintenance including jacking device
- (g) Other necessary accessories

2.2.21 Spare Parts

The following spare parts for the auto-transformer shall be furnished and quoted separately.

(1) Transformer

- (a) One (1) bushing of each type with conductor and terminal
- (b) One (1) complete set of gaskets
- (c) Two (2) sets of bursting plates with gaskets
- (d) One (1) set of dial type thermometers with gaskets
- (e) One (1) set of thermal image type thermometers with gaskets
- (f) One (1) set of oil level gauge with gaskets
- (g) One (1) set of oil pump and motor with gaskets
- (h) One (1) set of cooling fan and motor with gaskets
- (i) 100% of moisture absorbent
- (j) Other spare parts recommended by the manufacturer

The tenderer shall give a list of recommended spare parts together with the price of each item, based on the quantity needed for four years operation of the transformer.

Whether the recommended spare parts are purchased or not will be decided by the Employer before signing the contract.

(2) Control equipment for transformer

- (a) 100% of actual use of lenses for signal lamp of each type
- (b) 500% of actual use of bulbs for signal lamp of each type
- (c) 500% of actual use of fuses of each type
- (d) One (1) set of replacement components for the control equipment associated with the equipment supplied under this Contract such as valves, seats, thermostats and pressure serving elements, switches, rectifiers, resistors, transistor cards of each type for cooling system control cabinet and on-load tap-changer local driving mechanism panel.

2.2.22 Tests

(1) Shop tests

The following tests shall be carried out at the manufacturer's works in the presence of the Employer and the Engineer, in compliance with IEC recommendations unless otherwise specified herein.

- (a) Appearance check
- (b) Measurement of winding resistance at each tap
- (c) Measurement of voltage ratio on all taps
- (d) Check of phase relationship and polarity
- (e) Measurement of impedance voltage on each tap
- (f) Measurement of load loss at rated current
- (g) Measurement of no-load loss and current
- (h) Induced overvoltage withstand test
- (i) Power-frequency voltage withstand tests
- (j) Lightning impulse test (full-wave and chopped wave)
- (k) Temperature rise test
- (l) Test for built-in current transformers, including measurement of current ratio and check of relative polarities.
- (m) Auxiliary power input measurement
- (n) Oil pressure test for coolers
- (o) Operation tests for cooling equipment and on-load tap-changer
- (p) Tests for instruments
- (q) Calculation of efficiency and voltage regulation
- (r) Mechanical test for tank
 - Oil tightness check

- Vacuum test

- (s) Measurement of acoustic sound level
 - (t) Short circuit test (Calculation sheets may be acceptable)
- (2) Test at site

After the auto-transformer has been installed completely at site, the tests specified in Clause 1.9.2 of the General Specifications shall be carried out by the Contractor.

2.3 115/22 (15) KV MAIN TRANSFORMER

2.3.1 Type and Ratio

Each 115/22 (15) kV main transformer shall be of three-phase, oil immersed, three-winding, sealed, outdoor use type transformer with a stabilizing delta-connected winding. Each main transformer shall be provided with a tapped 115 kV winding having altogether 17 tappings, symmetrically placed, and the no-load ratio between the primary and secondary windings shall be $(115 \text{ kV} \pm 8 \times 1.5 \%) / 22(15) \text{ kV}$. The connection of the secondary winding shall be changeable for the rated voltages of 22 kV and 15 kV.

The transformer connection of the main transformer shall be YNyn0(y_n0)d1 of IEC 76-1 (1993) and the neutral of the both star connected windings shall be brought out for solid grounding.

2.3.2 Rated Power

The rated power of the main transformers for each 110 kV substations shall be as follows:

- (a) for Phan Thiet Substation: 25,000 kVA
- (b) for Thap Cham, Phan Ri, Cam Ranh
and Dien Khanh Substations 16,000 kVA

The above rated power values are specified under natural 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 main transformer.

2.3.3 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: 65 K by resistance method

2.3.4 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.

2.3.5 Insulation Levels

The transformers shall withstand the following voltages:

(1) 115 kV side:

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

(2) 22 kV side:

- Full-wave lightning impulse
1.2 x 50 micro-second 125 kV
- Power-frequency for one minute 50 kV

(3) Neutral terminals to be directly grounded:

- Power-frequency for one minute at least 38 kV

2.3.6 Impedance Voltage

Impedance voltage between the primary (115 kV side) and secondary (22 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.

2.3.7 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.

2.3.8 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.

2.3.9 Windings and Insulation

Full insulation shall be applied to all the windings. Graded insulation for the 115 kV star-connected windings will be acceptable on condition that a suitable surge arrester should be provided for the neutral point of each transformer under this Clause.

The connection of the secondary winding shall be changeable for the rated voltages of 22 kV and 15 kV and shall have a mechanism designed to be changed over easily from the outside of the transformer by a switch and the like. Such switch shall be enclosed in a suitable box with a lockable door.

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 winding 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.

2.3.10 Bushing

The bushings for the line terminals of 115 kV side shall be of oil impregnated paper condenser type outdoor-oil bushings. The bushing for the neutral terminal shall be of oil filled type. The bushings for the 22 kV side shall be of solid single-piece porcelain type. The porcelain of each bushing shall be brown-glazed and the glaze shall be uniform throughout the surface.

The neutral terminal of the 115 kV and 22 kV windings 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:

115 kV side: Hard-drawn copper conductor (HDCC) of 180 mm²

22 kV side: 12/20 kV, 800 mm², single core, crosslinked polyethylene

(XLPE) insulated cables, to be supplied under Section 6.

2.3.11 Tank

The three-phase tank shall be applied to each main transformer.

The core and winding assembly shall be completely enclosed and securely held in a tank made of stout steel plates. The tank 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. A bus duct of elephant, air-insulated type shall be provided on each main transformer at the 22 kV side terminals for cable connection. The bus duct shall be extended up to the ground level.

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 oil purifier to be supplied under Clause 3.4. 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 the 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 tank cover shall be designed so that the bushings can be easily removed and connections to the windings can be easily made.

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 mm² stranded copper conductors shall be welded to the bottom of each tank.

2.3.12 Cooling System

The cooling method of the main transformer shall be natural oil circulation and forced air cooled system (ONAF). The cooling equipment shall consist of finned-tube radiators 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/cm². The finned-tube type radiators shall be made of corrosion resistant materials.

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 cooling fans shall be equipped with an individual overload protective measure with alarm contacts.

The power source for the cooling fans shall be 400 V three-phase or 230 V single-phase, 50 Hz and shall be taken from the AC distribution panel to be supplied under Section 4. The power cables for the fans shall be supplied by the Contractor.

2.3.13 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.

2.3.14 Tap-Changer

An on-load tap-changer shall be provided on the auto-transformer to maintain the secondary voltage (22 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 2.3.13.
- (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 400 V three-phase or 230 V single-phase, 50 Hz to be taken from the AC distribution panel to be supplied in the control house under Section 4.

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. 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.

2.3.15 Base

Each main 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.

2.3.16 Protection and Alarm

The following protection and alarm shall be provided on each main 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 110 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 110 V DC to be taken from the DC distribution panel to be provided in the control house under Section 3.

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

2.3.18 Thermometer and Temperature Detector

The dial type indicating thermometers with maximum temperature pointer, calibrated in centigrade, and equipped with alarm contacts suitable for 110 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 2.3.19 below.

The current proportional to the load of the transformer; which is necessary for the winding temperature measurement, shall be supplied from the current transformer specified in Clause 2.3.18 below.

2.3.18 Current Transformers

Each main transformer shall be equipped with single-ratio current transformers in the neutral circuits of the 115 kV and 22 kV windings, for ground protection of the main transformer. The current transformers shall preferably be the built-in type in the bushings. The current transformers shall be rated as follows:

(1) Neutral circuit of 115 kV winding

- | | |
|---|--------------------------|
| (a) Highest system voltage | 123 kV |
| (b) Rated current ratio | 100/5 A |
| (c) Rated output | 30 VA |
| (d) Rated short-time thermal current | 25 kA for one (1) second |
| (e) Accuracy class
- for protective relaying | 5P10 |

(2) Neutral circuit of 22 kV winding

- | | |
|---|--------------------------|
| (a) Highest system voltage | 24 kV |
| (b) Rated current ratio | 200/5 A |
| (c) Rated output | 30 VA |
| (d) Rated short-time thermal current | 25 kA for one (1) second |
| (e) Accuracy class
- for protective relaying | 5P10 |

In addition, one current transformer with suitable current ratio shall be provided on the 115 kV line circuit for the thermal image type winding thermometer of the 115 kV winding. The rating of this current transformer shall be determined by the Contractor and shall be subject to the Engineer's approval.

2.3.19 Control Cabinet

One weather-proof type control cabinet shall be mounted on each transformer for control of the cooling system.

Necessary starters, molded case circuit breakers with alarm contacts, auxiliary relays, contacts, control switches, terminals and other equipment shall be mounted and wired in the control cabinet. A "Manual-Off-Auto" selector switch shall be provided for the operation of the cooling fans. Automatic start-stop operation of the cooling system shall be controlled by the winding temperature.

The group fault annunciator shall be provided on the control cabinet for the annunciation of the actuated protective relays and abnormal conditions listed in Clause 2.3.16. The group

fault annunciator shall be of target type indicator with a reset switch.

Each item of the protection and alarm specified in Clause 2.3.16 shall be provided with potential-free contact for remote indication.

Potential-free contacts for operation of the cooling fans and for cabinet door close shall also be provided in the control cabinet.

The control and annunciation system shall be suitable for 110 V DC. The DC power shall be taken from the DC distribution panel to be provided in the control room under Section 3.

The control cabinet shall contain the terminals for connections of all alarm contacts and controls. It shall be equipped with removal bottom plate of suitable size to be drilled at the Site as required for conduits and cables. The space below the cabinet shall be kept free of obstructions, which would interface with conduit connections.

Space heaters for 230 V single-phase or 400 V three-phase AC shall be provided inside the cabinet to prevent moisture condensation. A manual switch to control the heaters shall be provided on the cabinet.

The cabinet door shall be provided with suitable handles with locks and equipped with a door switch for remote annunciation of door open.

All control cables between the control cabinet and the control room shall be supplied by the Contractor under Section 5.

2.3.20 Accessories

The following accessories shall be provided for each main transformer:

- (a) Rating plate and connection diagrams with full details of rating in English.
- (b) Operating device for tap-changer
- (c) A ladder on the side of the tank to provide access for safe inspection while the transformer is energized. A barrier and locking device shall be equipped on the lower section of the ladder.
- (d) Clamp type grounding pad, two for each lower transformer tank
- (e) Dispatching number plate holder
- (f) Special tools for erection and maintenance including jacking device

- (g) Other necessary accessories

2.3.21 Spare Parts

The following spare parts shall be furnished for each main transformer and quoted separately.

- (1) Each main transformer
 - (a) One (1) bushing of each type with conductor and terminal
 - (b) One (1) complete set of gaskets
 - (c) Two (2) sets of bursting plates with gaskets
 - (d) One (1) set of dial type thermometers with gaskets
 - (e) One (1) set of thermal image type thermometers with gaskets
 - (f) One (1) set of oil level gauge with gaskets
 - (g) One (1) set of oil pump and motor with gaskets
 - (h) One (1) set of cooling fan and motor with gaskets
 - (i) 100% of moisture absorbent
 - (j) Other spare parts recommended by the manufacturer

The tenderer shall give a list of recommended spare parts together with the price of each item, based on the quantity needed for four years operation of the transformer.

Whether the recommended spare parts are purchased or not will be decided by the Employer before signing the contract.

- (2) Control equipment for each main transformer
 - (a) 100% of actual use of lenses for signal lamp of each type
 - (b) 500% of actual use of bulbs for signal lamp of each type
 - (c) 500% of actual use of fuses of each type
 - (d) One (1) set of replacement components for the control equipment associated with the equipment supplied under this Contract such as valves, seats, thermostats and

pressure serving elements, switches, rectifiers, resistors, transistor cards of each type for cooling system control cabinet and on-load tap-changer local driving mechanism panel.

2.3.22 Tests

(1) Shop tests

The following tests shall be carried out at the manufacturer's works in the presence of the Employer and the Engineer, in compliance with IEC recommendations unless otherwise specified herein.

- (a) Appearance check
- (b) Measurement of winding resistance at each tap
- (c) Measurement of voltage ratio on all taps
- (d) Check of phase relationship and polarity
- (e) Measurement of impedance voltage on each tap
- (f) Measurement of load loss at rated current
- (g) Measurement of no-load loss and current
- (h) Induced overvoltage withstand test
- (i) Power-frequency voltage withstand tests
- (j) Lightning impulse test (full-wave and chopped wave)
- (k) Temperature rise test
- (l) Test for built-in current transformer, including measurement of current ratio and check of relative polarities.
- (m) Auxiliary power input measurement
- (n) Oil pressure test for coolers
- (o) Operation tests for cooling equipment and on-load tap-changer
- (p) Tests for instruments

- (q) Calculation of efficiency and voltage regulation
 - (r) Mechanical test for tank
 - Oil tightness check
 - Vacuum test
 - (s) Measurement of acoustic sound level
 - (t) Short circuit test (Calculation sheets may be acceptable)
- (2) Test at site

After the main transformer has been installed completely at site, the tests specified in Clause 1.19.2 of the General Specifications shall be carried out by the Contractor.

2.4 200 kVA House-Service Transformers

2.4.1 Type and Ratio

Each house-service transformer shall be of three-phase, dry epoxy-resin molded, copper or aluminium conductor windings, self-cooled, indoor use type. The house-service transformer shall be provided with a tapped 22(15) kV winding having altogether 3 tappings, symmetrically placed, and the no-load ratio shall be $22(15) \text{ kV} \pm 1 \times 5\%/400 - 230 \text{ V}$ of three-phase four-wire system. The connection of the primary winding shall be changeable for the rated voltages of 22 kV and 15 kV.

The transformer connection of the house-service transformer shall be D(D)Yn11 of IEC 76-1 (1993) and the neutral of the star connected winding shall be brought out for solid grounding.

The house-service transformer shall be housed in a metal enclosed cubicle of robust construction.

