JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE SOCIALIST REPUBLIC OF VIET NAM
THE MINISTRY OF ENERGY

REHABILITATION OF DA NHIM POWER SYSTEM IN THE SOCIALIST REPUBLIC OF VIET NAM

DRAFT TECHNICAL SPECIFICATIONS

Volume II of III

JUNE 1995

NIPPON KOEI CO., LTD.
TOKYO, JAPAN

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DRAFT TECHNICAL SPECIFICATION

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GENERAL TECHNICAL SPECIFICATIONS

1.1 STANDARDS AND DESIGN BASIS

1.1.1 Standards

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

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

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

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

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

1.1.2 Units

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

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

1.1.3 Language

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

1.1.4 Service Conditions for Plant Design

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

(1) Ambient Air Temperature

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

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

(2) Altitude

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

(3) Relative Humidity

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

(4) Wind Pressure

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

(5) Seismic Coefficient

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

(6) Atmospheres

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

(a) Da Nhim Power Station : Lightly polluted atmospheres

(b) Saigon Substation : Very heavily polluted atmospheres

1.1.5 Tropicalization

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

1.1.6 Lubricating Oil and Insulating Oil

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

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

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

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

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

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

1.1.7 Labels, Plates and Tags

(1) General

All transformers, switchgear, cubicles, instruments, switches, relays, valves, pipelines, cables, etc., shall be clearly identified by nameplates, escutcheon plates, labels, tags and/or other approved means showing the function and proper use of each item. Such

identification shall be in English or Vietnamese language in accordance with the instruction of the Employer and must be intelligently and carefully designed to minimize errors and to avoid maloperation in operation or maintenance.

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

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

(2) Rating Plates

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

(3) Warning Notices

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

(4) Device Numbers

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

1.2 MATERIALS AND WORKMANSHIP

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

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

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

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

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

1.3 FOUNDATION OF EQUIPMENT

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

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

Dimensioned arrangement drawings for foundation details, block-outs, openings, cable trenches and the like required for installation of the Contractor's Plant shall be prepared by the Contractor and submitted to the Engineer for approval. Details and locations of such foundations and all embedded parts to be supplied by the Contractor shall be fully indicated on the drawings. The Contractor shall be responsible for the completeness and accuracy of his drawings.

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

(a) Transformer
   i) Location of center of gravity
   ii) Total weight of transformer with oil

iii) Moment on foundation around X-axis and Y-axis

(b) Switchgear and Structures

i) Location of center of gravity

ii) Vertical load; weight of equipment with bushing and supporting structure

iii) Horizontal load; wind load, working tension of conductor and seismic load, for X-axis and Y-axis directions

iv) Uplifting load

v) Moment on foundation around X-axis and Y-axis

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

1.4 WORKING STRESSES AND DESIGN

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

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

Suitable structural steel bases or frames shall be provided where necessary to transmit to the concrete foundations all loads imposed by the various parts of the equipment. Such bases or frames shall be supplied complete with suitable anchor bolts and shall be so proportioned that the bearing loads imposed on the concrete foundations will not exceed 4.9 MPa.

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

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

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

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

1.5 CORROSION PROTECTION AND FINAL PAINTING

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

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

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

All steel surfaces which are in permanent contact with oil shall be given three coats of an approved oil resistant paint.

No painting or protection is required for finished or unfinished stainless steel parts.

The final color of all steelworks and equipment shall be approved by the Engineer under the confirmation of the Employer, unless otherwise clearly specified in the Specifications. The Contractor shall propose a color scheme for the steelworks and shall submit color chips or paint samples. A color chip shall be included with the approved color schedule for each type of finish to be applied at the Site. The color of all undercoats shall match the color of the finish coat.

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

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

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

1.6 COMMON CLAUSES FOR ELECTRICAL PLANT

1.6.1 Electric Power Systems

The electric power for the Da Nhim Power Station and the Saigon Substation shall be as follows:

(1) 230 kV, 50 Hz, three-phase system with directly grounded neutral, for the transmission lines between the Da Nhim Power Station and the Saigon Substation.

(2) 110 kV, 50 Hz, three-phase system with directly grounded neutral. The existing 66 kV transmission lines are planned to be upgraded to 110 kV in the future.

(3) 66 kV, 50 Hz, three-phase system with grounded neutral through a resistor of 76 ohms.

(4) 31.5 kV, 50 Hz, three-phase system with directly grounded neutral.

(5) 22 kV, 50 Hz, three-phase system with directly grounded neutral. 22 kV is the future operational voltage of the distribution lines. The existing 15 kV distribution lines are planned to be upgraded to 22 kV in the future.

(6) 15 kV, 50 Hz, three-phase system with directly grounded neutral. 15 kV is the present operational voltage of the distribution lines.

(7) 13.2 kV, 50 Hz, three-phase system, with rounded neutral through a neutral grounding transformer, for the generator circuit for the Da Nhim Power Station

(8) 11 kV, 50 Hz, three-phase system, with grounded neutral through a resistor of 63.5 ohms., for the synchronous condenser circuit for the Saigon Substation

(9) 400/230 V, 50 Hz, three-phase, four-wire system with directly grounded neutral. 400/230 V is planned to be used for the house-sevice power supply voltage for the Saigon Substation after this Project.

(10) 380/220 V, 50 Hz, three-phase, four-wire system with directly grounded neutral. 380/220 V is the present house-service power supply voltage for the Da Nhim Power Station and the Saigon Substation.

(11) 220 V D.C. system, isolated from ground, for main and auxiliary control circuits, protective relays, lamp indications and closing source of the circuit breakers only for the Da Nhim Power Station and the Saigon Substation.

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

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

(12) 48 V D.C. system, positive pole grounded, to be supplied from the power supply unit for the power line carrier telephone system.

1.6.2 Insulation Requirements

All transformers, switchgear, controlgear, other electrical equipment and power cables shall withstand the following dielectric test voltages for the rated voltages at the standard atmospheric conditions (Ambient temperature of 20°C, atmospheric pressure of 1,013 millibars and humidity of 11 g/m^3):

Rated voltage	245 kV	123 kV	36 kV	24 kV	600 V
Full-wave lightning impulse of 1.2 x 50 micro-second	950 kV	550 kV	170 kV	125 kV	–
Power frequency for one minute	395 kV	230 kV	70 kV	50 kV	2.5 kV (3 kV)

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

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

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

	230 kV	110 kV	36 kV	22 kV	400 V
Power frequency for ten minutes	156.8 kV	78.7 kV	41.3 kV	28.8 kV	600 V

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

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

1.6.3 Insulators and Bushings

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

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

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

1.6.4 Enclosures

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

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

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

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

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

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

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

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

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

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

(a) Exterior surface of enclosure
- for indoor installation: 5Y7/1
- for outdoor installation: N7

(b) Frame of measuring instrument: N1.5

(c) Frame of protective relay: N1.5

(d) Handle of control switch

- for ordinary use: N1.5

- for emergency use: 7.5R4.5/14

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

1.6.5 Measuring Instruments

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

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

Digital type measuring and indicating instruments shall be suitable for operation with D.C. output of the related transducers. The number of digits of each digital instrument shall be selected to suit the indicating purpose intended. The indicating elements for each digital indicator shall be of seven-segment LED illumination type. The digital type instruments required to indicate flow direction shall be provided with "+" and "-" signs.

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

1.6.6 Selector and Control Switches

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

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

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

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

1.6.7 Indicating Light Units

The indicating light units for the switchgear and controlgear cubicles shall be the light-emitting diode (LED) illumination, flush mounted, dust-proof, heavy duty type indicators suitable for operation with 220 V D.C. service.