2.4.2 Rated Power

The continuous rated power of each house-service transformer shall be 200 kVA on any of the taps.

2.4.3 Temperature-Rise Limit

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

- | | |
|----------------------------|-------|
| (a) For class B insulation | 80 K |
| (b) For class F insulation | 100 K |
| (c) For class H insulation | 125 K |

2.4.4 Insulation Levels

The house-service transformers shall withstand the following voltages:

(1) 22 kV side:

- Full-wave lightning impulse
1.2 x 50 micro-second 125 kV
- Power-frequency for one minute 50 kV

(2) 400 V side:

- Full-wave lightning impulse
1.2 x 50 micro-second -
- Power-frequency for one minute 3 kV

2.4.5 Impedance Voltage

Impedance voltage shall be about 5 % 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.

2.4.6 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 and clamped securely with suitable method. 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, the core shall be provided with air ducts.

The core shall be electrically connected to the transformer base.

2.4.7 Windings and Insulation

Full insulation shall be applied to all windings.

The windings shall be of high conductivity copper or aluminium and shall be insulated with insulation materials of Class B, F or H.

The amount of insulation shall be determined not merely by normal voltage per turn but also by due consideration of the line voltage and the service conditions, including surges during switching and fault conditions.

The insulation of the end turns of each winding adjacent to the transformer terminals shall be reinforced between turns or provided with suitable means to protect the winding against surges and transients.

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.

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, a complete short circuit for a duration of at least three (3) seconds.

2.4.8 Terminals

Each house-service transformer shall be provided with suitable type terminals for connecting the following conductors:

22(15) kV side: 12/20 kV, 120 mm², three-core, crosslinked polyethylene (XLPE) insulated cable with compression type terminals, to be supplied under Section 6.

400 V line side: 0.6/1.0 kV, 70 mm², three-core, crosslinked polyethylene (XLPE) insulated cable with compression type terminals, to be supplied under Section 6.

400 V neutral side: 0.6/1.0 kV, 70 mm², single-core, crosslinked polyethylene (XLPE) insulated cable with compression type terminals, to be supplied under Section 6.

Suitable means shall be provided for supporting the terminals and cables in the cubicle.

2.4.9 Metal Enclosure

Each house-service transformer shall be housed in a metal enclosed cubicle of robust construction. The cubicle shall have a sufficient opening of ventilation for natural cooling

system of transformer with degree of protection of IP20 or high degree. Front doors and other necessary accessories shall be provided for the cubicle.

The transformer cubicle shall be located in the cubicle room in the control house of each substation and shall preferably be aligned with the 22 kV cubicles to be supplied under Section 3. The transformer cubicle shall be constructed suitable for alignment with the 22 kV cubicles.

One grounding pad for 95 mm² copper conductor, shall be welded to the base of the transformer.

2.4.10 Tap-Changer

Each house-service transformer shall be equipped with an off-circuit tap-changer on 22(15) kV side with taps at 22(15) kV $\pm 1 \times 5\%$. The tap-changer shall be capable of operating under off-circuit condition from the outside of the transformer.

Tap position must be clearly indicated and means of locking shall be provided. All taps shall be rated for full output.

2.4.11 Thermometer

A dial type indicating thermometer calibrated in centigrade and equipped with maximum pointer and high temperature alarm contacts suitable for 110 V DC shall be provided for indicating the temperature of winding at the convenient location on the transformer cubicle.

The winding temperature will be measured as the temperature of air between the primary and the secondary windings.

The alarm contacts shall be brought out to the terminals provided in the transformer cubicle for control cable connection to the annunciation system to be established in the control room under Section 5.

2.4.12 Wheels

Roller wheels shall be equipped on the transformer base to facilitate handling the house-service transformer in and out of the cubicle.

The transformer shall be fixed on the foundation by means of appropriate devices after placing in position.

2.4.13 Neutral Current Transformer

The house-service transformer shall be equipped with a neutral current transformer on the neutral circuit of the secondary winding for earth leakage fault detection on the 400-230 V circuits and to provide an alarm to the control room.

The neutral current transformer shall have suitable magnetic flux saturation characteristics against complete ground fault on the 400 V circuit with solidly grounding system, to protect the instruments connected to the current transformer secondary circuit from undesirable induced overcurrent by the use of saturable current transformer with air gap, etc.

2.4.14 Accessories

The following accessories shall be provided for each house-service transformer:

- (a) Rating plate and connection diagrams with full details of rating in English.
- (b) Terminal box for connections of all alarm contacts and control.
- (c) Clamp type grounding pad.
- (d) Channel base for the metal enclosure.
- (e) Foundation bolts and nuts.
- (f) Nameplate on the metal enclosure.
- (g) Other necessary accessories.

2.4.15 Spare Parts

The following spare parts shall be furnished for each house-service transformer and quoted separately:

- (a) One (1) dial type thermometer.
- (b) One (1) set of spares recommended by the manufacturers

2.4.16 Tests

- (1) Shop tests

The following tests shall be carried out at the manufacturer's works in the presence of the Employer and the Engineer, in compliance with IEC recommendations unless otherwise specified herein.

- (a) Appearance check
 - (b) Measurement of winding resistance at each tap
 - (c) Measurement of voltage ratio on all taps
 - (d) Check of phase relationship and polarity
 - (e) Measurement of impedance voltage on each tap
 - (f) Measurement of load loss at rated current
 - (g) Measurement of no-load loss and current
 - (h) Power-frequency voltage withstand test
 - (i) Lightning impulse test of full-wave
 - (j) Temperature rise test.
- (2) Test at site

After the house-service transformer has been installed completely at site, the tests specified in Clause 1.19.2 of the General Specifications shall be carried out by the Contractor.

2.5 Oil Handling and Purifying Equipment

2.5.1 General

During treatment of insulating oil of the transformers, the oil transported or stored in 200-liter metal drums will be transferred to an insulating oil tank. An oil transfer pump and strainer will be used to handle the insulating oil. A vacuum oil purifier will be used to remove contaminating gases, sludge, insoluble solids and moisture from insulating oil. An oil tester will also be used for the insulating oil.

The electric source for oil handling and purifying equipment shall be 400 V three-phase or 230 V single-phase, 50 Hz.

2.5.2 Oil Transfer Pump and Strainer

One oil transfer pump shall be provided and rated to handle the most viscous oil at the lowest average daily ambient temperature. The pump shall have a discharge rate of about 100 liters per minute when pumping oil to the top oil level of the transformer. The pump pressure rating

shall include an allowance for hydraulic losses in the hoses, connecting pipes and filter. The pump shall be provided with a relief valve connected to discharge to the pump suction and set to protect the pump from over-pressure. A pressure gauge shall be provided to the pump discharge and shall be fitted with a filter-pulsation damper. The pump shall be driven by an electric motor.

The transfer pump and strainer shall be mounted on a mobile cart. The cart shall be provided with oil resistant tired casters, lifting lugs and pull bar. Racks shall be provided on the cart for storing hoses and the electrical power cable.

A suction and a discharge oil resistant hose shall be provided, each about 20 meters in length for connection to the pump, strainer and oil sumps or transformers. These hoses shall also be used for connecting the oil purifier to the sump or the transformer. All hose connections shall be of the swivel coupling type, and corresponding adapters and coupling valves shall be provided on the sump for fill and drain connection.

An electrical oil resistant insulated cable of 25 meter length shall be provided with a metal plug suitable for the outlets.

The strainer shall be mounted on the mobile cart and shall be rated for the transfer pump discharge at corresponding viscosity. The strainer shall be fitted with a differential pressure gauge and the body shall be rated for the pressure setting of the pump relief valve. The filtering medium shall be of non-corrosion metal or synthetic fiber and shall be cleanable. The filter shall effectively remove particles of 0.25 mm size up to 98 percent and shall, when 2/3 blocked, pass the rated flow at a differential of 1 kg/cm². The filter element shall not blow out or fail at this differential pressure and shall not form channels which will conduct the flow. The strainer body shall have a suitable drain, supports and easy means of access to the filter element. A suitable flexible connection shall be provided between the pump and strainer.

2.5.3 Vacuum Oil Purifier

A vacuum oil purifier shall be provided to dehydrate, de-aerate, purify and filter the transformer insulation oil. The Purifier shall be complete with all components, controls, valves thermostats, pumps, motors, starters, relays, filters etc., required to control the unit and ensure the removal of water to a concentration of 10 ppm and of solids greater than a particle size of one micron. The capacity of the unit shall be within the range from 5,000 to 6,000 liters per hours.

In the purifier uses disposal filtering or oil dispersion material, the Contractor shall supply with the unit not less than 5 years supply of such material. The quantity of filtering material

shall be sufficient to allow changing the filtering media after an annual treatment of the oil for the transformers. The filtering media shall be changed after the treatment of the quantity for oil in each sump or system.

The purifier shall be movable and provided with all attachments appropriate to obtaining easy maneuverability and to locating the purifier adjacent to the transformers.

2.5.4 Oil Tester

A portable dielectric oil tester shall be provided. The rating shall be about 10 kW, with maximum capacity of a test voltage of 60 kV. The test voltage shall be adjustable by the voltage regulator and indicated on a voltmeter with maximum voltage pointer. The unit shall be complete with switches, instruments and accessories.

2.5.5 Transfer Cart

The Contractor shall supply a transfer cart of steel construction with oil resistance tired casters, lifting lugs and pull bar. The transfer cart shall be designed to carry two 200-liter shipment containers.

2.5.6 Spare Parts

The following spare parts shall be furnished and quoted.

- (1) One (1) set of replacement seals and gaskets for pumps and valves of the oil purifier and pump
- (2) One (1) set of replacement bearing or bushings, including one of each size and type used in the pumps, motors, wheels or other rotating component of the equipment supplied under Clause 2.5.3.
- (3) One (1) set of replacement components for the control equipment associated with the equipment supplied under Clause 2.5.3, such as contactors, relays, valve springs, and seats, thermostat and pressure switch serving element.
- (4) Other spare parts recommended by the manufacturer

The tenderer shall give a list of recommended spare parts together with the price of each item, based on the quantity needed for four years operation of the equipment. Whether the recommended spare parts are purchased or not will be decided by the Employer before signing of the Contract.

2.5.7 Tests

The following tests shall be carried out at the manufacturer's works in compliance with this Specifications:

- (1) Construction check
- (2) Operation test
- (3) Treatment characteristic test
- (4) Continuous operation and leakage test
- (5) Power-frequency voltage withstand test

SECTION 3

TECHNICAL SPECIFICATIONS FOR SWITCHGEAR

3.1 GENERAL

3.1.1 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 switchgear to be installed in the Da Nhim Power Station, the Thap Cham Substation, the Phan Ri Substation, the Phan Thiet Substation, the Cam Ranh Substation and the Dien Khanh Substation.

(1) Da Nhim Power Station

(a) 230 kV switchgear

i) Three (3) surge arresters for 230/121 kV transformer circuit

(b) 110 kV switchgear

The 110 kV bus connection will employ the single bus scheme.

i) Two (2) circuit breakers

ii) One (1) disconnecter having two earthing switches for 230/121 kV transformer circuit

iii) Two (2) disconnectors, each of them having an earthing switch, for transmission line circuit

iv) One (1) coupling-capacitor voltage transformer for transmission line circuit

v) Three (3) current transformers for transmission line circuit

vi) Three (3) surge arresters for transmission line circuit

The existing surge arresters for the 230/121 kV transformer will be used as they were. In addition, the existing voltage transformers will be used by relocating to the 110 kV bus extension circuit.

(2) Thap Cham Substation

(a) 110 kV switchgear

The 110 kV bus connection will employ the single bus scheme.

- i) Four (4) circuit breakers
 - One for a 115/22 kV transformer circuit
 - Three for three transmission line circuits
- ii) One (1) disconnecter having two earthing switches for a 115/22 kV transformer circuit
- iii) Six (6) disconnectors, each of them having an earthing switch, for three transmission line circuits
- iv) One (1) disconnecter of single-phase type for neutral circuit of a 115/22 kV transformer primary
- v) Three (3) capacitor voltage transformers for a 110 kV bus circuit
- vi) Three (3) coupling-capacitor voltage transformers for three transmission line circuits
- vii) Twelve (12) current transformers
 - Three for a 115/22 kV transformer circuit
 - Nine for three transmission line circuits
- viii) Twelve (12) surge arresters
 - Three for a 115/22 kV transformer circuit
 - Nine for three transmission line circuits

(b) 22 kV switchgear

- i) One (1) set of 22 kV indoor switchgear assembly housed in metal-clad cubicles for the following circuits:
 - One 115/22 kV transformer circuit
 - One 22 kV bus circuit
 - Four 22 kV distribution line circuits
 - One house-service transformer circuit
- ii) Four (4) three-pole mechanically hand operated outdoor disconnectors to be

mounted on the dead end poles of four 22 kV distribution lines

- iii) Twelve (12) surge arresters to be mounted on the dead end poles of four 22 kV distribution lines

(3) Phan Ri Substation

(a) 110 kV switchgear

The 110 kV bus connection will employ the single bus scheme.

- i) Three (3) circuit breakers
 - One for a 115/22 kV transformer circuit
 - Two for two transmission line circuits
- ii) One (1) disconnecter having two earthing switches for a 115/22 kV transformer circuit
- iii) Four (4) disconnectors, each of them having an earthing switch, for two transmission line circuits
- iv) One (1) disconnecter of single-phase type for neutral circuit of a 115/22 kV transformer primary
- v) Three (3) capacitor voltage transformers for a 110 kV bus circuit
- vi) Two (2) coupling-capacitor voltage transformers for two transmission line circuits
- vii) Nine (9) current transformers
 - Three for a 115/22 kV transformer circuit
 - Six for two transmission line circuits
- viii) Nine (9) surge arresters
 - Three for a 115/22 kV transformer circuit
 - Six for two transmission line circuits

(b) 22 kV switchgear

- i) One (1) set of 22 kV indoor switchgear assembly housed in metal-clad cubicles for the following circuits:
 - One 115/22 kV transformer circuit
 - One 22 kV bus circuit

- Three 22 kV distribution line circuits
- One house-service transformer circuit
- ii) Three (3) three-pole mechanically hand operated outdoor disconnectors to be mounted on the dead end poles of three 22 kV distribution lines
- iii) Nine (9) surge arresters to be mounted on the dead end poles of three 22 kV distribution lines

(4) Phan Thiet Substation

(a) 110 kV switchgear

The 110 kV bus connection will employ the single bus scheme.