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

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

1.6.8 Printed Circuit Boards

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

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

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

1.6.9 Molded Case Circuit Breakers and Miniature Circuit Breakers

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

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

The circuit breakers shall be rated as follows:

		A.C. circuit	D.C. circuit
(a)	Rated insulation voltage	600 V	250 V
(b)	Rated operational voltage	400 V or 230 V	220 V

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

1.65.10 Electric Motors

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

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

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

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

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

1.6.11 Power and Control Cables

(1) Power Cables

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

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

(2) Control Cables

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

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

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

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

(a) For current transformer secondary circuit

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

(b) For voltage transformer secondary circuit

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

(c) For AC control and indication circuits

Allowable voltage drop in the cables shall be as follows:

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

(d) For DC control and indication circuits

Allowable voltage drop in the cables shall be 5 V.

1.6.12 Wiring and Terminals

(1) General

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

The bunching of wiring shall be kept in bunched condition by means of strips of special plastic ribbon material at suitable intervals. Lacing of wire bunched with textile or plastic cord or metal buckle type clips will not be accepted. Wherever wiring is cleated to metalwork, it shall be insulated from the metal surface and shall be cleated by means of insulated straps in an approved manner. All wiring shall be left sufficiently long and neatly looped to allow a fresh termination to be made.

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

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

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

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

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

(2) Phase Arrangement

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

(3) Wiring Color Code

All wires shall be colored as follows:

Circuit	Color
Voltage transformers	Red
Current transformers	Black
A.C. circuit	Yellow
D.C. circuit	Blue
Grounding circuit	Green with yellow stripe

(4) Phase and Polarity Color Code

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

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

1.6.13 Cabling Works

(1) General

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

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

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

At the portion where the cables are passing through the openings on the building walls and floors and at inlet and outlet of cable conduits, suitable sealing materials shall be supplied by the Contractor to seal spaces between the cables and the openings for

complete rain and moisture tightness, for vermin-proof and for pretension of fire spreading. Sealing materials shall be non-inflammable type approved by the Engineer.

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

(a) Cable identification

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

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

(d) Route length.

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

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

(2) Cabling and Wiring

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

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

(3) Conduits

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

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

(4) Conduits Installation

Steel conduit systems shall be electrically and mechanically continuous.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1.6.14 Grounding of Equipment and Cables

(1) General

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

(2) Ground Connection to Station Ground Grid

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

(3) Grounding of Cubicles

A continuous copper grounding busbar shall run through the assembled switchgear and controlgear cubicles and all non-current carrying metal parts shall be effectively connected to it. The ground busbar shall be not less than 50 mm by 6 mm in size.

Connections shall be made by welds or by approved clamp type fittings and no soldered connections shall be used. The grounding busbar shall be effectively and electrically connected to the station grounding grid of each 110 kV substation.

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

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

(4) Grounding of Cables

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

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

1.7 PARTICULAR REQUIREMENTS FOR OUTDOOR ELECTRICAL PLANT

1.7.1 General Requirements

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

The design of all line conductor fittings, vibration dampers, insulator sets, etc., shall avoid sharp corners or projections which would produce high electromechanical stress under normal working conditions. The design of adjacent metal parts and melting surfaces shall be such as to prevent corrosion of the contact surfaces and to maintain good electrical contact under any service conditions. Particular care shall be taken during manufacture of conductors and fittings and during subsequent handling to ensure smooth surfaces free from abrasion.

1.7.2 Marking

(1) Members of Towers and Outdoor Steel Structures

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

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

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

(2) Insulator Units and Bushings

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

The marks shall be impressed before firing the glaze.

(3) Others

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

1.7.3 Bolts and Nuts

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

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

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

The nuts of all bolts for attaching insulator sets and groundwire fittings to the towers and outdoor steel structures shall be locked in an approved manner. These nuts shall be finger tight on the bolt and will be rejected if, in the opinion of the Engineer, they are considered to have an excessively loose or tight fit.

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

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

1.7.4 Galvanizing

(1) General

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

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

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

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

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

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

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

(2) White Rust

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

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

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

1.7.5 General Requirements on Arrangement of Outdoor Switchyard

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

(a)	Minimum clearance from the ground level to the bottom level of the bushings or supporting insulators:	2.5 m
(b)	Minimum clearance from the ground level to the nearest unscreened live conductors in air	
	i) 230 kV circuit:	4.5 m
	ii) 110 kVcircuit	3.4 m
	iii) 66 kV circuit	3.0 m
	iv) 31.5 kV circuit	2.7 m
	v) 22 kV circuit:	2.6 m
(c)	Height of supporting structures for equipment from the ground level:	To be adjusted according to the height of equipment and bushings

1.8 SPARE PARTS

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

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

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

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

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

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

1.19 Tests

1.19.1 Tests at Manufacturer's Works

(1) General

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

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

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

If two or more auxiliary equipment of identical design are supplied under the Contract, a complete performance test shall be carried out on the first unit of each kind of auxiliary

equipment. As for the Plants identically designed with those well tested and proven for the other projects, submission of the previous type test certificates and test reports may be acceptable instead of further complete performance tests upon the written approval of the Engineer.

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

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

(2) Dates for Inspection and Testing

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

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

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

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

(3) Test Reports

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

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

(4) Rectification of Deficiencies

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

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

(5) Inspection Certificates

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

1.19.2 Tests at Site

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

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

(1) Preliminary test during erection of equipment

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

(f) Oil tightness check and gas leakage tests

(g) Measurement of the resistance of the main circuit

(2) Performance test

(a) Transformers

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

(b) Circuit breakers

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

(c) Disconnecting switches and earthing switches

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

(d) Current transformers and voltage transformers

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

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

(e) Lightning arresters

i) Measurement of insulation resistance

(f) Busbars in switchgear cubicles

i) Measurement of insulation resistance
ii) Withstand voltage test

(g) Control and measuring equipment

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

(h) Protective relaying equipment

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

(i) Storage battery

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

(j) Battery charger

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

(k) Power Line Carrier Equipment

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

ii) Test of coupling capacitor voltage transformers

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

iii) Power supply equipment

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

(l) Power cables

i) Withstand voltage test
ii) Insulation resistance measurement

(m) Control cables

i) Insulation resistance measurement

(3) Testing Personnels and Facilities

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

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

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

(4) Maintenance during Site Tests

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

(5) Test Reports

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

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

(6) Rectification of Deficiencies

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

SECTION 2

TECHNICAL SPECIFICATIONS FOR TRANSFORMERS

2.1 SCOPE

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

(1) For Da Nhim Power Station

(a) Rehabilitation of four (4) banks of the 13.2/230 kV main transformers "1T", "2T", "3T" and "4T"

(b) Replacement of four (4) banks of the 13.2/0.38 kV house-service transformers "11T", "12T", "13T" and "14T"

(c) Replacement of one (1) bank of the 31.5/13.2/6.6 kV transformer "6T"

(d) Rehabilitation of one (1) bank of the 13.2/66 kV transformer "5T"

(2) For Saigon Substation

(a) Rehabilitation of four (4) single-phase 230/66/11 kV main transformers "1T"

(b) Replacement of one (1) bank of 230/66/11 kV main transformer "2T"

(c) Replacement of one (1) bank of 11/0.38 kV house-service transformer "5T"

(d) Replacement of one (1) bank of 0.38 kV house-service transformer "7T"

(e) Replacement of two (2) banks of 66/15 kV transformers "3T" and "4T"

(f) Replacement of one (1) bank of 66/15 kV transformer "9T"

2.2 BASIC REQUIREMENTS FOR REHABILITATION OF TRANSFORMERS

The replacement components for the partial rehabilitation of the existing transformers shall be brand new, equivalent specifications and suitably fitted to the original structures in case the design of the components is modified. The new components shall be complete with all the

necessary parts and materials for modification and restoration of the original structures.

The new gaskets for replacement shall preferably be prepared in the factory referring to the original manufacturing drawings. If the then drawings are missing, the new gaskets shall be shaped by adjusting to the original structures at the site. Special tools to shape the gaskets at the site shall be supplied by the Contractor, if necessary.

The new transformers for replacement shall be fabricated in compliance with the specified type and rating and shall also be designed suitably for connection to the existing cables and conductors. The new transformers shall be complete with all the necessary accessories, erection and maintenance tools and spare parts.

The new transformers shall in principle be located at the same places as the existing ones. If the new transformers cannot use the existing foundations, dimensioned arrangement drawings for the new foundation details shall be prepared by the Contractor and submitted to the Engineer for approval as specified in Clause 1.3 of the General Specifications.

2.3 TRANSFORMERS TO BE REHABILITATED

2.3.1 Type and Rating of Existing Transformers

(1) 13.2/230 kV main transformers "1T", "2T", "3T" and "4T" for Da Nhim Power Station

(a)	Type of transformer:	Three-phase, two-winding, oil-immersed type
(b)	Type of cooling:	Forced oil circulation, forced water cooling (OFWF)
(c)	Rated power:	45,000 kVA
(d)	Voltage ratio:	13.2/230 kV
(e)	Tap changer:	None
(f)	Connection symbol:	YNd1
(g)	Impedance voltage:	11.11 % (1T), 11.05 % (2T), 11.28 % (3T)
(h)	Circulating oil:	4,800 liter/min.
(i)	Cooling water:	320 liter/min.
(j)	Total weight:	92,000 kg

(k)	Weight of core and windings:	44,500 kg
(l)	Insulating oil volume:	23,400 liters
(m)	Name of manufacturer:	Fuji Electric, Japan
(n)	No. of manufacture:	131872A (1T), 131873A (2T), 131874A (3T), 131875A (4T)
(o)	Year of manufacture	1963

(2) 13.2/66 kV transformer "5T" for Da Nhim Power Station

(a)	Type of transformer:	Three-phase, two-winding, oil-immersed type
(b)	Type of cooling:	Natural oil circulation, forced air cooling (ONAF)
(c)	Rated power:	22,500 kVA
(d)	Voltage ratio:	13.2/69 - 66 R - 63 kV
(e)	Tap changer:	Off-circuit tap-changer at 66 kV side
(f)	Connection symbol:	YNd1
(g)	Impedance voltage:	7.04 %
(h)	Total weight:	40,200 kg
(i)	Weight of core and windings:	21,500 kg
(j)	Insulating oil volume:	9,400 liters
(k)	Name of manufacturer:	Nikki Electric Works, Japan
(l)	No. of manufacture:	NT-9033
(m)	Year of manufacture	1973

(3) 230/66/11 kV main transformer for Saigon Substation

(a)	Type of transformer:	Single-phase, three-winding, oil-immersed type
(b)	Type of cooling:	Forced oil circulation, forced air cooling (OFAF)
(c)	Rated power:	26,000/28,000/13,000 kVA

(d)	Voltage ratio:	230 R - 220 - 210/66/11 kV
(e)	Tap changer:	Off-circuit tap-changer at 230 kV side
(f)	Connection symbol:	YNyn0d1
(g)	Impedance voltage:	10.21 % (#131877A), 10.28 % (#131878A), 10.30 % (#131879A), 10.44 % (#131880A), 10.38 % (#131882A), 10.38 % (#131883A)
(h)	Circulating oil:	2,000 liter/min.
(i)	Cooling air:	1,008 liter/min.
(j)	Total weight:	66,500 kg
(k)	Weight of core and windings:	34,000 kg
(l)	Insulating oil volume:	18,500 liters
(m)	Name of manufacturer:	Fuji Electric, Japan
(n)	No. of manufacture:	131878A (1T-A), 131879A (1T-B), 131877A (1T-C), 131880A (2T-A) 131882A (2T-C), 131883A (2T-C) 131881A (spare)
(o)	Year of manufacture	1963

2.3.2 Scope of Rehabilitation Works of Transformers

(1) 13.2/230 kV main transformers "1T", "2T", "3T" and "4T" for Da Nhim Power Station

The following works shall be executed for the rehabilitation of all the four main transformers.

(a) Replacement of all bushings

Three (3) 230 kV line bushings, one (1) 230 kV neutral bushing and three (3) 13.2 kV bushings per each bank shall be replaced with new ones.

The new bushings shall be the current standard design. If the new bushing is smaller in size than the existing ones, a suitable adapter shall be provided as its accessory to fit the new bushing to the transformer tank. The new bushings shall

be complete with suitable line terminal connectors to connect with the existing conductors and insulation materials to restore the lead wire insulation which will be broken during the replacement work.

(b) Countermeasure against vibration of transformer

The necessary repairs for the vibration problem, such as re-tightening of the cores, shall be executed upon the overhaul inspection.

(c) Change of insulating oils

The insulating oil for each main transformer shall be changed after completion of the overhaul. The quantity of the insulating oil supplied shall be sufficient for the required overall net amount plus 10 percent extra oil.

(d) Replacement of oil pumps

All the four (4) oil pumps per each bank shall be replaced with new ones. The oil pumps shall be provided with all the necessary materials for their replacement works. Control cables between the new oil pumps and the existing local control box shall also be replaced with new ones.

(e) Replacement of mechanical protective relays

All the mechanical protective relays; namely, one (1) buchholtz relay, four (4) oil flow relays, two (2) water flow relays and one (1) dial thermometer per each bank shall be replaced with new ones. The mechanical protective relays shall be provided with all the necessary materials for the replacement works. Control cables between the respective relays and the existing local control box shall also be replaced with new ones.

(f) Replacement of oil preservation system

The existing oil preservation system of nitrogen gas sealing type shall be replaced by a diaphragm type with an oil-resistant synthetic rubber air cell in the conservator. The new oil preservation system shall be provided with a dehydrating air breather and an oil level gauge with a low oil level alarm on the conservator. Control cables between the oil level gauge and the existing local control box shall also be replaced with new ones.

(g) Repair painting on the transformers

All the exposed surfaces of the transformer, especially for the damaged paint and

rusted parts, shall be re-painted.

(h) Supply of spare parts

The following items shall be supplied as spare parts for the main transformers.

i) One 230 kV phase bushing

ii) One 230 kV neutral bushing

iii) One 13.2 kV bushing

iv) One buchholtz relay

v) Four oil flow relays

vi) One water flow relay

vii) Two dial thermometers

viii) One oil level gauge

(2) 13.2/66 kV transformer "5T" for Da Nhim Power Station

The following works shall be executed for the rehabilitation of the 13.2/66 kV transformer.

(a) Replacement of the air breather

The dehydrating air breather shall be replaced with new one. The air breather shall be provided with all the necessary materials for its replacement work.

(b) Replacement of cooling fan control unit

The cooling fan control unit and its dial thermometer shall be replaced with new ones. They shall be provided with all the necessary materials for their replacement works. Control cables for their circuits shall also be replaced with new ones.

(c) Repair painting on the transformer

All the exposed surfaces of the transformer, especially for the damaged paint and rusted parts, shall be re-painted.

(d) Supply of spare parts

One dial thermometer shall be supplied as spare parts for the 66 kV transformer "5T".