- i) Two (2) circuit breakers
 - One for a 115/22 kV transformer circuit
 - One for a transmission line circuit
- ii) One (1) disconnector having two earthing switches for a 115/22 kV transformer circuit
- iii) Two (2) disconnectors, each of them having an earthing switch, for a transmission line circuit
- iv) One (1) disconnector of single-phase type for neutral circuit of a 115/22 kV transformer primary
- v) Three (3) capacitor voltage transformers for 110 kV bus circuit
- vi) One (1) coupling-capacitor voltage transformer for a transmission line circuit
- vii) Six (6) current transformers
 - Three for a 115/22 kV transformer circuit
 - Three for a transmission line circuit
- viii) Six (6) surge arresters
 - Three for 115/22 kV transformer circuit
 - Three for a transmission line circuit

(b) 22 kV switchgear

- i) One (1) set of 22 kV indoor switchgear assembly housed in metal-clad cubicles

- One 115/22 kV transformer circuit
 - One 22 kV bus circuit
 - Three 22 kV distribution line circuits
 - One house-service transformer circuit
- ii) Three (3) three-pole mechanically hand operated outdoor disconnectors to be mounted on the dead end poles of three 22 kV distribution lines
 - iii) Nine (9) surge arresters to be mounted on the dead end poles of three 22 kV distribution lines

(5) Cam Ranh Substation

(a) 110 kV switchgear

The 110 kV bus connection will employ the main and transfer bus scheme with a bus-tie circuit.

- i) Five (5) circuit breakers
 - One for a 115/22 kV transformer circuit
 - Three for three transmission line circuits
 - One for a bus-tie circuit
- ii) Five (5) disconnectors, each of them having an earthing switch
 - Three for three transmission line circuits
 - Two for a bus-tie circuit
- iii) Nine (9) disconnectors
 - Three for a 115/22 kV transformer circuit
 - Six for three transmission line circuits
- iv) One (1) disconnector of single-phase type for neutral circuit of a 115/22 kV transformer primary
- v) Three (3) capacitor voltage transformers for a 110 kV bus circuit
- vi) Three (3) coupling-capacitor voltage transformers for three transmission line circuits
- vii) Twelve (12) current transformers
 - Three for a 115/22 kV transformer circuit
 - Nine for three transmission line circuits

- viii) Twelve (12) surge arresters
 - Three for a 115/22 kV transformer circuit
 - Nine for three transmission line circuits

(b) 22 kV switchgear

- i) One (1) set of 22 kV indoor switchgear assembly housed in metal-clad cubicles for the following circuits:
 - One 115/22 kV transformer circuit
 - One 22 kV bus circuit
 - Four 22 kV distribution line circuits
 - One house-service transformer circuit
 - One power capacitor circuit
- ii) Four (4) three-pole mechanically hand operated outdoor disconnectors to be mounted on the dead end poles of four 22 kV distribution lines
- iii) Twelve (12) surge arresters to be mounted on the dead end poles of four 22 kV distribution lines
- iv) One (1) bank of static power capacitor

(6) Dien Khanh Substation

(a) 110 kV switchgear

The 110 kV bus connection will employ the main and transfer bus scheme with a bus-tie circuit.

- i) Four (4) circuit breakers
 - One for a 115/22 kV transformer circuit
 - Two for two transmission line circuits
 - One for a bus-tie circuit
- ii) Four (4) disconnectors, each of them having an earthing switch
 - Two for two transmission line circuits
 - Two for a bus-tie circuit
- iii) Seven (7) disconnectors
 - Three for a 115/22 kV transformer circuit
 - Four for two transmission line circuits

- iv) One (1) disconnecter of single-phase type for neutral circuit of a 115/22 kV transformer primary
 - v) Three (3) capacitor voltage transformers for a 110 kV bus circuit
 - vi) Two (2) coupling-capacitor voltage transformers for two transmission line circuits
 - vii) Nine (9) current transformers
 - Three for a 115/22 kV transformer circuit
 - Six for two transmission line circuits
 - viii) Nine (9) surge arresters
 - Three for a 115/22 kV transformer circuit
 - Six for two transmission line circuits
- (b) 22 kV switchgear
- i) One (1) set of 22 kV indoor switchgear assembly housed in metal-clad cubicles for the following circuits:
 - One 115/22 kV transformer circuit
 - One 22 kV bus circuit
 - Four 22 kV distribution line circuits
 - One house-service transformer circuit
 - One power capacitor circuit
 - ii) Four (4) three-pole mechanically hand operated outdoor disconnectors to be mounted on the dead end poles of four 22 kV distribution lines
 - iii) Twelve (12) surge arresters to be mounted on the dead end poles of three 22 kV distribution lines
 - iv) One (1) bank of static power capacitor

3.1.2 General Arrangement

The 230 kV and 110 kV switchgear will be located in the outdoor switchyard of each station, while the 22 kV switchgear cubicles will be located in the cubicle room of the control house for each substation.

The single line diagram of the main circuits and the general arrangement of the 110 kV switchgear for each substation as well as those for the 230 kV and 110 kV switchgear are

shown on the drawings appended herewith.

These arrangement drawings are not considered to be defining the design of the equipment, but are intended to show the general layout. Minor modifications may be made to suite the design of the equipment furnished by the Contractor, if the Engineer deems such modifications are acceptable.

3.1.3 Insulation Levels

The switchgear and equipment shall withstand the following voltages:

(1) 230 kV switchgear

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

(2) 110 kV switchgear

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

(3) 22 kV switchgear

- Full-wave lightning impulse
1.2 x 50 micro-second 125 kV
- Power-frequency for one minute 50 kV

3.1.4 Insulating Oil

The requirements for the insulating oils for the switchgear and the power capacitors shall be referred to Clause 1.1.6 of the General Specifications.

3.1.5 Electrical and Mechanical Design

The electrical and mechanical design of all switchgear and equipment shall be made referring to the requirements specified in the relevant clauses of the General Specifications.

3.1.6 Power and Control Sources

AC power source for the auxiliary equipment of the switchgear for the Substations of Thap Cham, Phan Ri, Phan Thiet, Cam Ranh and Dien Khanh shall be 400 V three-phase or 230 V single-phase, 50 Hz to be taken from the AC distribution panel specified to be supplied under

Clause 3.4. Meanwhile, AC control source available in the Da Nhim Power Station shall be 380 V three-phase or 220 V single-phase, 50 Hz to be taken from the existing AC distribution panel located in the powerhouse control room.

DC control source for the main and auxiliary control circuits, protective relays, lamp indications and closing source of the switchgear for the five Substations to be taken from the DC distribution panel specified in Clause 3.4. On the other hand, the DC control source available in the Da Nhim Power Station shall be 220 V DC to be taken from the existing DC distribution panel.

3.1.7 Tests

The tests to be carried out before shipment at the manufacturer's works are as specified in the relevant clauses herein. The preliminary tests and performance tests specified in Clause 1.19.2 of the General Specifications shall be executed at the site as far as applicable.

3.2 230 kV SURGE ARRESTERS

(1) Type

The surge arresters shall be of outdoor use, explosion-proof, metal-oxide gapless type and of heavy duty type designed for a nominal discharge current of 10 kA.

Each surge arrester shall be provided with a supporting structure.

(2) Rating

The surge arresters shall be rated as follow:

- | | |
|---|-------------------|
| (a) Rated voltage | 204 kV or higher |
| (b) Max. continuous operating voltage
(line to ground) | 156 kV or higher |
| (c) Nominal discharge current | 10 kA |
| (d) Residual voltage level (RVL)
defined as follows: | Not more than 2.7 |

$$RVL = \frac{\text{Residual voltage at 10kA (kV crest)}}{\text{Rated voltage (kV rms)}}$$

- | | |
|----------------------------|--------|
| (e) Rated insulation level | 950 kV |
|----------------------------|--------|

(f) Pressure-relief class A

(3) Accessories

The following accessories shall be provided for the surge arresters:

(a) For each surge arrester

- i) Rating plate
- ii) Pressure relief device
- iii) Discharge counter with leakage current meter
- iv) Discharge current recorder
- v) Insulation base
- vi) Line terminal connectors of compression type for Hard-drawn copper conductor (HDCC) of 400 mm²
- vii) Mounting bolts and nuts
- viii) Foundation bolts and nuts, and anchor setting plates
- viii) Other necessary accessories

(b) For all surge arresters

- i) Discharge current measuring device for each substation

(4) Tests

(a) The following tests shall be carried out at the manufacturer's works before shipment:

- i) Appearance check
- ii) Power-frequency starting voltage test
- iii) Measurement of leakage current
- iv) Power-frequency voltage dry test
- v) Discharge counter operation test

(b) The certificates of the following type test items shall be submitted with the test report:

- i) Residual voltage test
- ii) Power-frequency voltage wet test
- iii) Impulse voltage test
- iv) Pressure-relief device test

3.3 110 kV SWITCHGEAR

3.3.1 Circuit Breakers

(1) Type

The circuit breakers shall be of outdoor use, three-phase, hydraulically or pneumatically operated, trip-free in any position, SF₆ gas type with porcelain supporting insulator.

Especially, the circuit breakers for transmission line circuits shall be of three-phase (three units of sing-pole), single throw type capable of making both high-speed single-phase reclosing and three-phase reclosing operation.

The circuit breakers shall be complete with operating mechanism, supporting structure, piping, conduits wiring and any other accessories needed for operation.

(2) Rating

The circuit breakers shall be rated as follows:

- | | |
|--|----------------------------|
| (a) Rated voltage | 123 kV |
| (b) Rated insulation level | 550 kV |
| (c) Rated normal current | 1,250 A |
| (d) Rated short-circuit breaking current | 25 kA |
| (e) Rated interrupting time | 3 cycles |
| (f) Rated operating sequence | |
| - for transmission line circuit | 0 - 0.3 sec - CO - 3 min.- |
| CO | |

- for bus-tie circuit 0 - 3 min.- CO - 3 min.- CO

(g) Control circuit voltage

- for the Da Nhim Power Station 220 V DC

- for the other five Substations 110 V DC

(3) Operating mechanism

The circuit breaker shall be provided with an operating mechanism of remote and local electrical controls to be driven by pressure oil or compressed air and local manual operation for emergency and test purposes. Each circuit breaker shall be provided with an individual pressure oil supply system or an individual compressed air supply system. The hydraulic accumulator or air reservoir of the system shall have a sufficient capacity for satisfactory performance of the rated operating sequence at the minimum operating pressure, without oil or air supply. The output of the oil pump or air compressor shall be sufficient to raise the pressure in the system within 20 minutes from the minimum operating pressure to the maximum operating pressure. Each operation mechanism shall have an ample capacity for at least two times CO operations from normal operating pressure to minimum operating pressure, without pressure oil supply from oil pump or pressure air supply from air compressor.

The power source for the oil pump and air compressor shall be 400 V three-phase AC or 230 V single-phase AC for the five Substations and 380 V three-phase AC or 220 V single-phase AC for the Da Nhim Power Station as specified in Clause 3.1.6.

(4) Control cabinet

The control cabinet of the circuit breaker shall be vermin-proof, dust-proof and weather-proof and shall contain closing and tripping controls, oil or air supply system control, protective relays, fault annunciators, all necessary mechanical and electrical devices and accessories required.

The protective relays shall be suitable for the protection and alarm items listed in Paragraph (5) below. The fault annunciators shall be of target type indicators with a reset switch.

The cabinet shall be provided with suitable space heaters to prevent moisture condensation. A manual switch to control the heaters shall be provided.

The cabinet doors shall be provided with suitable handles with locks.

The lead wires and cables shall enter the cabinet from the bottom.

(5) Protection and alarm

The following trouble and abnormal conditions shall be indicated on the fault annunciator to be mounted on the cabinet as well as on the control board in the control house for each of the five Substations and on the main control board in the powerhouse for the Da Nhim Power Station.

- (a) GCB open-phase tripping
- (b) GCB gas pressure, low (1st stage)
- (c) GCB gas pressure, low (2nd stage)
- (d) GCB oil or air pressure, low
- (e) GCB tripping coil, broken
- (f) GCB oil or air supply system, trouble

(6) Accessories

The following items shall be provided for the circuit breakers:

- (a) For each circuit breaker:
 - i) Rating plate
 - ii) Position indicating lamps; red and green
 - iii) One (1) 10-stage auxiliary switches
 - iv) Oil or air valves, pressure gauges and piping
 - v) Pressure switches for oil pump or air compressor control, low pressure alarm, etc.
 - vi) SF₆ gas pressure gauges, pressure switches, valves and piping
 - vii) Space heater
 - viii) Operation counter
 - ix) Line terminal connectors of compression type for the following conductors:
 - for Da Nhim Power Station Hard-drawn copper conductor (HDCC)

- for other five substations of 240 mm²
Hard-drawn copper conductor (HDCC)
of 200 mm²

- x) Grounding terminals
 - xi) Supporting structures
 - xii) Dispatching number plate holder to be mounted on the supporting structure
 - xiii) Mounting bolts and nuts
 - xiv) Foundation bolts and nuts, and anchor setting plates
 - xv) Other necessary accessories
- (b) For all circuit breakers:
- i) One (1) set of maintenance tools
 - ii) One (1) set of SF₆ gas charging device
 - iii) One (1) set of SF₆ gas leakage detector
 - iv) One (1) set of SF₆ gas transfer cart

(7) Spare parts

The following parts shall be furnished for each substation and quoted separately:

- (a) One (1) complete phase
- (b) Three (3) closing coils
- (c) Three (3) tripping coils
- (d) Two (2) complete sets of gaskets
- (e) 500% of actual use of indicating lamps and fuses
- (f) One (1) set of indicating lamp lenses; red and green
- (g) One (1) set consisting of contacts, coils, relays, small components, etc. for control gear recommended by the manufacturer.
- (h) One (1) oil pump or air compressor replacement kit including all moving parts,

springs, seals, unloader, pressure regulator and other control valve, gauge components, starter, contactors, etc. and all other recommended parts by the manufacturer.