(3) 230/66/11 kV main transformer for Saigon Substation

The following works shall be executed for the rehabilitation of the four single-phase main transformers that will be chosen from the five existing transformers of #131877A, #131878A, #131880A, #131881A and #131882A.

(a) Replacement of bushings and gaskets

The gaskets for one (1) 230 kV line bushing, one (1) 230 kV neutral bushing and two (2) 66 kV bushings per each single-phase transformer shall be replaced with new ones. The new gaskets shall be identical in shape with the originals.

The insulating oil of the bushing shall be changed when the gaskets are replaced. Type and grade of the insulating oil to be supplied shall be suitable for the existing bushings.

On the other hand, the 11 kV bushings shall be replaced with new ones. The new bushings shall be of the current standard design. If the new bushing is smaller in size than the existing ones, a suitable adapter shall be provided as its accessory to fit the new bushing to the transformer tank. The new bushings shall be complete with suitable line terminal connectors to connect with the existing conductors.

Suitable insulation materials shall be supplied to restore the lead wire insulation which will be broken during the replacement works of the gaskets and the bushings.

(b) Replacement of oil pumps and radiator valves

All the four oil pumps and eight radiator valves per each single-phase transformer shall be replaced with new ones. The oil pumps and radiator valves shall be provided with all the necessary materials for their replacement works. Control cables between the new oil pumps and the existing local control box shall also be replaced with new ones.

(c) Replacement of mechanical protective relays

All the mechanical protective relays; namely, one (1) buchholtz relay, four (4) oil flow relays and one (1) dial thermometer per each bank shall be replaced with new

ones. The mechanical protective relays shall be provided with all the necessary materials for the replacement works. Control cables between the respective relays and the existing local control box shall also be replaced with new ones.

(d) Renewal of oil preservation system

The existing oil preservation system of nitrogen gas sealing type shall be replaced by a diaphragm type with an oil-resistant synthetic rubber air cell in the conservator. The new oil preservation system shall be provided with a dehydrating air breather and an oil level gauge with a low oil level alarm on the conservator. Control cables between the oil level gauge and the existing local control box shall also be replaced with new ones.

(e) Change of insulating oils

The insulating oil shall be changed after completion of all the rehabilitation works. The quantity of the insulating oil supplied shall be sufficient for the required overall net amount plus 10 percent extra oil.

(f) Repair paint on the transformers

All the exposed surfaces of the transformer, especially for the damaged paint and rusted parts, shall be re-painted.

(g) Supply of spare parts

The following items shall be supplied as spare parts for the main transformers.

i) One 230 kV phase bushing

ii) One 230 kV neutral bushing

iii) Two 66 kV bushings

iv) Two 11 kV bushings

v) One buchholtz relay

vi) One oil flow relay

vii) One dial thermometer

viii) One oil level gauge

2.4 NEW TRANSFORMERS FOR REPLACEMENT

2.4.1 Type and Ratio

(1) 13.2/0.38 kV house-service transformers for Da Nhim Power Station

The 13.2/0.38 kV house-service transformers shall be three-phase, oil immersed, two windings, sealed, outdoor use type with an off-circuit tap-changer. The house-service transformer shall be provided with a tapped 13.2 kV winding having altogether 3 tappings, symmetrically placed, and the no-load ratio shall be 13.8 - 13.2 R - 12.8 kV/380 - 220 V of three-phase four-wire system.

The transformer connection of the house-service transformer shall be Dyn11 of IEC 76-1 (1993) and the neutral of the star connected winding shall be brought out for solid grounding.

(2) 31.5/13.2/6.6 kV transformer "6T" for Da Nhim Power Station

The 31.5/13.2/6.6 kV transformer shall be three-phase, oil immersed, three-windings, sealed, outdoor use type with an off-circuit tap-changer. The transformer shall be provided with a tapped 31.5 kV winding having altogether 3 tappings, symmetrically placed, and the no-load ratio shall be (33 - 31.5 R - 30)/13.2/(6.9 - 6.6 R- 6.3) kV

(3) 230/115(69)/11 kV main transformer "2T" for Saigon Substation

The 230/115(69)/11 kV main transformer shall be of three-phase, oil immersed, three-winding, sealed, on-load tap-changing, outdoor use type transformer with a delta-connected winding for connection of the existing gas turbine circuit. The main transformer shall be provided with a tapped 230 kV winding having altogether 17 tappings, symmetrically placed, and the no-load ratio shall be (230 kV ± 8 x 1.5 %)/115(69)/11 kV. The connection of the secondary winding shall be changeable for the rated voltages of 115 kV and 69 kV.

The transformer connection of the main transformer shall be YNyn0(yn0)d1 of IEC 76-1 (1993) and the neutral of the both star connected windings shall be brought out for solid grounding.

(4) 11/0.4 kV house-service transformer "5T" for Saigon Substation

The 11/0.4 kV house-service transformers shall be three-phase, oil immersed, two windings, sealed, outdoor use type with an off-circuit tap-changer. The house-service transformer shall be provided with a tapped 11 kV winding having altogether 3

tappings, symmetrically placed, and the no-load ratio shall be 11.5 - 11 R - 10.5 kV/400 - 230 V of three-phase four-wire system.

The transformer connection of the house-service transformer shall be Dyn11 of IEC 76-1 (1993) and the neutral of the star connected winding shall be brought out for solid grounding.

(5) 22(15)/0.4 kV house-service transformer "7T" for Saigon Substation

The 22(15)/0.4 kV house-service transformers shall be three-phase, oil immersed, two windings, sealed, outdoor use type with an off-circuit tap-changer. 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) kV ± 1 x 5%)/400 - 230 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 Dyn11 of IEC 76-1 (1993) and the neutral of the star connected winding shall be brought out for solid grounding.

(6) 115(69)/22(15) kV transformers "3T", "4T", "9T" for Saigon Substation

The 115(69)/22(15) kV transformers shall be of three-phase, oil immersed, two-winding, sealed, on-load tap-changing, outdoor use type transformer with an on-load tap-changer. The main transformer shall be provided with a tapped 115(69) kV winding having altogether 17 tappings, symmetrically placed, and the no-load ratio shall be (115(69) kV ± 8 x 1.5 %)/22(15) kV. The connection of the primary winding shall be changeable for the rated voltages of 115 kV and 69 kV. The connection of the secondary winding shall also be changeable for the rated voltages of 22 kV and 15 kV.

The transformer connection of the main transformer shall be YN(YN)yn0(yn0) of IEC 76-1 (1993) and the neutral of the both star connected windings shall be brought out for solid grounding.

2.4.2 Rated Power

(1) 13.2/0.38 kV house-service transformers "11T", "12T", "13T", "14T" for Da Nhim Power Station

The continuous rated power of the transformer shall be 500 kVA, under natural oil circulation, natural air cooling, on any of the taps.

(2) 31.5/13.2/6.6 kV transformer "6T" for Da Nhim Power Station

The continuous rated power of the transformer shall be 10,000/10,000/3,000 kVA, under natural oil circulation, forced air cooling, on any of the taps.

(3) 230/115(69)/11 kV main transformer "1T" for Saigon Substation

The continuous rated power of the transformer shall be 125,000/125,000/40,000 kVA, under forced directed oil circulation, forced air cooling, on any of the taps.

(4) 11/0.4 kV house-service transformer "5T" for Saigon Substation

The continuous rated power of the transformer shall be 400 kVA under natural oil circulation, natural air cooling, on any of the taps.

(5) 22(15)/0.4 kV house-service transformer "7T" for Saigon Substation

The continuous rated power of the transformer shall be 400 kVA under natural oil circulation, natural air cooling, on any of the taps.

(6) 115(69)/22(15) kV transformers "3T", "4T", "9T" for Saigon Substation

The continuous rated power of the transformers "3T" and "4T" shall be 31,500 kVA under natural oil circulation, forced air cooling on any of the taps.

The continuous rated power of the transformer "9T" shall be 12,500 kVA under natural oil circulation, forced air cooling on any of the taps.

2.4.3 Temperature-Rise Limit

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

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

2.4.4 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.

2.4.5 Insulation Levels

The transformers shall withstand the following voltages:

(1) 230 kV side:

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

(2) 115 kV side:

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

(3) 31.5 kV side:

- Full-wave lightning impulse
  1.2 x 50 micro-second 170 kV
- Power-frequency for one minute 70 kV

(4) 22 kV side:

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

(5) 13.2 kV sides:

- Full-wave lightning impulse
  1.2 x 50 micro-second 95 kV
- Power-frequency for one minute 38 kV

(6) 11 kV side:

- Full-wave lightning impulse

1.2 x 50 micro-second 75 kV

- Power-frequency for one minute 28 kV

(7) 6.6 kV side:

- Full-wave lightning impulse
  1.2 x 50 micro-second 60 kV
- Power-frequency for one minute 20 kV

(8) 400 V and 380 V sides:

- Power-frequency for one minute 38 kV

(9) Neutral terminal to be directly grounded:

- Power-frequency for one minute at least 38 kV

2.4.6 Impedance Voltage

Impedance voltage between the primary and secondary windings of each transformer on the basis of the rated power on the rated tap shall preferably be almost same value as listed below for the existing transformer:

(a) 13.2/0.38 kV house-service transformers: 4.5 %

(b) 31.5/13.2/6.6 kV transformer: 3.5 %

(c) 230/115(69)/11 kV main transformer: 10 %

(d) 11/0.4 kV house-service transformer: 4.5 %

(e) 22(15)/0.4 kV house-service transformer: 4.5 %

(f) 115(69)/22(15) kV transformers: 7.5 %

The impedance voltage 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.

2.4.7 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.

2.4.8 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.

2.4.9 Windings and Insulation

Graded insulation shall be applied to the 230 kV windings where their neutral points are directly grounded. Full insulation shall be applied to other windings.

The windings shall be of high conductivity copper.

The amount of insulation shall be determined not only by normal voltage per turn, but also by due consideration of the line voltage and the service conditions, including impulse phenomena caused by lightning strokes on the transmission line and surges during switching operation of circuit breakers and other associated fault conditions.

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

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

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

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

and degassed oil under vacuum.

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

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

2.4.10 Bushing

The bushings for the line terminals of 230 kV and 115 kV sides shall be of oil impregnated paper condenser type outdoor-oil bushings. The bushings for their neutral terminals shall be of oil filled type. The bushings for the terminals of 31.5 kV or less 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 each winding shall be connected with a copper conductor of bar or rod or pipe, which shall run down to ground, supported by insulators on the transformer tank. The neutral conductor shall be fitted with a terminal for the grounding wires of two 95 sq. mm stranded copper.

Each bushing shall be provided with suitable type terminals for connection with the existing conductors.

2.4.11 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.

The tank shall be provided with oil sampling valve, oil drain valve, oil fill valve, air vent plug and explosion vent. The valves shall have fittings suitable for connecting the existing oil purifier.

A suitable pressure relief device shall be provided on the explosion vent of each transformer. As for the transformer with the rated power of 10,000 kVA or larger, the pressure relief devices shall be provided with an alarm contact and an oil discharge pipe shall be provided to lead the oil gushed out from the explosion vent to the ground level.

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

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

The 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 mm^2 stranded copper conductors shall be welded to the bottom of each tank.

2.4.12 Cooling System

The cooling method of each transformer shall be as follows:

(1) 13.2/0.38 kV house-service transformers "11T", "12T", "13T", "14T" for Da Nhim Power Station

The cooling method of the house-service transformers shall be natural oil circulation and neutral air cooling system (ONAN). The cooling equipment shall consist of finned-tube radiators.

(2) 31.5/13.2/6.6 kV transformer "6T" for Da Nhim Power Station

The cooling method of the transformer shall be natural oil circulation and forced air cooling system (ONAF). The cooling equipment shall consist of finned-tube radiators and cooling fans.

(3) 230/115(69)/11 kV main transformer "2T" for Saigon Substation

The cooling method of the transformer shall be forced oil circulation and forced air cooling system (OFAF). The forced directed oil circulation system (OD) will also be acceptable. The cooling equipment shall consist of finned-tube radiators, oil pumps and cooling fans.

(4) 11/0.4 kV house-service transformer "5T" for Saigon Substation

The cooling method of the house-service transformers shall be natural oil circulation and neutral air cooling system (ONAN). The cooling equipment shall consist of finned-tube radiators.

(5) 22(15)/0.4 kV house-service transformer "7T" for Saigon Substation

The cooling method of the house-service transformers shall be natural oil circulation and neutral air cooling system (ONAN). The cooling equipment shall consist of finned-tube radiators.

(6) 115(69)/22(15) kV transformers "3T", "4T", "9T" for Saigon Substation

The cooling method of the transformer shall be natural oil circulation and forced air cooling system (ONAF). The cooling equipment shall consist of finned-tube radiators and cooling fans.

The cooling equipment shall consist of several units plus an extra stand-by unit and shall have sufficient capacity, without the stand-by unit, not only to maintain the insulating oil at proper temperature under the specified service condition but also to prevent overheating the transformer when operating continuously with the rated power.

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

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

An oil pump shall be provided on each radiator unit and located below the unit. The oil pump shall be designed to prevent cavitation pitting. An oil-immersed motor shall be incorporated with the oil pump integrally in a totally enclosed casing to prevent oil leakage. Suitable stop

valves shall be provided on both sides of each pump for easy maintenance. The oil pumps shall be provided with suitable oil filters at the oil inlet to prevent foreign materials such as the transformer insulation materials and spaces from entering into the oil pump.

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

In case of OF type, an oil flow indicator with low-flow alarm contact shall be provided for each radiator unit and located between radiator and oil pump.

The power source for the oil pumps and the cooling fans of the transformers for the Da Nhim Power Station shall be 380 V three-phase or 220 V single-phase AC to be taken from the AC distribution panel in the power house. While, it for the Saigon Substation shall be 400 V three-phase or 230 V single-phase AC to be taken from the AC distribution panel in the control room. The power cables for the pumps and fans shall be supplied by the Contractor.

2.4.13 Oil Preservation System

Each 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.

2.4.14 Tap-Changer

(1) Off-circuit tap-changer

Each of the following transformers shall be equipped with an off-circuit tap-changer at the primary voltage side.

(a) 13.2/0.38 kV house-service transformers "11T", "12T", "13T", "14T" for the Da Nhim Power Station

(b) 31.5/13.2/6.6 kV transformer "6T" for the Da Nhim Power Station

(c) 11/0.4 kV house-service transformer "5T" for the Saigon Substation

(d) 22(15)/0.4 kV house-service transformer "7T" for the Saigon Substation

The tap-changer shall be able to operate 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) On-load tap-changer

On-load tap-changers shall be provided on 230/115(69)/11 kV main transformer "2T" and 115(69)/22(15) kV transformers "3T", "4T", "9T" for the Saigon Substation to maintain their secondary voltages at the predetermined value by changing the tapping connection of the windings while the transformers are 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 2.4.13.

(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 220 V single-phase, 50 Hz to be taken from the AC distribution panel in the control room.