- (i) SF₆ gas cylinder with gas and accessories which can be replaced the whole gas of one set of circuit breaker.

(8) Tests

- (a) The following tests shall be carried out at the manufacturer's works before shipment, in compliance with IEC 56.

- i) Appearance check
- ii) Power-frequency voltage dry test on the main circuit
- iii) Voltage withstand tests on control and auxiliary circuits
- iv) Measurement of the resistance of the main circuit
- v) Mechanical operating test
- vi) Measurement of making and breaking time
- vii) SF₆ gas leakage test

- (b) The certificates of the following type test items shall be submitted with the test report:

- i) Mechanical test
- ii) Temperature rise test
- iii) Impulse voltage test
- iv) Power-frequency voltage wet test
- v) Short-circuit making and breaker test
- vi) Short-time current test
- vii) Hydrostatic test for tank
- viii) Test of pressure switches

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

3.3.2 Disconnectors and Earthing Switches

(1) Type

The following types of the disconnectors shall be supplied to the respective stations:

(a) For Da Nhim Power Station

- i) Three-pole, horizontal-break, local manual operated type combined with two earthing switches at both sides, for 230/121 kV transformer circuit
- ii) Three-pole, horizontal-break, local manual operated type combined with an earthing switch, for transmission line circuit

(b) For Thap Cham, Phan Ri and Phan Thiet Substations

- i) Three-pole, horizontal-break, electric motor driven type combined with two earthing switches, for 115/22 kV transformer line circuits
- ii) Three-pole, horizontal-break, electric motor driven type combined with an earthing switch, for transmission line circuits
- iii) Single-pole, vertical-break, local manual operated type for 115/22 kV transformer neutral circuits

(c) For Cam Ranh and Dien Khanh Substations

- i) Three-pole, horizontal-break, electric motor driven type combined with an earthing switch, for bus-tie and transmission line circuits
- ii) Three-pole, horizontal-break, electric motor driven type (without earthing switch), for 115/22 kV transformer and transmission line circuits
- iii) Single-pole, vertical-break, local manual operated type for neutral circuits of 115/22 kV transformers

All the earthing switches shall be of local manual operated type.

Each disconnector shall be provided with a grounding pad on each phase.

(2) Ratings

The disconnectors shall be rated as follows:

- | | |
|--|-----------------------------|
| (a) Rated voltage | 123 kV |
| (b) Rated insulation level | 550 kV |
| (c) Rated normal current | 1,250 A |
| (d) Rated short-time withstand current | 25 kA for three (3) seconds |
| (e) Control circuit voltage | |
| - for the Da Nhim Power Station | 220 V DC |
| - for the other five Substations | 110 V DC |

(3) Construction

(a) Disconnector

The disconnectors shall be designed to ensure easy installation, adjustment and operation, and to facilitate maintenance and inspection without loosening the tightened portions.

The conducting parts shall be provided with sufficient current capacity and designed so as to provide a high contact pressure. All contacts shall be of silver to ensure stable contact. The blades shall be made of copper or corrosion-resistant aluminium alloy to ensure a high mechanical strength for long service life.

The disconnectors shall be provided with suitable measure for safely breaking the peak value of the prospective loop current during the transient period following initiation.

Each of the disconnector and earthing switch assembly shall be provided with a suitable supporting structure. However, the disconnectors to be connected to the transfer bus for the Cam Ranh and Dien Khanh Substations shall be constructed so that they can be mounted on the steel beam structures.

All steel parts shall be hot-dipped galvanized.

(b) Earthing switch

The earthing switch shall be constructed to combine with the associated disconnectors and shall be safely and smoothly operable by one operator.

The earthing switch shall be mechanically interlocked with the disconnecter so that the earthing switch cannot be closed when the disconnecter is in closed position and also the disconnecter cannot be closed when the earthing switch is in closed position.

The earthing switch shall be capable of making without any damage the peak value of the prospective loop current in a pole during the transient period following the initiation of current during a making operation.

The earthing switch shall be designed to withstand the rated short-time withstand current equal to that assigned to the disconnecter for three (3) seconds.

(4) Operating mechanism

Each of the disconnecter of local manual type and the earthing switch shall be provided with a manual operating mechanism consisting of a manual operating handle, electrical and mechanical interlocks among the associated circuit breaker, disconnecter and earthing switch(es), and a local control box with auxiliary switch for remote indication and an ON/OFF position indicator.

The disconnecter of motor driven type shall be provided with a motor operating mechanism for local and remote electrical controls. The motor operating mechanism shall have an electric motor, its control system, electrical and mechanical interlocks with the associated circuit breakers and earthing switch(es), a local control box and all the necessary accessories. The motor operating mechanism shall also be provided with a manual operating feature with a manual operating handle and necessary interlocks between the motor operation and the manual operation. The power source for the motor shall be 400 V three-phase or 230 V single-phase AC which will shall be taken from the AC distribution panel.

The operating mechanism shall be designed to ensure that the disconnecter and the earthing switch can be safely and smoothly operated by one operator on the ground.

Each local control box shall contain the control, remote indication and interlock circuits with auxiliary switch(es), ON/OFF pushbutton switches for local electrical control, ON/OFF position indicator, a signal lamp to provide the operating instruction, a padlock, a grounding pad and other necessary accessories. The local control box shall be of weather-proof construction with a suitable space heater to prevent moisture condensation.

(5) Accessories

The following items shall be provided for the disconnectors:

(a) For each disconnector and earthing switch:

- i) Rating plates for disconnector and earthing switch
- ii) Position indicating lamps; red and green
- iii) 6-stage auxiliary switches
- iv) Line terminal connectors of compression type for the following conductors:
 - for Da Nhim Power Station Hard-drawn copper conductor (HDCC) of 240 mm²
 - for other five substations Hard-drawn copper conductor (HDCC) of 200 mm²
- v) Grounding terminals
- vi) Supporting Structures
- vii) Dispatching number plate holder to be mounted on the supporting structure
- viii) Mounting bolts and nuts
- ix) Foundation bolts and nuts, and anchor setting plates
- x) Other necessary accessories

(b) For all disconnectors:

- i) Two (2) manual operating handles for each substation

(6) Spare parts

The following spare parts shall be furnished for each substation and quoted separately:

- (a) One (1) complete set of the disconnector for each current rating (excluding supporting structure)
- (b) One (1) operating motor for each type
- (c) Three (3) operating coils for each type

- (d) 500% of actual use of indicating lamps and fuses
- (e) One (1) set of indicating lamp lenses; red and green
- (f) One (1) set consisting of contacts, coils, small components, etc. recommended by the manufacturer.

(7) Tests

- (a) The following tests shall be carried out at the manufacturer's works before shipment:

- i) Appearance check
- ii) Power-frequency voltage dry test on the main circuit
- iii) Voltage withstand tests on auxiliary and control circuits
- iv) Measurement of the resistance of the main circuit
- v) Mechanical operating tests

- (b) The certificates of the following type test items shall be submitted with the test report:

- i) Impulse voltage test
- ii) Power-frequency voltage wet test
- iii) Temperature rise test
- iv) Short-time current test
- v) Operating and mechanical endurance test

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

3.3.3 Current Transformers

(1) Type

The current transformers shall be of single-phase, oil-immersed, outdoor use, hermetically sealed construction.

Each current transformer shall have three cores and shall be provided with a supporting structure.

(2) Ratings

The current transformers shall be rated as follows:

- | | |
|--|-----------------------------|
| (a) Highest system voltage | 123 kV |
| (b) Rated insulation level | 550 kV |
| (c) Rated current ratio | |
| - for transmission line circuit | 400-200/5-5-5 A |
| - for 16 MVA 115/22 kV transformer circuit | 125/5-5-5 A |
| - for 25 MVA 115/22 kV transformer circuit | 200/5-5-5 A |
| (d) Rated output | Not less than 30 VA |
| (e) Rated short time thermal current | 25 kA for three (3) seconds |
| (f) Accuracy class | |
| - for measuring | 1.0 |
| - for protective relaying | 5P20 |

The rated output of each current transformer shall be determined by the Contractor to suit the actual burden required for the protective relays, measuring instruments, transducers, cables, wires, etc., however, the minimum output shall be 30 VA. The detailed calculation sheets for the rated output shall be submitted for approval.

(3) Accessories

The following items shall be provided for each current transformer:

- | | |
|--|---|
| (a) Rating plate | |
| (b) Lifting lugs | |
| (c) Line terminal connectors of compression type for the following conductors: | |
| - for Da Nhim Power Station | Hard-drawn copper conductor (HDCC) of 240 mm ² |
| - for other five substations | Hard-drawn copper conductor (HDCC) of 200 mm ² |

- (d) Grounding terminals
 - (e) Weather-proof secondary terminal box
 - (f) Oil level indicator and oil valve (if any)
 - (g) Cable conduits
 - (h) Mounting bolts and nuts
 - (i) Foundation bolts and nuts, and anchor setting plates
 - (j) Other necessary accessories
- (4) Tests
- (a) The following tests shall be carried out at the manufacturer's works before shipment:
 - i) Appearance check
 - ii) Verification of terminal marking
 - iii) Power frequency tests on primary windings
 - iv) Power frequency tests on secondary windings
 - v) Overvoltage inter-turn tests
 - vi) Determination of errors
 - (b) The certificates of the following type test items shall be submitted with the test report:
 - i) Short-time current tests
 - ii) Temperature rise tests
 - iii) Impulse voltage tests
 - (c) The test as specified in Clause 1.19.2 of the General Specifications shall be carried out by the Contractor at the Site.

3.3.4 Capacitor Voltage Transformers

(1) Type

The capacitor voltage transformers shall be of single-phase, oil-immersed, outdoor use, hermetically sealed construction.

Each capacitor voltage transformer shall have two separate secondary windings; one for measuring and the other for protective relaying.

Each capacitor voltage transformer shall be mounted on a supporting structure.

(2) Ratings

The capacitor voltage transformers shall be rated as follows:

- | | |
|----------------------------|---|
| (a) Highest system voltage | 123 kV |
| (b) Rated voltage ratio | $110 \text{ kV}/\sqrt{3} : 110 \text{ V}/\sqrt{3} : 110 \text{ V}/\sqrt{3}$ |
| (d) Rated output | |
| - for each winding | Not less than 100 VA |
| (e) Rated voltage factor | |
| - for each winding | 1.2 for continuous
1.5 for 30 seconds |
| (f) Rated insulation level | 550 kV |
| (g) Accuracy class | |
| - for measuring | 1.0 |
| - for protective relaying | 3 P |

The rated output of the capacitor voltage transformer shall be determined by the Contractor to suit the actual burdens of the protective relays, measuring instruments, transducers, cables and wires, etc., however, the minimum output shall be 100 VA. The detailed calculation sheets for the rated output shall be submitted for approval.

(3) Accessories

The following items shall be provided for each capacitor voltage transformer:

- (a) Rating plate

- (b) Lifting lugs
 - (c) Line terminal connectors of compression type for the following conductors:
 - for Da Nhim Power Station Hard-drawn copper conductor (HDCC)
of 240 mm²
 - for other five substations Hard-drawn copper conductor (HDCC)
of 200 mm²
 - (d) Grounding terminals
 - (e) Weather-proof secondary terminal box
 - (f) Oil level indicator
 - (g) Drain and filling plugs (if any)
 - (h) Gap gauge
 - (i) Cable conduit
 - (j) Mounting bolts and nuts
 - (k) Foundation bolts and nuts, and anchor setting plate
 - (l) Other necessary accessories
- (4) Tests
- (a) The following tests shall be carried out at the manufacturer's plant:
 - i) Appearance check
 - ii) Verification of terminal markings
 - iii) Check of relative polarity
 - iv) Test for accuracy
 - v) Measurement of capacitance and tangent loss angle
 - vi) Power-frequency voltage dry test on primary winding
 - vii) Power-frequency voltage dry test on secondary winding
 - viii) Spherical gap spark-over voltage test.

- (b) The certificates of the following type test items shall be submitted with the test report:
- i) Temperature rise test
 - ii) Impulse voltage test
 - iii) Power-frequency voltage wet test
- (c) The tests as specified in Clause 1.19.2 of the General Specifications shall be carried out by the Contractor at the Site.

3.3.5 Coupling-Capacitor Voltage Transformers

(1) Type and requirement

The coupling-capacitor voltage transformers shall be of single-phase, oil-immersed, outdoor use, hermetically sealed construction for arrester protected area, to be used not only for measurement of transmission line voltage but also as a coupling capacitor for the power line carrier system to be supplied under Section 5.

Each coupling-capacitor voltage transformer shall be self-standing type to be mounted on a supporting structure and shall be designed to mount the line trap to be supplied under Section 5 on the top.

The coupling-capacitor voltage transformer shall be provided with a weather-proof steel box at the side of the voltage transformer housing to contain the secondary terminal blocks of the transformer and the coupling filter to be supplied under Section 5. A carrier grounding switch and surge protective device shall be connected to the ground side of the coupling-capacitor and shall be provided in the steel box.

The steel box shall be so constructed as to be possible to inspect and test these equipment safely under the energized condition of line.

(2) Ratings

The coupling-capacitor voltage transformer shall be rated as follows:

- | | |
|----------------------------|--|
| (a) Highest system voltage | 123 kV |
| (b) Rated voltage ratio | $110 \text{ kV}/\sqrt{3} : 110 \text{ V}/\sqrt{3}$ |
| (c) Rated output | Not less than 100 VA |

- | | |
|----------------------------|--|
| (e) Rated voltage factor | 1.2 for continuous
1.5 for 30 seconds |
| (f) Rated insulation level | 550 kV |
| (g) Accuracy class | |
| - for measuring | 1.0 |
| - for protective relaying | 3P |
| (h) Rated capacitance | about 4,000 pF |

The rated output of the coupling capacitor voltage transformer shall be determined by the Contractor to suit the actual burdens of the measuring instruments, cables and wires, etc., however the minimum output shall be 100 VA. The detailed calculation sheets for the rated output shall be submitted for approval.

(3) Accessories

The following items shall be provided for each coupling-capacitor voltage transformer:

- (a) Rating plate
- (b) Lifting lugs
- (c) Lead wire and terminals of suitable size for connecting the line trap
- (d) Grounding terminals
- (e) Oil level indicator
- (f) Drain and filling plugs (if any)
- (g) Gap gauge
- (h) Cable conduits
- (i) Mounting bolts and nuts
- (j) Foundation bolts and nuts, and anchor setting plates
- (k) Other necessary accessories

(4) Tests

- (a) The following tests shall be carried out at the manufacturer's works before

shipment:

- i) Appearance check
 - ii) Verification of terminal markings
 - iii) Check of relative polarity
 - iv) Test for accuracy
 - v) Measurement of capacitance and tangent of loss angle
 - vi) Power-frequency voltage dry test on primary winding
 - vii) Power-frequency voltage dry test on secondary winding
 - viii) Spherical gap spark-over voltage test
- (b) The certificates of the following type test items shall be submitted with the test report:
- i) Temperature rise test
 - ii) Impulse voltage test
 - iii) Power-frequency voltage wet test
 - iv) Measurement of stray earth capacitance
 - v) Measurement of high-frequency static capacitance
 - vi) Measurement of equivalent series resistance
 - vii) Frequency characteristic test
- (c) The tests as specified in Clause 1.19.2 of the General Specifications shall be carried out by the Contractor at the Site.

3.3.6 Surge Arresters

(1) Type

The surge arresters shall be of outdoor use, explosion-proof, metal-oxide gapless type and of heavy duty type designed for a nominal discharge current of 10 kA.

Each surge arrester shall be provided with a supporting structure.

(2) Rating

The surge arresters shall be rated as follow:

- | | |
|---|-------------------|
| (a) Rated voltage | 102 kV or more |
| (b) Max. continuous operating voltage
(line to ground) | 78 kV |
| (c) Nominal discharge current | 10 kA |
| (d) Residual voltage level (RVL)
defined as follows: | Not more than 2.7 |

$$RVL = \frac{\text{Residual voltage at 10kA (kV crest)}}{\text{Rated voltage (kV rms)}}$$

- | | |
|----------------------------|--------|
| (e) Rated insulation level | 550 kV |
| (f) Pressure-relief class | A |

(3) Accessories

The following accessories shall be provided for the surge arresters:

- (a) For each surge arrester
- i) Rating plate
 - ii) Pressure relief device
 - iii) Discharge counter with leakage current meter
 - iv) Discharge current recorder
 - v) Insulation base
 - vi) Line terminal connectors of compression type for the following conductors:
 - for Da Nhim Power Station Hard-drawn copper conductor (HDCC)
of 240 mm²
 - for other five substations Hard-drawn copper conductor (HDCC)
of 200 mm²
 - vii) Mounting bolts and nuts

viii) Foundation bolts and nuts, and anchor setting plates

viii) Other necessary accessories

(b) For all surge arresters

i) Discharge current measuring device for each substation

(4) Tests

(a) The following tests shall be carried out at the manufacturer's works before shipment:

i) Appearance check

ii) Power-frequency starting voltage test

iii) Measurement of leakage current

iv) Power-frequency voltage dry test

v) Discharge counter operation test

(b) The certificates of the following type test items shall be submitted with the test report:

i) Residual voltage test

ii) Power-frequency voltage wet test

iii) Impulse voltage test

iv) Pressure-relief device test

3.4 22 kV Switchgear

3.4.1 Circuits and Components

The 22 kV switchgear shall be provided for the secondary circuit (low voltage side) of the 115/22 kV main transformer for each substation of Thap Cham, Phan Ri, Phan Thiet, Cam Ranh and Dien Khanh. The 22 kV circuits for each Substation are described in Clause 3.1.1.

The 22 kV switchgear shall be the metal-clad type switchgear assembly and shall consist of the following components in the enclosures:

- (1) For each 115/22 (15) kV transformer circuit
 - (a) One (1) set of three-phase busbars
 - (b) One (1) three-pole circuit breaker
 - (c) Six (6) current transformers
 - Three for measuring
 - Three for 115/22 kV differential protective relaying
- (2) For each 22 kV bus circuit
 - (a) One (1) set of three-phase busbars
 - (b) Three (3) voltage transformers
- (3) For each 22 kV distribution line circuit
 - (a) One (1) set of three-phase busbars
 - (b) One (1) three-pole circuit breaker
 - (c) Six (6) current transformers
 - Three for measuring
 - Three for distribution line protective relaying
- (4) For each house-service transformer circuit
 - (a) One (1) three-pole fuse disconnecter
- (5) For each power capacitor circuit
 - (a) One (1) set of three-phase busbars
 - (b) One (1) three-pole circuit breaker
 - (c) Six (6) current transformers
 - Three for measuring
 - Three for power capacitor protective relaying

In addition to the above indoor switchgear assembly, the following outdoor use switchgear shall be supplied for each 22 kV distribution line circuit as specified in Clause 3.1.1.

- (a) Three-pole mechanically hand operated outdoor disconnectors to be mounted on the dead end poles of each 22 kV distribution line

- (b) Surge arresters to be mounted on the dead end poles of 22 kV distribution lines

Also, one bank of power capacitor of outdoor installation shall be supplied for the Cam Ranh and the Dien Khanh Substations.

3.4.2 Enclosure

(1) Type

The 22 kV switchgear shall be of floor-standing, indoor installation, metal-clad type conforming to IEC 298 (1981) and of robust construction.

The degree of protection for the enclosures and partitions, conforming to IEC 529 (1976), shall be as follows:

- | | |
|----------------|------|
| (a) Enclosure | IP41 |
| (b) Partitions | IP3X |

(2) Construction requirements

The enclosures for the switchgear shall be constructed by rigid framed, floor-standing structure completely enclosed by sheet steel.

The withdrawable type equipment compartment shall be provided with an automatic shutter to prevent exposure of stationary live contacts when the equipment is in the disconnected, test or removed position. The enclosures shall be provided with access doors to facilitate inspections of the equipment. The position indicating lamps and inspection windows for the circuit breakers and fuse disconnectors shall be provided on the front doors. The door shall be provided with suitable handles with locks.

The enclosures shall be provided with suitable cable terminal compartments for the following power cables:

- (a) For each 115/22 kV transformer secondary circuit

12/20 kV, 800 mm², single-core, crosslinked polyethylene (XLPE) insulated cables with compression type terminals

- (b) For each 22 kV distribution circuit

12/20 kV, 240 mm², three-core, crosslinked polyethylene (XLPE) insulated cables with compression type terminals

- (c) For each house-service transformer circuit

12/20 kV, 120 mm², three-core, crosslinked polyethylene (XLPE) insulated cable with compression type terminals

- (d) For each power capacitor circuit

12/20 kV, 240 mm², three-core, crosslinked polyethylene (XLPE) insulated cables with compression type terminals

The power cables shall be supplied under Section 6. Suitable means shall be provided for supporting the terminals and cables.

A copper ground busbar of not less than 50 mm by 6 mm in size shall be provided at the bottom of the enclosure. Clamp type grounding terminals shall be provided for connecting the ground busbar to the lead wire of the station grounding system.

- (3) Accessories

The following items shall be provided for the enclosures:

- (a) Nameplates for the equipment to be housed
- (b) Floor sills
- (c) Foundation bolts and nuts
- (d) Grounding pads
- (e) Other necessary accessories

- (4) Tests

- (a) The following tests shall be carried out at the manufacturer's works before shipment:

- i) Appearance check
- ii) Power-frequency voltage test

- (b) The certificates of the following type test items shall be submitted with the test reports:

- i) Impulse voltage test

ii) Temperature rises test

3.4.3 Busbars and Connections

(1) Type

The busbars and electrical connections shall be of electrolytic copper or aluminium alloy, air insulated, and shall be sufficiently insulated from ground and from each other. Oil or compound filled bus will not be acceptable.

The busbars, connections and their insulated supports shall be of mechanically strong, and shall withstand all the stresses which will be imposed upon them in ordinary working due to fixing, vibration, fluctuation in temperature, short-circuit or other causes.

All busbar connections shall be silver coated and contacted securely.

(2) Ratings

The busbar shall be rated as follows:

(a) Rated voltage	24 kV
(b) Rated insulation level	125 kV
(c) Rated normal current	1,250 A
(d) Rated short-time withstand current	16 kA for three (3) seconds

The busbars shall be designed to carry continuously the rated normal current without exceeding a temperature rise of 50 K at an ambient temperature not exceeding 40°C.

3.4.4 Circuit Breakers

(1) Type

The circuit breakers shall be of three-pole, withdrawable, surge suppressive type vacuum or SF₆ gas type, electrically and mechanically trip-free in any position with anti-pumping feature, complete with necessary controls and wirings, drawout wheels, and any other accessories needed for operation.

(2) Ratings

The circuit breakers shall be rated as follows:

- | | |
|--|---------------------|
| (a) Rated voltage | 24 kV |
| (b) Rated insulation level | 125 kV |
| (c) Rated normal current | |
| - for each 115/22 kV transformer circuit | 1,250 A |
| - for each 22 kV distribution circuit | 630 A |
| - for each power capacitor circuit | 630 A |
| (d) Rated short-circuit breaking current | 16 kA |
| (e) Rated interrupting time | 5 cycles |
| (f) Rated operating sequence | O-3 min-CO-3 min-CO |
| (g) Rated supply voltage for closing
and tripping | 110 V DC |

(3) Operating mechanism

The circuit breaker shall be provided with operating mechanism capable of remote and local electrical controls, driven by 110 V DC and also local manual operation. Test operation at test position shall also be available.

Molded case circuit breaker shall be provided in the DC supply circuit to the circuit breaker.

(4) Accessories

The following accessories shall be provided for the circuit breaker:

- (a) Rating plates
- (b) Position indicating lamps; red and green
- (c) 10-stage auxiliary switches
- (d) Operation counter
- (e) Closing spring condition indicator
- (f) Drawout unit with handle and guide
- (g) Necessary terminal connections

- (h) Local control box with pushbuttons of "ON" and "OFF"
 - (i) One (1) set of maintenance tools
 - (j) One (1) manual charging handle
 - (h) One (1) moving cart
 - (l) Other necessary accessories
- (5) Spare parts

The following spare parts shall be furnished for each substation and quoted separately:

- (a) One (1) complete circuit breaker
 - (b) Three (3) closing coils
 - (c) Three (3) tripping coils
 - (d) One (1) spring charging motor (if applicable)
 - (e) One (1) bushing of each type
 - (f) 200% of actual use of indicating lamps and fuses
 - (g) 200% of actual use of indicating lamp lenses; red and green
 - (h) One (1) set of contacts, coils, relays, valves and other small components
- (6) Tests
- (a) The following test shall be carried out at the manufacturer's works before shipment:
 - i) Appearance check
 - ii) Power-frequency voltage dry test on the main circuit
 - iii) Voltage withstand tests on control and auxiliary circuits
 - iv) Measurement of the resistance of the main circuit
 - v) Mechanical operating test
 - vi) Measurement of making and breaking time

(b) The certificates of the following type test items shall be submitted with the test reports:

- i) Mechanical test
- ii) Temperature rise test
- iii) Impulse voltage test
- iv) Short-circuit making and breaking test
- v) Short-time current test

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

3.4.5 Fuse Disconnectors

(1) Type

The fuse disconnectors shall be the indoor use, three-pole, mechanically hand operated type disconnector in which a fuse-link forms the moving contact of each pole. The fuse disconnector shall be suitable for mounting in the enclosure.

The fuse shall be suitable for the overcurrent protection of the 200 kVA house-service transformer supplied under Section 2.

Striker and suitable signalling device shall be provided to indicate visually at the fuse and to deliver an alarm signal to the control room when the fuse has operated.

(2) Rating

The fuse disconnectors shall be rated as follows:

(a) Disconnector

- i) Rated voltage 24 kV
- ii) Rated current 400 A
- iii) Rated insulation level 125 kV
- iv) Rated short-time withstand current 16 kA for three (3) seconds

(b) Fuse-link

- | | |
|-----------------------------|----------------------------------|
| i) Rated voltage | 24 kV |
| ii) Rated current | To be selected by the Contractor |
| iii) Rated breaking current | 16 kA |

The rated current of the fuse-link shall be selected by the Contractor with due regard to the transient phenomena in the circuit related to switching the house-service transformer, and coordination with the molded case circuit breaker and other protective devices in the secondary circuit of the house-service transformer.

(3) Accessories

The following accessories shall be provided for the fuse disconnecter:

- (a) Rating plate
- (b) Manual operation handle or hook
- (c) Necessary terminal connections
- (d) Grounding terminals
- (e) Other necessary accessories

(4) Spare parts

The following parts shall be furnished for each substation and quoted separately:

- (a) 200% of actual use of fuses
- (b) One set of spares recommended by the manufacturer

(5) Tests

- (a) The following tests shall be carried out at the manufacturer's works before shipment:

- i) Appearance check
- ii) Power-frequency voltage dry test

- (b) The certificates of the following type test items shall be submitted with the test

report:

- i) Impulse voltage dry test
 - ii) Temperature rise test
 - iii) Breaking test for fuse-link
 - iv) Tests for time/current characteristics
 - v) Test of striker
- (c) The tests as specified in Clause 1.19.2 of the General Specifications shall be carried out by the Contractor at the Site.

3.4.6 Current Transformers

(1) Type

The current transformers shall be of single-phase, epoxy mold type.

(2) Ratings

The current transformers shall be rated as follows:

- | | |
|---|-----------------------------|
| (a) Highest system voltage | 24 kV |
| (b) Rated insulation level | 125 kV |
| (c) Rated current ratio | |
| - for each 16 MVA 115/22 kV transformer circuit | 750/5 A |
| - for 25 MVA 115/22 kV transformer circuit | 1,000/5 A |
| - for each distribution circuit | 200/5 A |
| - for each power capacitor circuit | 200/5 A |
| (d) Rated output | Not less than 30 VA |
| (e) Rated short time thermal current | 16 kA for three (3) seconds |
| (f) Accuracy class | |
| - for measuring | 1.0 |
| - for protective relaying | 5P20 |

The rated output of the each current transformer shall be selected by the Contractor to suit the actual burden required for the protective relays, measuring instruments,

transducers, cables and wires, however, the minimum output shall be 30 VA for each transformer. The detailed calculation sheets for the rated output shall be submitted for approval.