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

The control system of the on-load tap-changer shall be designed to permit automatic control, remote electrical control, local manual control and hand operation. The automatic control shall be made by action of an adequate voltage regulating relay to be connected to the 230 kV or 110 kV voltage transformer. The remote electrical control shall be made remotely from the main control board to be supplied under Section 4 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.

2.4.15 Base

Each 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.

2.4.16 Protection and Alarm

The following protection and alarm shall be provided on each transformer as applicable:

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

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

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

(d) Low oil level; for alarm

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

(f) Low oil flow; for alarm

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

(h) Cooling system circuit low voltage; for alarm

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

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

Electrical protective relays for protection of each transformer shall be supplied under Section 4.

2.4.17 Thermometer and Temperature Detector

The dial type indicating thermometers shall be provided to indicate the top oil temperature of each transformer. As for the transformers with the rated power of 10,000 kVA or larger, the dial type thermometers for the winding temperatures shall also be provided. Each dial type thermometer shall be provided with maximum temperature pointer, calibrated in centigrade, and equipped with alarm contacts suitable for 220 V DC, shall be provided to indicate the temperature of the top oil and winding for each transformer.

The thermometer shall be of vapor pressure type or mercury filled type and variation of the volume or pressure arising from temperature change shall be transmitted to a Bourdon tube

fitted to the indicator through the capillary tube of the flexible interconnecting pipe. The sensing bulb of the thermometer shall be installed at the hottest oil near the top of the tank. The dial type indicators shall be mounted on the tank or the control cabinet specified in Clause 2.2.19 below.

The current proportional to the load of the transformer; which is necessary for the winding temperature measurement, shall be supplied from the built-in current transformer specified in Clause 2.4.18 below.

Each transformer except the house-service transformers shall be provided with resistance type temperature detectors of 100 ohm at 0 °C of platinum element for temperature measurements of the top oil and winding. These oil and winding temperatures will be indicated on the control boards to be supplied under Section 4. The resistance type temperature detectors shall be wired to the terminals of the control cabinet for connection to the control boards. Control cables between the detector and the control boards and necessary transducers shall be supplied by the Contractor.

2.4.18 Current Transformers

(1) Built-in current transformers

Each transformer other than the house-service transformers shall be equipped with single-ratio ring-core type current transformers in each bushing. The current transformers shall be rated as follows:

(a) 31.5/13.2/6.6 kV transformer "6T" for the Da Nhim Power Station

i) 31.5 kV line bushings

- Quantity:	1 core for measuring
	1 core for protective relaying
- Rated current ratio	250/5 A
- Rated output	Not less than 30 VA
- Rated short-time thermal current	12.5 kA for three (3) seconds
- Accuracy class	1.0 for measuring
	5P20 for protective relaying

In addition, one ring-core type current transformer with suitable current ratio shall be provided in the 31.5 kV line bushing for the thermal image type winding thermometer of the 31.5 kV winding. The rating of this current transformer shall be determined by the Contractor and shall be subject to the Engineer's approval.

ii) 31.5 kV neutral bushing

- Quantity:	1 core for protective relaying
- Rated current ratio	100/5 A
- Rated output	Not less than 30 VA
- Rated short-time thermal current	12.5 kA for three (3) seconds
- Accuracy class	5P20 for protective relaying

iii) 13.2 kV bushings

- Quantity:	1 core for protective relaying
- Rated current ratio	600/5 A
- Rated output	Not less than 30 VA
- Rated short-time thermal current	20 kA for three (3) seconds
- Accuracy class	5P20 for protective relaying

iv) 6.6 kV line bushings

- Quantity:	1 core for measuring
	1 core for protective relaying
- Rated current ratio	400/5 A
- Rated output	Not less than 30 VA
- Rated short-time thermal current	12.5 kA for three (3) seconds
- Accuracy class	1.0 for measuring
	5P20 for protective relaying

(b) 230/115(69)/11 kV main transformer "2T" for Saigon Substation

i) 230 kV line bushings

- Quantity:	1 core for measuring
	3 cores for protective relaying
- Rated current ratio	400/1 A
- Rated output	Not less than 30 VA
- Rated short-time thermal current	20 kA for three (3) seconds
- Accuracy class	0.5 for measuring
	5P20 for protective relaying

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

Engineer's approval.

ii) 230 kV neutral bushing

- Quantity:	1 core for protective relaying
- Rated current ratio	200/1 A
- Rated output	Not less than 30 VA
- Rated short-time thermal current	20 kA for three (3) seconds
- Accuracy class	5P20 for protective relaying

iii) 115(69) kV line bushings

- Quantity:	1 core for measuring
	3 cores for protective relaying
- Rated current ratio	1,000/1 A
- Rated output	Not less than 30 VA
- Rated short-time thermal current	25 kA for three (3) seconds
- Accuracy class	0.5 for measuring
	5P20 for protective relaying

iv) 115(69) kV neutral bushing

- Quantity:	1 core for protective relaying
- Rated current ratio	300/1 A
- Rated output	Not less than 30 VA
- Rated short-time thermal current	25 kA for three (3) seconds
- Accuracy class	5P20 for protective relaying

v) 11 kV bushings

- Quantity:	1 core for measuring
	1 core for protective relaying
- Rated current ratio	2,500/1 A
- Rated output	Not less than 30 VA
- Rated short-time thermal current	25 kA for three (3) seconds
- Accuracy class	0.5 for measuring
	5P20 for protective relaying

(c) 115(69)/22(15) kV transformers "3T", "4T" for Saigon Substation

i) 115(69) kV bushings

- Quantity:	1 core for measuring 3 cores for protective relaying
- Rated current ratio	250/1 A
- Rated output	Not less than 30 VA
- Rated short-time thermal current	25 kA for three (3) seconds
- Accuracy class	0.5 for measuring 5P20 for protective relaying

ii) 22(15) kV line bushings

- Quantity:	1 core for measuring 1 core for protective relaying
- Rated current ratio	1,250/1 A
- Rated output	Not less than 30 VA
- Rated short-time thermal current	25 kA for three (3) seconds
- Accuracy class	0.5 for measuring 5P20 for protective relaying

iii) 22(15) kV neutral bushing

- Quantity:	1 core for protective relaying
- Rated current ratio	300/1 A
- Rated output	Not less than 30 VA
- Rated short-time thermal current	25 kA for three (3) seconds
- Accuracy class	5P20 for protective relaying

(d) 115(69)/22(15) kV transformers "9T" for Saigon Substation

i) 115(69) kV bushings

- Quantity:	1 core for measuring 3 cores for protective relaying
- Rated current ratio	100/1 A
- Rated output	Not less than 30 VA
- Rated short-time thermal current	25 kA for three (3) seconds
- Accuracy class	0.5 for measuring 5P20 for protective relaying

ii) 22(15) kV line bushings

- Quantity:	1 core for measuring 1 core for protective relaying

- Rated current ratio	500/1 A
- Rated output	Not less than 30 VA
- Rated short-time thermal current	25 kA for three (3) seconds
- Accuracy class	0.5 for measuring
	5P20 for protective relaying

iii) 22(15) kV neutral bushing

- Quantity:	1 core for protective relaying
- Rated current ratio	150/1 A
- Rated output	Not less than 30 VA
- Rated short-time thermal current	25 kA for three (3) seconds
- Accuracy class	5P20 for protective relaying

2.4.19 Control Cabinet

One weather-proof type control cabinet shall be mounted on each 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 2.4.16. The group fault annunciator shall be of target type indicator with a reset switch.

Each item of the protection and alarm specified in Clause 2.2.18 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 control room of the respective stations.

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 220/230 V single-phase or 380/400 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 6.

2.4.20 Accessories

The following accessories shall be provided for each transformer as applicable:

(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

2.4.21 Spare Parts

The following spare parts shall be furnished for each transformer 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.