(3) Accessories

The following accessories shall be provided for each current transformer:

- (a) Rating plate
- (b) Necessary terminal connections
- (c) Other necessary accessories

(4) Spare parts

The following spare parts shall be furnished for each substation and quoted separately:

- (a) One (1) current transformer of each rating

(5) Tests

- (a) The following tests shall be carried out at the manufacturer's works before shipment:

- i) Appearance check
- ii) Measurement of current ratio
- iii) Check of relative polarities
- iv) Power-frequency voltage test on primary winding

- (b) The certificates of the following type test items shall be submitted with the test reports:

- i) Short-time current test
- ii) Temperature rise test
- iii) Impulse voltage test
- iv) Tests for accuracy

3.4.7 Voltage Transformers

(1) Type

The voltage transformers shall be of single-phase, epoxy mold type with two separate secondary windings.

(2) Ratings

The voltage transformers shall be rated as follows:

(a) Highest system voltage	24 kV
(b) Rated voltage ratio	$15 \text{ kV}/\sqrt{3} : 110 \text{ V}/\sqrt{3} : 110 \text{ V}/\sqrt{3}$
(c) Rated output	Not less than 60 VA
(f) Rated voltage factor	1.2 for continuous 1.9 for 30 seconds
(g) Rated insulation level	125 kV
(h) Accuracy class	
- for measuring	1.0
- for protective relaying	3P

The rated output of the each voltage transformer shall be determined by the Contractor to suit the actual burden required for the protective relays, measuring instruments, transducers, cables and wires, however, the minimum output shall be 60 VA for each transformer. The detailed calculation sheets for the rated output shall be submitted for approval.

(3) Accessories

The following accessories shall be provided for each voltage transformer:

- (a) Rating plate
- (b) Necessary terminal connections
- (c) Fuse for secondary circuit
- (d) Other necessary accessories

(4) Spare parts

The following spare parts shall be furnished for each substation and quoted separately:

- (a) One (1) voltage transformer of each rating
- (b) 200% of actual use of fuses

(5) Tests

(a) The following tests shall be carried out at the manufacturer's works before shipment:

- i) Appearance check
- ii) Measurement of voltage ratio
- iii) Check of relative polarity
- iv) Power-frequency voltage test on primary winding

(b) The certificates of the following type test items shall be submitted with the test reports:

- i) Temperature rise test
- ii) Impulse voltage test
- iii) Tests for accuracy

3.4.8 Outdoor Three-Pole Disconnecting Switches

(1) Type

The disconnecting switches shall be of outdoor use, pole or steel frame-work mounted, three-pole, single throw, manual gang-operated type with manually operated earthing switch.

(2) Ratings

The disconnecting switch shall be rated as follows:

- (a) Rated voltage 24 kV
- (b) Rated insulation level 125 kV

- (c) Rated normal current 400 A
- (d) Rated short-time withstand current 16 kA for three (3) seconds

(3) Accessories

The following items shall be provided for the outdoor disconnecting switches:

- (a) Rating plate
- (b) Manual operating mechanism with operating handle assembly with padlock and keys
- (c) Required materials for installing the disconnecting switch unit on the pole or steel frame-work, such as cross arms, braces, arm bands, bolts and nuts, etc.
- (d) Necessary terminal connections
- (e) Grounding terminals
- (f) Earthing switch with padlock
- (g) Other necessary accessories

(4) Tests

- (a) The following tests shall be carried out at the manufacturer's works before shipment:
 - i) Appearance check
 - ii) Power-frequency voltage dry test
- (b) The certificates of the following type test items shall be submitted with the test report:
 - i) Impulse voltage dry test
 - ii) Temperature rise test
- (c) The tests as specified in Clause 1.19.2 of the General Specifications shall be carried out by the Contractor at the Site.

3.4.9 Lightning Arresters

(1) Type

The lightning arresters shall be of outdoor use, pole mounted, explosion-proof, gapless type.

(2) Ratings

The lightning arresters shall be rated as follows:

- | | |
|---|-------------------------|
| (a) Rated voltage | 27 kV or more |
| (b) Max. continuous operating voltage
(line to ground) | Not less than 20 kV rms |
| (c) Nominal discharge current | 10 kA |
| (d) Residual voltage level (RVL)
defined as follows: | Not more than 2.7 |
| $RVL = \frac{\text{Residual voltage at 10 kA (kV crest)}}{\text{Rated Voltage (kV rms)}}$ | |
| (e) Rated insulation level | 125 kV |
| (f) Pressure-relief class | A |

(3) Accessories

The following items shall be provided for the lightning arresters:

- (a) Rating plates
- (b) Required materials for installing the lightning arresters on the pole such as mounting base, cross arms, braces, arm bands, bolts and nuts, etc.
- (c) Necessary terminal connections
- (d) Grounding terminals
- (e) Other necessary accessories

(4) Test

(a) The following tests shall be carried out at the manufacturer's plant:

- i) Appearance check
- ii) Power-frequency starting voltage test
- iii) Measurement of leakage current
- iv) Power-frequency voltage dry test

(b) The certificates of the following type test items shall be submitted with the test report:

- i) Residual voltage test
- ii) Power-frequency voltage wet test
- iii) Impulse voltage test
- iv) Pressure-relief device test

3.5 22 kV STATIC POWER CAPACITOR

(1) General

One (1) bank of the static power capacitor shall be provided on the 22 kV circuit of the Cam Ranh Substation and the Dien Khanh Substation. The static power capacitor bank shall have a rated bank capacity of 4,000 kvar and shall consist of three-phase capacitor units, series reactors, discharge coils, mounting racks and other necessary materials for its installation.

(2) Type and rating

The static power capacitor bank shall be outdoor, open rack type shunt capacitor bank and shall be rated as follows:

- (a) Highest system voltage 24 kV
- (b) Nominal operating voltage 22(15) kV
- (c) Rated insulation level
 - Full-wave lightning impulse

1.2 x 50 micro-second	125 kV
- Power-frequency for one minute	50 kV
(d) Number of phase for capacitor unit	Three-phase
(e) Number of phase for bank	Three-phase
(f) Rated capacity of bank	4,000 kvar

The number of the capacitor units and the unit capacity shall be determined by the Contractor and shall be subject to the Engineer's approval.

The capacitor bank will be arranged in double-wye connection with ungrounded neutral.

Each capacitor unit shall be of outdoor use, three-phase, oil-immersed, film type, hermetically sealed construction with a stainless steel container.

The series reactor shall be provided at a neutral point of the bank that shall not be grounded. The series reactor shall be of outdoor use, three-phase, oil-immersed, self-cooled type.

The discharge coil shall be provided on each phase to fully protect the capacitor bank and shall incorporate the secondary winding to operate capacitor protective relays.

The capacitor bank shall be installed on the ground level.

(3) Accessories

The following accessories shall be provided:

(a) For capacitor bank

- i) Rating plate and connection diagrams with full details
- ii) Mounting brackets with mounting bolts and nuts.
- iii) Other necessary accessories

(b) For each capacitor

- i) Rating plate
- ii) Line terminal connectors
- iii) Grounding terminals

- iv) Mounting brackets with mounting bolts and nuts
- (c) For each series reactor
 - i) Rating plate
 - ii) Oil level gauge
 - iii) Dial type thermometer
 - iv) Mounting brackets with mounting bolts and nuts
 - v) Line terminal connectors
 - vi) Grounding terminals
 - vii) Other necessary accessories
- (d) For discharge coil
 - i) Rating plate
 - ii) Mounting brackets with mounting bolts and nuts
 - iii) Line terminal connectors
 - iv) Grounding terminals
 - v) Other necessary accessories
- (4) Spare parts

The following spare parts shall be furnished and quoted separately:

- (a) Two (2) capacitor units
- (b) One (1) series reactor
- (c) One (1) discharge coil
- (d) One (1) bushing of each type with line terminal connector
- (e) One (1) complete set of gaskets for one capacitor bank
- (f) One (1) dial type thermometer with gaskets

- (g) One (1) oil level gauge with gaskets
- (h) Other spare parts recommended by the manufacturer

(4) Tests

- (a) The following tests shall be carried out at the manufacturer's works before shipment:

Capacitor unit

- i) Construction check
- ii) Capacitance test
- iii) Capacitor loss test
- iv) Power frequency withstand voltage test

Series reactor

- i) Construction check
- ii) Measurement of winding resistance
- iii) Measurement of impedance
- iv) Measurement of insulation resistance
- v) Power frequency withstand voltage test

Discharge coil

- i) Construction check
- ii) Measurement of insulation resistance
- iii) Power frequency withstand voltage test
- iv) Discharge capacity test

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

SECTION 4

TECHNICAL SPECIFICATIONS FOR CONTROL AND PROTECTION EQUIPMENT

4.1 GENERAL

4.1.1 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 control and relaying equipment to be installed in the Thap Cham Substation, the Phan Ri Substation, the Phan Thiet Substation, the Cam Ranh Substation and the Dien Khanh Substation.

(1) Thap Cham Substation

- (a) One (1) set of duplex type, control and relay boards consisting of:
 - i) One (1) control and relay board for a 115/22 kV main transformer circuit
 - ii) Three (3) control and relay boards for three 110 kV transmission line circuits
 - iii) One (1) control and relay board for a 110 kV bus circuit
 - iv) Two (2) control and relay boards for four 22 kV distribution line circuits
- (b) One (1) manual synchronizing panel
- (c) One (1) set of AC and DC distribution panels
- (d) One (1) set of station batteries
- (e) One (1) battery charger
- (f) One (1) lot of accessories and spare parts

(2) Phan Ri Substation

- (a) One (1) set of duplex type, control and relay boards consisting of:
 - i) One (1) control and relay board for a 115/22 kV main transformer circuit

- ii) Two (2) control and relay boards for two 110 kV transmission line circuits
 - iii) One (1) control and relay board for a 110 kV bus circuit
 - iv) Two (2) control and relay boards for three 22 kV distribution line circuits
- (b) One (1) manual synchronizing panel
- (c) One (1) set of AC and DC distribution panels
- (d) One (1) set of station batteries
- (e) One (1) battery charger
- (f) One (1) lot of accessories and spare parts
- (3) Phan Thiet Substation
- (a) One (1) set of duplex type, control and relay boards consisting of:
- i) One (1) control and relay board for a 115/22 kV main transformer circuit
 - ii) One (1) control and relay board for a 110 kV transmission line circuit
 - iii) One (1) control and relay board for a 110 kV bus circuit
 - iv) Two (2) control and relay boards for three 22 kV distribution line circuits
- (b) One (1) manual synchronizing panel
- (c) One (1) set of AC and DC distribution panels
- (d) One (1) set of station batteries
- (e) One (1) battery charger
- (f) One (1) lot of accessories and spare parts
- (4) Cam Ranh Substation
- (a) One (1) set of duplex type, control and relay boards consisting of:
- i) One (1) control and relay board for a 115/22 kV main transformer circuit
 - ii) Three (3) control and relay boards for three 110 kV transmission line circuits

- iii) One (1) control and relay board for a 110 kV bus-tie circuit
 - iv) Two (2) control and relay boards for four 22 kV distribution line circuits
 - v) One (1) control and relay board for a power capacitor bank
- (b) One (1) manual synchronizing panel
 - (c) One (1) fault locator
 - (d) One (1) set of AC and DC distribution panels
 - (e) One (1) set of station batteries
 - (f) One (1) battery charger
 - (g) One (1) lot of accessories and spare parts
- (5) Dien Khanh Substation
- (a) One (1) set of duplex type, control and relay boards consisting of:
 - i) One (1) control and relay board for a 115/22 kV main transformer circuit
 - ii) Two (2) control and relay boards for two 110 kV transmission line circuits
 - iii) One (1) control and relay board for a 110 kV bus-tie circuit
 - iv) Two (2) control and relay boards for four 22 kV distribution line circuits
 - v) One (1) control and relay board for a power capacitor bank
 - (b) One (1) manual synchronizing panel
 - (c) One (1) set of AC and DC distribution panels
 - (d) One (1) set of station batteries
 - (e) One (1) battery charger
 - (f) One (1) lot of accessories and spare parts
- (6) One (1) lot of testing equipment and instruments

4.1.2 Requirements for Design

The equipment for the control system shall be highly reliable, long service life and suitable for continuous operation.

The equipment shall be designed to be fail-safe for the possible failure of any major circuit during the operation and shall provide a safeguard against possible surges, fail-safe against disrupted signals due to outside interference that would normally be associated with the cable communication lines and any other provisions necessary for the efficient operation of the equipment.

All instrument scales, switches, indicators, transducers and protective relays shall be suitable for the apparatus controlled or the purpose intended.

The control and relay boards provided under this Section shall be located in the control rooms of the control houses for the respective Substations.

It shall be the Contractor's responsibility to properly design the electrical control, protective relaying, alarm and indication schemes related to all equipment to be provided under this Contract.

The Contractor shall prepare arrangement and detailed drawings, equipment lists and wiring diagrams based on the requirements for meters, relays, control switches, indicating lamps and other devices including those to be supplied under other Sections and also for the remote control system from the control rooms of the respective stations.

4.2 CONTROL SYSTEM

(1) Control system for 115/22 kV main transformer

The control system of the on-load tap-changer for each 115/22 kV main transformer shall be designed to automatic control, remote electrical control, local manual control and hand operation.

The automatic control shall be made by action of the voltage regulating relay to be mounted on the relay board for the main transformer. The remote electrical control shall be made remotely from the main control board.

The local manual control shall be made on the front of the driving mechanism panel on the transformer.

(2) Control system for 110 kV switchgear

All 110 kV circuit breakers and disconnectors shall be controlled remotely from the control boards in the control house of each Substation. The switching positions for all the 110 kV circuit breakers and disconnectors shall be indicated on the associated control boards. The remote control from the control board shall be the direct wire control.