2.4.22 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.

SECTION 3

TECHNICAL SPECIFICATIONS FOR SWITCHGEAR

3.1 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 and the Saigon Substation.

(1) Da Nhim Power Station

(a) 230 kV switchgear

i) Replacement of air pressure switches and door gaskets for seven (7) control boxes of the existing 230 kV air-blast circuit breakers

ii) Replacement of eighteen (18) control boxes of the existing 230 kV disconnectors

iii) Replacement of three (3) single-phase voltage transformers for 230 kV transmission line circuit

(b) 66 kV switchgear

i) Replacement of air pressure switches and door gaskets for two (2) control boxes of the existing 66 kV air-blast circuit breakers

ii) Replacement of nine (9) control boxes of the existing 66 kV disconnectors

(c) 13.2 kV switchgear

i) Replacement of one (1) parallel resistors for the existing 13.2 kV air-blast circuit breaker "543", phase A

(d) 6.6 kV switchgear

i) Replacement of two (2) pilot contacts for the existing 6.6 kV magnetic-blast circuit breakers "636" and "672"

(e) Compressed air supply systems for air-blast circuit breakers

i) Replacement of two (2) air compressors for outdoor circuit breakers

ii) Replacement of one (1) air compressor for indoor circuit breakers

iii) Additional installation of one (1) air reservoir to the existing compressed air supply system for outdoor circuit breakers

(2) Saigon Substation

(a) 66 kV switchgear

i) Additional installation of one (1) circuit breaker for the additional power capacitor bank

ii) Additional installation of one (1) disconnector for the additional power capacitor bank

iii) Replacement of air pressure switches and door gaskets for fifteen (15) control boxes of the existing 66 kV air-blast circuit breakers

iv) Replacement of forty (40) control boxes of the existing 66 kV disconnector

v) Replacement of six (6) single-phase current transformers for the existing current transformers "772" and "777"

vi) Replacement of three (3) single-phase voltage transformers for the 66 kV bus No. 1

vii) Replacement of thirty-three (33) single-phase lightning arresters for three 115/22 kV transformer circuits and eight feeder circuits

viii) Additional installation of six (6) single-phase lightning arresters for the 66 kV bus No. 1 and No. 2

ix) Replacement of one (1) air compressor for 66 kV circuit breakers

x) Supply of spare parts for the existing 66 kV air-blast circuit breakers

- Six sets of moving and fix contacts for 1,000 A
- Three sets of moving and fix contacts for 800 A
- Three sets of moving and fix contacts for 400 A
- 40 kg of grease for dash-pot

(b) 15 kV switchgear

i) Replacement of five (5) disconnectors for "577-1", "577-7", "579-1", "579-7", "581-1" and "581-7"

(c) 66 kV power capacitor bank

i) Additional installation of one (1) capacitor bank

3.2 TYPE AND RATING OF EXISTING SWITCHGEAR FOR PARTIAL REHABILITATION

(1) 230 kV air-blast circuit breaker for Da Nhim Power Station

(a)	Manufacturer's type	OPB-350B-PA
(b)	Applied standard	JEC-145
(c)	Rated voltage	230 kV
(d)	Rated insulation level	
	- Full-wave lightning impulse	900 kV
	- Power frequency for one minute	395 kV
(e)	Rated normal current	
	- for main transformer circuit	600 A
	- for 230/110 kV transformer circuit	800 A
	- for transmission line circuit	800 A
	- for bus-tie circuit	800 A
(f)	Rated interrupted capacity	3,500 MVA (230 kV)
(g)	Rated interrupting time	3 cycles
(h)	Rated operating sequence	
	- for main transformer circuit	0 - 1 min.- CO - 3 min.- CO
	- for 230/110 kV transformer circuit	0 - 0.35 sec - CO - 3 min.- CO
	- for transmission line circuit	0 - 0.35 sec - CO - 3 min.- CO
	- for bus-tie circuit	0 - 1 min.- CO - 3 min.- CO
(i)	Control circuit voltage	220 V DC
(j)	Rated operating air pressure	15 kg/cm^2

(k)	Capacity of air tank	1,210 liters x 3
(l)	Name of manufacturer	Hitachi, Ltd. Japan
(m)	Manufacturer's serial number	
	- for main transformer circuit	421334-1 & 2, 421335-1 & 2
	- for 230/110 kV transformer circuit	422170-1
	- for bus-tie circuit	421335-3
	- for transmission line circuit	421333-1
(n)	Year of manufacture	1962

(2) 230 kV disconnectors for Da Nhim Power Station

(a)	Manufacturer's type	PHL-RA
(b)	Applied standard	JEC-125
(c)	Rated voltage	230 kV
(d)	Rated insulation level	
	- Full-wave lightning impulse	900 kV
	- Power frequency for one minute	395 kV
(e)	Rated normal current	
	- for main transformer circuit	400 A
	- for 230/110 kV transformer circuit	800 A
	- for transmission line circuit	800 A
	- for bus-tie circuit	800 A
(f)	Rated short-time withstand current	20 kA
(g)	Name of manufacturer	Hitachi, Ltd. Japan
(h)	Manufacturer's serial number	
	- for main transformer circuit	478216-1 to 4, 478217-1 to 4
	- for 230/110 kV transformer circuit	470734-1 to 3
	- for transmission line circuit	478214-1 to 5
	- for bus-tie circuit	478215-1 & 2
(n)	Year of manufacture	1963

(3) 66 kV air-blast circuit breaker for Da Nhim Power Station

(a)	Manufacturer's type	PPM-73
(b)	Applied standard	JEC-145
(c)	Rated voltage	72 kV
(d)	Rated insulation level - Full-wave lightning impulse	350 kV
(e)	Rated normal current	600 A
(f)	Rated interrupted capacity	1,500 MVA (72 kV)
(g)	Rated interrupting time	5 cycles
(h)	Rated operating sequence	0 - 1 min.- CO - 3 min.- CO
(i)	Control circuit voltage	220 V DC
(j)	Rated operating air pressure	15 kg/cm^2
(k)	Capacity of air tank	460 liters x 3
(l)	Name of manufacturer	Nissin Electric Japan
(m)	Manufacturer's serial number	735089, 735090
(n)	Year of manufacture	1973

(4) 66 kV disconnectors for Da Nhim Power Station

(a)	Manufacturer's type	LLV-620
(b)	Applied standard	JEC-125
(c)	Rated voltage	72 kV
(d)	Rated insulation level - Full-wave lightning impulse	350 kV
(e)	Rated normal current	600 A
(f)	Rated short-time withstand current	27 kA

(g)	Name of manufacturer	Nissin Electric Japan
(h)	Manufacturer's serial number	440014, 440015, 440016, 440017
(n)	Year of manufacture	1974

(5) 13.2 kV air-blast circuit breaker "543" for Da Nhim Power Station

(a)	Manufacturer's type	PBO-100PA
(b)	Applied standard	JEC-145
(c)	Rated voltage	13.2 kV
(d)	Rated insulation level - Full-wave lightning impulse	125 kV
(e)	Rated normal current	600 A
(f)	Rated interrupted capacity	1,000 MVA (13.2 kV)
(g)	Rated interrupting time	5 cycles
(h)	Rated operating sequence	0 - 1 min.- CO - 3 min.- CO
(i)	Control circuit voltage	220 V DC
(j)	Rated operating air pressure	15 kg/cm^2
(k)	Capacity of air tank	330 liters
(l)	Name of manufacturer	Hitachi, Ltd. Japan
(m)	Manufacturer's serial number	421339-1
(n)	Year of manufacture	1962