The operation of the 110 kV earthing switches shall be performed by local manual control at the operating mechanism. Only their switching positions shall be indicated on the control board.

Electrical interlocks as required for the disconnectors and the earthing switches shall be provided in the control board to prevent maloperation of the switchgear.

The control system shall be designed to communicate with the SCADA system to be established in the future. All the necessary provisions for this purpose shall be incorporated in the system.

(3) Synchronizing operation of 110 kV transmission lines

The synchronizing operation between each 110 kV transmission line and 110 kV bus shall be made on the front of the associated control board by manual control of the circuit breaker for each transmission line circuit with supervising the synchronoscope on the manual synchronizing panel.

The manual synchronizing operation mode shall be selected on the associated control board by an selector switch with two positions of "ON" and "OFF". One (1) removable

type switch shall be provided for common use to all the transmission circuits for each Substation and shall be pulled out at "OFF" position.

(4) Automatic reclosing of 110 kV switchgear

The automatic reclosing system shall be provided for each substation 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) "1 ϕ ": 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.

4.3 MEASURING ITEMS

The electrical quantities to be measured and indicated properly on the control boards shall be as shown on the single line diagrams appended herewith.

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.

4.4 PROTECTION AND ALARM

(1) General

Protection against electrical faults and abnormal conditions on the main transformers, 110 kV and 22 kV switchgear shall be conducted by the protective relays and switches. The mechanical relays and switches shall be provided under the relevant clauses of the main transformers and switchgear. The electrical protective relays shall be provided under this Section.

The Contractor shall ensure that the protection and alarm schemes are in every respect suitable for the equipment.

All trip and alarm contacts of protective relays shall be brought out to the terminals on the related local control panels and relays panels for the connection to the supervisory control system for the Renun Power station or to the SCADA system for the Load Dispatching Center.

(2) Main transformers

The protection and alarm for the main transformer shall be conducted by the following relays and conditions as applicable.

(a) Protection

- i) Main transformer percentage differential relay
- ii) Main transformer buchholtz relay (2nd stage)
- iii) Main transformer overcurrent relay
- iv) Main transformer ground overcurrent relay for neutral circuit

(b) Alarm

- i) Main transformer buchholtz relay (1st stage)

- ii) Main transformer winding temperature, high
- iii) Main transformer oil temperature, high
- iv) Main transformer oil level, low
- v) Main transformer main tank pressure relief device, operated
- vi) Main transformer elephant case pressure relief device, operated
- vii) Main transformer fire
- viii) Main circulation oil, low flow
- ix) Main transformer oil pumps or cooling fan, troubled
- x) Main transformer cooling system circuit voltage, low
- xi) Main transformer fire protection equipment, operated

(3) 110 kV transmission line

The main protection for the 150 kV transmission lines shall be made by the directional distance relays 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.

Fault annunciation with visual and audible alarm shall be provided on the control board for the following faults and conditions:

- (a) Bell alarm
 - i) Tripping by operation of the main protective relay for short-circuit fault
 - ii) Tripping by operation of the back-up protective relay for short-circuit fault
 - iii) Tripping by operation of the main protective relay for ground fault
 - iv) Tripping by operation of the back-up protective relay for ground fault
 - v) Final tripping
- (b) Buzzer alarm
 - i) Transmission line protective relay, failure
- (c) Melody chime
 - i) Success of auto-reclosing
- (4) 110 kV switchgear

Protection against the gas pressure drop in the circuit breaker shall be arranged in two stages as follows:

First stage

When the gas pressure drops to the preset alarm pressure, the first stage pressure relay shall be operated to provide buzzer alarm with fault indication on the associated control board.

Second stage

In the event that the gas pressure drops down extremely to the preset lockout pressure, the second stage pressure relay shall be operated to provide bell alarm with fault

indication on the related control board.

The protection and alarm for the 150 kV switchgear shall be as follows:

- (a) Protection
 - i) Circuit breaker gas pressure, extremely low (2nd stage)
 - ii) Circuit breaker phase-unbalanced closing or tripping
- (b) Alarm
 - i) Circuit breaker gas pressure, low (1st stage)
 - ii) Circuit breaker oil or air pressure, low
 - iii) Circuit breaker oil or air supply system troubled
 - iv) Circuit breaker tripping coil, broken
 - v) Lightning arrester, operated
 - vi) Capacitor voltage transformer, troubled
 - vii) Disconnecting switch, troubled

4.5 CONTROL AND RELAY BOARDS

4.5.1 General

Each control and relay board to be located in the substations 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 annunciators, 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.

4.5.2 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 110 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.

4.5.3 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 watthour 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 watthour meter shall be provided with a reverse running stop and a pulse transmitter.

4.5.4 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.

4.5.5 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 110 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.

4.5.6 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 110 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.

4.5.7 Indicating Lamp Assemblies

The indicating lamp assemblies 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 110 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.

4.6 ELECTRICAL PROTECTIVE RELAYS

All the electrical protective relays shall preferably be digital relays suitable for operation with the current transformer secondary of 5 A 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 110 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 4.5.

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.

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 or 110 V DC.

The watt and var transducers shall be suitable for measurement of bidirectional 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 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 110 kV transmission line voltage and the 110 kV bus voltage for manual synchronizing of each 110 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.

The manual synchronizing panel shall be furnished with the necessary provisions to connect additional synchronizing circuits of the future extension.

4.9 FAULT LOCATOR

One (1) fault locator shall be provided at the Cam Ranh Substation for calculation of the distance to the fault point on the 110 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 as an optional function of the relays.

4.10 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 110 V DC buses
- (b) One (1) DC voltmeter
- (c) Molded case circuit breakers in total

4.11 STATION BATTERY

4.11.1 Type and Rating

One (1) set of station battery consisting of 94 cells each in sealed plastic transparent container shall be provided for each substation to supply 110 V DC power, coordinating with battery chargers specified in Clause 4.12 below. The battery shall be of nickel cadmium alkaline, enclosed type, 110 V and 500 ampere-hour at 5-hours discharge rate.

4.11.2 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 4.12.

4.12 BATTERY CHARGER

One (1) battery charger shall be provided for each 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 400 V AC. 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 4.11.

The battery charger shall be provided with a load voltage compensating device (silicon 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 | Three-phase, 400 V |
| (b) Rated DC output voltage | Equal to equalizing charge voltage for the station battery of 94 cells |
| (c) Rated DC output current | 300 A |
| (d) DC output voltage regulation | |
| - floating charge voltage | Within $\pm 2\%$ |
| - boost charge voltage | Within $\pm 2\%$ |
| (e) DC output voltage adjustable range | |
| - for floating charge voltage | $\pm 3\%$ or more |
| - for equalizing charge voltage | $\pm 3\%$ 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

4.13 ELECTRICAL TESTING EQUIPMENT AND INSTRUMENTS

The following electrical testing equipment and instruments shall be supplied for maintenance and inspection.

- (a) One (1) High voltage testing facilities with mobile car
- (b) One (1) Tangent δ measuring equipment
- (c) One (1) Standard AC voltmeter, 0-300/600 V, class 0.5
- (d) One (1) Standard AC voltmeter, 0-150/750 V, class 0.5

- (e) Three (3) Standard AC voltmeter, 0-75/150 V, class 0.5
- (f) One (1) Standard AC ammeter, 0-0.2/1 A, class 0.5
- (g) Two (2) Standard AC ammeter, 0-2/10 A, class 0.5
- (h) One (1) Standard AC ammeter, 0-10/50 A, class 0.5
- (i) Two (2) Standard AC ammeter/voltmeter, 13 range, class 0.5
- (j) One (1) Split-core, AC ammeter/voltmeter, 6-300 A, 150-600 V, class 2.5
- (k) One (1) Standard DC voltmeter, 0-150/300 V, class 0.5
- (l) One (1) Standard DC voltmeter, 0-75 mV, class 0.5
- (m) One (1) Standard DC ammeter, 0-100/300 mA, class 0.5
- (n) Two (2) Standard DC ammeter/voltmeter, 17 range, class 0.5
- (o) One (1) Standard wattmeter, three-phase, 120-240 V, 5A, class 0.5
- (p) One (1) Standard varmeter, three-phase, 120-240 V, 5A, class 0.5
- (q) Two (2) Standard frequency meter, 45-55 Hz, class 0.2
- (r) One (1) Phase sequence indicator
- (s) One (1) Insulation tester, 500 V, 1000 M-ohm
- (t) One (1) Insulation tester, 1000 V, 2000 M-ohm
- (u) One (1) Earth tester
- (v) Three (3) Handy digital multimeter
- (w) One (1) Relay testing equipment
- (x) One (1) Portable oil tester
- (y) One (1) Oil handling and oil purifying equipment of mobile type
- (z) One (1) Aquameter to measure amount of moisture in oil
- (aa) One (1) Oscillographic recorder with 16 channels

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
 - (l) Other accessories recommended by the manufacturer
- (2) 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 each 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) auxiliary relays of each type
- (h) Two (2) timing relays of each type
- (i) Two (2) transducers of each type
- (j) Two (2) control and selector switches of each type
- (k) One (1) protective relay of each type
- (l) One (1) printed circuit board of each type
- (m) One (1) power supply unit of each type
- (n) 10% of installed quantity of marking strips and phase ferrules for wiring
- (o) One (1) pair of plug-in type connection accessories of each type
- (p) Two (2) years' supply of other expendables
- (q) 30% of diluted potassium and two (2) cells in seal for the storage battery
- (r) 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) 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

(c) Station battery

- i) Construction check
- ii) Capacity test for 5 cells
- iii) Electrolyte purity measurement

(d) 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

(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 TELEPHONE
EQUIPMENT

5.1 GENERAL

5.1.1 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 equipment to be installed in the Da Nhim Power Station, the Thap Cham Substation, the Phan Ri Substation, the Phan Thiet Substation, the Cam Ranh Substation and the Dien Khanh Substation.

(1) Da Nhim Power Station

- (a) One (1) set of PLC telephone equipment
- (b) One (1) set of coupling capacitor voltage transformer
- (c) One (1) set of coupling filter
- (d) One (1) set of line trap
- (e) One (1) set of line protective device
- (f) One (1) set of private automatic branch exchange (PABX)
- (g) Two (2) telephone sets
- (h) One (1) set of power supply equipment
- (i) One (1) lot of miscellaneous materials.

(2) Thap Charm Substation

- (a) Three (3) sets of PLC telephone equipment
- (b) Three (3) sets of coupling filter
- (c) Three (3) sets of line traps

- (d) One (1) set of line protective devices
 - (e) One (1) set of power supply equipment
 - (f) One (1) lot of miscellaneous materials
- (3) Phan Ri Substation
- (a) Two (2) sets of PLC telephone equipment
 - (b) Two (2) sets of coupling filter
 - (c) Two (2) sets of line trap
 - (d) Two (2) set of line protective device
 - (f) One (1) set of power supply equipment
 - (g) One (1) lot of miscellaneous materials
- (4) Phan Thiet Substation
- (a) One (1) set of PLC telephone equipment
 - (b) One (1) set of coupling filter
 - (c) One (1) set of line trap
 - (d) One (1) set of line protective device
 - (e) One (1) set of power supply equipment
 - (f) One (1) lot of miscellaneous materials
- (5) Cam Ranh Substation
- (a) Two (2) sets of PLC telephone equipment
 - (b) Two (2) sets of coupling filter
 - (c) Two (2) sets of line trap
 - (d) Two (2) sets of line protective device
 - (e) One (1) set of power supply equipment

- (f) One (1) lot of miscellaneous materials
- (6) Dien Khanh Substation
- (a) One (1) set of PLC telephone equipment
 - (b) One (1) set of coupling filter
 - (c) One (1) set of line trap
 - (d) One (1) set of line protective device
 - (e) One (1) set of power supply equipment
 - (f) One (1) lot of miscellaneous materials

5.2 GENERAL

5.2.1 Coupling

The coupling of the carrier signal to each transmission line shall be the phase-to-ground coupling type, one coupling capacitor, coupling filter, coaxial cable, line protective device and other necessary accessories.

5.2.2 Transmission Line

Principal features of the power transmission line will be as follows:

- (1) Line length:
- between Da Nhim P/S and Thap Cham S/S 41 km
 - between Thap Cham S/S and Phan Ri S/S 80 km
 - between Phan Ri S/S and Phan Thiet S/S 57 km
 - between Thap Cham S/S and Cam Ranh S/S 46 km
 - between Cam Ranh S/S and Dien Khanh S/S 46 km
- (2) Normal line voltage : 110 kV

- | | |
|---|---|
| (3) Number of circuit : | Single circuit |
| (4) Conductor: | |
| Da Nhim - Thap Cham, Thap Cham-Cam Ranh | ACSR 336.4 MCM |
| Cam Ran - Dien Khanh | ACSR 300 MCM |
| Thap Cham - Phan Ri, - Phan Thiet | ACSR 185 mm ² |
| (5) Overhead grounding wire: | |
| Da Nhim-Thap Cham-Cam Ranh - Dien Khanh | Galvanized steel wire of 22 mm ² |
| Thap Cham - Phan Ri - Phan Thiet | Galvanized steel wire of 50 mm ² |
| (6) Support : | Steel pole and concrete pole |
| (7) Grounding system : | Directly grounding system |

5.2.3 Power Source

An ac power source for the equipment available in each station shall be as follows

- (1) Da Nhim Power station
AC 380/220 V 50 Hz at station service ac panel
- (2) Other Substations
AC 400/230 V, 50 Hz at station service control panel

The D.C.48 power supply system consisting of the storage batteries of nickel cadmium alkaline (NICA) type and the battery chargers shall be supplied under Clause 5.10 below.

5.3 POWER LINE CARRIER TELEPHONE EQUIPMENT

5.3.1 General

Each power line carrier telephone equipment (hereinafter called as "PLC equipment") shall be of the single side band amplitude modulated type with reduced carrier transmission. The

channels shall be modulated with a nominal carrier frequency band of 4 kHz.

Each PLC equipment shall have a following channel

- (1) For the Da Nhim Power Station
 - One (1) set of four (4) channel for the Thap Cham Substation
- (2) For the Thap Cham Substation
 - One (1) set of four (4) channel for the Da Nhim Power Station
 - Two (2) sets of two (2) channel for the Phan Ri substation and the Cam Rauh Substation
- (3) For the Phan Ri Substation
 - One (1) set of two (2) channel for the Thap Cham Substation
 - One (1) set of one (1) channel for the Phan Thiet Substation
- (4) For the Phan Thiet Substation
 - One (1) set of one (1) channel for the Phan Ri Substation
- (5) For the Cam Rang Substation
 - One (1) set of two (2) channel for the Thap Cham Substation
 - One (1) set of one (1) channel for the Dien Khanh Substation
- (6) For the Dien khan Substation
 - One (1) set of one (1) channel for the Cam Ranh Substation

The PLC equipment shall have shall be designed to perform the transmission of any combination of the following types of information.

- (a) Speech for telephone communication
- (b) Telephone signalling

The PLC equipment shall be constructed on modular basis with printed circuit boards of plug-in insert and rack mounted type and shall operate form D.C48 V power supply system.

5.3.2 Technical Requirement

The offered PLC equipment shall satisfy the following requirements:

- (1) Transmission system : Single side band amplitude modulated type with reduced carrier
- (2) Communication system : Full duplex
- (3) Nominal carrier frequency band : 4 kHz
- (4) Voice frequency band
 - (a) Speech : 300 - 2,000 Hz
 - (b) Voice frequency telegraph (VFT)
Channel : 2,160 - 3,400 Hz
 - (c) Telephone signalling : 3,640±60 Hz
- (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 signalling : - ditto -
- (7) Speech and signals
input/output levels : To be recommended by the manufacturer
- (8) 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 to show that the
proposed equipment will meet this requirement.)
- (9) 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
- (10) Transmit/receive frequency difference : Zero difference
- (11) Synchronizing system : Pilot-controlled of subcarrier
- (12) Compandor : Syllabic type with compression ratio of 1/2 and expansion ratio of 2.
- (13) Nominal impedance:
 - (a) Carrier-frequency output circuit : 75 ohms (unbalanced)
 - (b) Speed and signal input and output circuits : 600 ohms (balanced)
- (14) Noise generated within the PLC equipment : Not exceed - 60 dBm Op when measured by a psophometer (Without compandor)
- (15) Audio Distortion factor : Less than 30 dB at 800 Hz
- (16) Signing margin : More than 12 dB when the 2-wire ends are terminated in 400 ohms not inductive resistance
- (17) 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 stated in Clause 5.10 hereunder.

5.3.3 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.

5.3.4 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
- (e) Measuring circuit for output power with measuring instruments
- (f) Test oscillator
 - Oscillating frequency : 300 Hz to 3.85 kHz
 - Output : -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.

5.3.5 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 section 1.6.4 of the General Specifications and shall be designed suitable for side-by-side alignment.

5.4 HIGH FREQUENCY COUPLING EQUIPMENT

5.4.1 General

Each high frequency coupling equipment comprise a coupling capacitor (voltage transformer) and a coupling filter unit.

The coupling capacitor voltage transformers except for the Da Nhim Power Station will be supplied by the contractor under section 3.3.5.

The coupling filters shall be of outdoor use suitable for mounting the coupling capacitor voltage transformers.

5.4.2 Coupling-Capacitor Voltage Transformer

The coupling-capacitor voltage transformers shall be of single-phase, oil-immersed, outdoor use, hermetically sealed construction for arrester protected area, to be used not only for measurement of transmission line voltage but also as a coupling capacitor for the power line carrier system to be supplied under Section 5.

Each coupling-capacitor voltage transformer shall be self-standing type to be mounted on a supporting structure and shall be designed to mount the line trap to be supplied under Section 5.5 on the top.

The coupling-capacitor voltage transformer shall be provided with a weather-proof steel box at the side of the voltage transformer housing to contain the secondary terminal blocks of the transformer and the coupling filter to be supplied under Section 5.4.3 carrier grounding switch and surge protective device shall be connected to the ground side of the coupling-capacitor and shall be provided in the steel box.

The steel box shall be so constructed as to be possible to inspect and test these equipment safely under the energized condition of line.

The coupling-capacitor voltage transformer shall be rated as follows:

- (a) Highest system voltage 123 kV
- (b) Rated voltage ratio $110 \text{ kV}/\sqrt{3} : 110 \text{ V}/\sqrt{3}$
- (c) Rated output Not less than 100 VA
- (e) Rated Voltage factor
1.2 for continuous
1.5 for 30 seconds
- (f) Rated insulation level 550 kV
- (g) Accuracy class
- for measuring 1.0
- for protective relaying 3P
- (h) Rated capacitance about 4,000 pF

The rated output of the coupling capacitor voltage transformer shall be determined by the Contractor to suit the actual burdens of the measuring instruments, cable and wires, etc., however the minimum output shall be 100 VA. The detailed calculation sheets for the rated output shall be submitted for approval.

5.4.3 Coupling Filters

The coupling filter shall be of outdoor use type and shall be housed in a weather - proof steel box to be mounted on the base structure of the coupling capacitor and the coupling - capacitor voltage transformer.

The coupling filter shall be provided with a coaxial cable terminal, a carrier grounding switch and surge protective device and they shall also be housed in the steel box.

The grounding switch shall be interlocked with the box door so that the door cannot be opened unless the grounding switch is closed to ground the coupling unit.

The coupling filter shall be rated as follows:

- (a) Type Band-pass filter type
- (b) Frequency range 50 to 500 kHz

- | | |
|---|---------------------------|
| (c) Impedance | |
| - Impedance for line side | 600 ohms \pm 20 percent |
| - Impedance for cable side | 75 ohms \pm 35 percent |
| (d) Attenuation loss at specified frequency range | Less than 1.5 dB |
| (e) Insulation strength | A.C. 6 kV for one minute |
| (f) Return loss | Not less than 12 dB |

5.5 LINE TRAPS

The line traps shall be of outdoor use, self-supporting, band filter type and shall be mounted on the top of the coupling-capacitor voltage trans-formers specified in section 3.3.5.

The line traps shall be provided with a lightning arrester for protection of tuning device against surge voltage on the transmission line and shall be equipped with a bird-barrier for prevention from bird nesting.

Each line trap shall be attached with suitable line terminal connector on both sides, for HDCC 240 mm² and 200 mm².

The line trap shall be rated as follows:

- | | |
|--------------------------------------|----------------------------|
| (a) Type | : Band filter type |
| (b) Highest system voltage | : 120 kV |
| (c) Rated continuous current | : 630 A |
| (d) Rated frequency range | : 50 - 500 kHz |
| (e) Impedance at specified frequency | : More than 800 ohms |
| (f) Tapping loss | : Less than 2.5 dB |
| (g) Short circuit current strength | : 20 kA for one (1) second |

5.6 LINE PROTECTIVE DEVICES

The line protective devices shall be of a wall mounting type or steel box mounting type next to the coupling filter, consisting of two gas-tube type lightning arresters, two fuses and a grounding changeover switch, suitably designed for protection of the PLC equipment and coaxial cables against impulse voltage and abnormal currents and voltages.

- (a) Rated voltage : 100 V A.C.
- (b) Rated Current : 2 A A.C.
- (c) Rated short-time current : 10 A A.C. for 1 minute
- (d) Temperature rise : Less than 60 °C
- (e) Power frequency withstand voltage between terminals, and terminals and ground : 3 kV a.C. for 1 minute
- (f) Impulse withstand voltage : 6 kV (1.2/50 micro-seconds) positive and negative polarities, five times each
- (g) Carrier frequency attenuation : Less than 0.1 dB
- (h) Current capacity of fuses : Less than 10 A
- (i) Impulse discharge current:
 - Line side arrester : 10 kA
 - Equipment side arrester : 20 kA
- (j) Sparkover voltages of lightning arresters : 200 - 300 V A.C. (Equipment side)
1,000 - 1,200 V A.C. (Line side)

5.7 COAXIAL CABLE

5.7.1 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.

5.7.2 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

5.8 PRIVATE AUTOMATIC BRANCH EXCHANGE

The private automatic branch exchanges (hereinafter called as "PABX") for the Da Nhim Power Station shall be supplied by using the existing PABX. The private automatic transit exchanges (hereinafter called as PABX) for the Da Nhim Power Station shall be supplied with the PLC equipment. Electronic switching PABX, fully compatible with the existing one.

Capability of the PABX shall be as follows

- (a) Extension : 8
- (b) Trunk connection with public : 1
- (c) Tie line with the station's PABX : 4
- (d) Intra-office trunk : 2

The PABX shall have the following main features:

- Ability to establish telephone communication with all other extensions, except limited access extensions, on the network
- Priority access; enabling selected extensions to interrupt busy extensions on either request of force the freeing or the busy extensions. Both priority levels to be available

- Conference call; both three way conference establish by a normal extension or a multi-party conference
- Call transfer; to enable a calling party to be transferred to another extension
- Automatic call transfer; to enable a called extension to be answered by another extension by keying the other extension number and prefix code or by use of a special push button

5.9 TELEPHONE SET

Two (2) telephone sets to be supplied and installed by the Contractor at the Da Nhim Power Station shall be as follows:

- (1) Type : Push button, desk top mounted type.
- (2) Special button : Button for call transfer and priority access shall be provided.
- (3) Communication system : Direct automatic call to or from Load Dispatching Center or any telephone in the net work shall be possible through the PABX.
- (4) Colour : Colour of the telephone set shall be subject to approval by the Employer.

The two telephone sets shall be mounted on the operator desk in the control room.

5.10 POWER SUPPLY EQUIPMENT

5.10.1 General

The D.C power supply equipment consisting of one (1) set of storage batteries and one (1) battery charger shall be provided for the Da Nhim Power Station, the Thap Cham Substation, the Phan Ri substation, the Phan Thiet substation, the Cam Rauh substation and the Dien Khanh Substation to supply 48-volt D.C power for the power line carrier system equipment provided under this Subsection.

Each power supply equipment shall be housed in an indoor installation, floor-standing, metal-enclosed cabinet.

The power supply equipment shall be arranged so that in the event of failure in the A.C. power supply, automatic switchover from the battery charger to the storage batteries shall be made to supply D.C. power to the loads.

5.10.2 Storage Battery

One (1) set of storage batteries each in sealed plastic transparent container shall be provided for each station to supply 48-volt D.C. power in coordination with the battery charger specified in Clause 5.10.3. The battery shall be of nickel cadmium alkaline, enclosed type.

The storage battery shall be designed for the nominal voltage of 48 V and operation under the floating charge condition, and shall have a sufficient capacity to operate respective equipment for a period of not less than eight hours at full load without charging.

The battery shall be positive grounded.

5.10.3 Battery Chargers

The battery charger shall be designed to give a stable floating charging and D.C. supply voltage shall be maintained within plus or minus 3 percent of the rated voltage.

The battery charger shall be suitable for operation with single-phase 230-volt A.C.

The battery charger shall be so designed that equalizing charging can be performed manually when required, and shall be returned to the floating charging automatically after the pre-set time has elapsed.

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

- | | |
|-------------------------------|--|
| (a) Type of rectifier | : Static construction thyristor type |
| (b) Cooling system | : Natural cooling |
| (c) Rating | : Continuous |
| (d) A.C. input voltage | : AC 230 V \pm 10%, 50 Hz, single-phase |
| (e) Rated D.C. output voltage | : Equal to equalizing charge voltage for storage battery |

- (f) Rated D.C. output current : To be recommended by the Tenderer
- (g) Regulation of D.C. output voltage : Less than $\pm 3\%$
- (h) Noise voltage : Less than 5 mV (battery - disconnected)
- (i) Ripple : Less than 300 mV (P - P)

5.10.4 Equipment and Instruments

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

- (a) Pilot lamp with auxiliary voltage transformer on A.C. input voltage side
- (b) D.C. ammeter for rectifier circuit with shunt
- (c) D.C. ammeter for battery circuit with shunt
- (d) D.C. voltmeter
- (e) Selector switch for D.C. voltmeter with two positions of "Battery Charger" and "Battery"
- (f) Molded case circuit breakers
- (g) Test Blocks
- (h) Load voltage compensating device with control, if required
- (i) Other necessary accessories

5.11 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

5.12 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 transformers 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) set of tuning device of each type for line trap, to be supplied for each station
- (i) One (1) set of lightning arrester of each type for line trap, to be supplied for each station
- (j) One (1) joint terminal of coaxial cable to PLC equipment, to be supplied for each station
- (k) One (1) joint terminal of coaxial cable to coupling equipment, to be supplied for each station

- (l) One (1) telephone set
- (m) 30% of diluted potassium for storage batteries

5.13 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) Coupling Capacitor Voltage Transformer
 - (a) Appearance check
 - (b) Verification of terminal markings

- (c) Check of relative polarity
- (d) Test for accuracy
- (e) Measurement of capacitance and tangent of loss angle
- (f) Power-frequency voltage dry test on primary winding
- (g) Power-frequency voltage dry test on secondary winding
- (h) Spherical gap spark-over voltage test

The certifications of the following type test items shall be submitted with the test report:

- (i) Temperature rise test
- (j) Impulse voltage test
- (k) Power-frequency voltage wet test
- (l) Measurement of stray earth capacitance
- (m) Measurement of high-frequency static capacitance
- (n) Measurement of equivalent series resistance
- (o) Frequency characteristic test

(3) Coupling filters:

- (a) Impedance characteristics test.
- (b) Frequency characteristics test.
- (c) Measurement of attenuation loss.
- (d) Measurement of insulation resistance.

(4) Line traps:

- (a) Construction check.
- (b) Impedance characteristics.
- (c) Tapping loss.

- (d) Impulse withstand voltage of main coil and tuning device without protective device.
 - (e) A.C. sparkover voltage of lightning arrester.
 - (f) Impulse sparkover voltage of lightning arrester.
 - (g) Inductance measurement of main coil.
 - (h) Short-time current (type test certificate acceptable).
- (5) 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.
- (6) Batteries (Sample test):
- (a) Capacity test.
 - (b) Characteristics test.
- (7) Battery chargers:
- (a) Temperature rise test.
 - (b) Current/voltage characteristics test.

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