(6) 6.6 kV magnetic-blast circuit breaker "636" and "672" for Da Nhim Power Station

(a)	Manufacturer's type	BMA-15C MA
(b)	Applied standard	JEC-145
(c)	Rated voltage	7.2 kV

(d)	Rated insulation level - Full-wave lightning impulse	125 kV
(e)	Rated normal current	400 A
(f)	Rated interrupted capacity	150 MVA (6.6 kV)
(g)	Rated interrupting time	5 cycles
(h)	Rated operating sequence	0 - 1 min.- CO - 3 min.- CO
(i)	Control circuit voltage	220 V DC
(j)	Name of manufacturer	Hitachi, Ltd. Japan
(k)	Manufacturer's serial number	442204-3 ("636") 442204-2 ("672")
(l)	Year of manufacture	1962

(7) AC-motor diriven air compressors for Da Nhim Power Station

		Unit 1	Unit 2
(a)	for outdoor air-blast circuit breakers		
	i) Air pressure	25 kg/cm^2	30 kg/cm^2
	ii) Piston displacement volume	1.28 m^3/min	1.692 m^3/min
	iii) Rotational speed	415 rpm	1,160 rpm
	iv) Motor rating	15 kW	11 kW
	v) Manufacturer's name	Hitachi, Ltd.	Kaji Iron Works
	vi) Manufacturer's serial number	8016768	90115054
	vii) Year of manufacture	1962	1972

(b)	for indoor air compressors	
	i) Air pressure	25 kg/cm^2
	ii) Piston displacement volume	0.469 m^3/min
	iii) Rotational speed	625 rpm

iv)	Motor rating	5.5 kW
v)	Manufacturer's name	Hitachi, Ltd.
vi)	Manufacturer's serial number	8096765
vii)	Year of manufacture	1962

(8) 66 kV air-blast circuit breaker for Saigon Substation

(a)	Manufacturer's type	OPB-250 PA
(b)	Applied standard	JEC-145
(c)	Rated voltage	72 kV
(d)	Rated insulation level	
	- Full-wave lightning impulse	350 kV
(e)	Rated normal current	
	- "753", "754", "755", "756"	400 A
	- "733", "734", "771", "778"	800 A
	- Others	1,000 A
(f)	Rated interrupted capacity	2,500 MVA (72 kV)
(g)	Rated interrupting time	5 cycles
(h)	Rated operating sequence	0 - 1 min.- CO - 3 min.- CO
(i)	Control circuit voltage	220 V DC
(j)	Rated operating air pressure	15 kg/cm^2
(k)	Capacity of air tank	355 liters x 3
(l)	Name of manufacturer	Hitachi, Ltd. Japan
(m)	Manufacturer's serial number	421356-1 to 4, 421360-1 to 6 421361-1 to 3, 422220-1 & 2
(n)	Year of manufacture	1962

(9) 66 kV disconnectors for Saigon Substation

(a)	Manufacturer's type	PHL-RA (28 sets) PHL-RGA (5 sets) Not identified (7 sets)
(b)	Applied standard	JEC-125
(c)	Rated voltage	69 kV
(d)	Rated insulation level - Full-wave lightning impulse	386 kV
(e)	Rated normal current	400 A (10 sets) 600 A (6 sets) 1,000 A (17 sets) Not identified (7 sets)
(f)	Rated short-time withstand current	20 kA for two seconds
(g)	Name of manufacturer	Hitachi, Ltd. Japan
(h)	Manufacturer's serial number	478275, 478277, 478278, 478279, 478281, 470901, 470902, 478235504
(n)	Year of manufacture	1962

(10) AC-motor diriven air compressors for 66 kV circuit breakers for Saigon Substation

(a)	Air pressure	25 kg/cm^2
(b)	Piston displacement volume	1.28 m^3/min
(c)	Rotational speed	415 rpm
(d)	Motor rating	15 kW
(e)	Manufacturer's name	Hitachi, Ltd.
(f)	Manufacturer's serial number	8016767
(g)	Year of manufacture	1962

3.3 BASIC REQUIREMENTS FOR REHABILITATION OF SWITCHGEAR

The replacement components for the partial rehabilitation of the existing switchgear shall be brand new, equivalent specifications and suitably fitted to the original structures in case the design of the components is modified. The new components shall be complete with all the necessary parts and materials for modification and restoration of the original structures.

The new gaskets for replacement shall preferably be prepared in the factory referring to the original manufacturing drawings. If the then drawings are missing, the new gaskets shall be shaped by adjusting to the original structures at the site. Special tools to shape the gaskets at the site shall be supplied by the Contractor, if necessary.

The new switchgear for replacement and additional installation shall be fabricated in compliance with the specified type and rating and shall also be designed suitably for connection to the existing cables and conductors. The new switchgear shall be complete with all the necessary accessories, erection and maintenance tools and spare parts.

The new switchgear shall in principle be located at the same places as the existing ones. If the new switchgear cannot use the existing foundations, dimensioned arrangement drawings for the new foundation details shall be prepared by the Contractor and submitted to the Engineer for approval as specified in Clause 1.3 of the General Specifications.

3.4 LOCAL CONTROL BOXES FOR DISCONNECTORS

The new local control boxes for the 230 kV and 66 kV disconnectors shall be fabricated by stainless steel with the same structure and size as the originals. Each local control box shall be provided with an auxiliary switches of six or more stages and cable terminal blocks. Each auxiliary switch shall be operated by linking to the existing manual operating handle. Each local control box shall also be provided with a signal lamp on the top to indicate the operational instruction given from the control room.

3.5 AIR COMPRESSORS FOR AIR-BLAST CIRCUIT BREAKERS

The new air compressors will be of AC motor driven type. The air pressure and displacement volume of the new air compressors will be the same as those of the existing ones. As for the two air compressors for outdoor circuit breakers, the same rating will be applied to both of them although the existing ones have different ratings. The principal rating of the new air compressors will be as follows.

(1) Air compressors for outdoor air-blast circuit breakers (two units)

(a)	Air pressure	25 kg/cm^2
(b)	Displacement volume	1.28 m^3/min or more

(2) Air compressors for indoor air blast circuit breakers (one unit)

(a)	Air pressure	25 kg/cm^2
(b)	Displacement volume	0.47 m^3/min or more

The air reservoir to be installed additionally for the outdoor air-blast circuit breakers shall be designed for the nominal air pressure of 25 kg/cm^2 and shall have a capacity of 1 m^3. The air reservoir shall be provided with all the necessary materials for connection to the existing compressed air supply sytem.

3.6 230 KV CAPACITOR VOLTAGE TRANSFORMERS

(1) Type

The capacitor voltage transformers for the Da Nhim Power Station 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 provided with a supporting structure.

(2) Ratings

The capacitor voltage transformers shall be rated as follows:

(a)	Highest system voltage	245 kV
(b)	Rated voltage ratio	230 kV/$\sqrt{3}$: 110 V/$\sqrt{3}$: 110 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

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

(g) Accuracy class
- for measuring 1.0
- for protective ralaying 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. to be supplied under Sections 4 and 6. 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 to connect with the existing conductors.

(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 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 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.

3.7 66 KV SWITCHGEAR

3.7.1 Circuit Breaker

(1) Type

The circuit breaker for the static power capacitor circuit for the Saigon Substation shall be of outdoor use, three-phase, hydraulically or pneumatically operated, trip-free in any position, SF_6 gas type with porcelain supporting insulator.

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	72.5 kV
(b)	Rated insulation level	
	- Full-wave lightning impulse 1.2 x 50 micro-second	325 kV
	- Power-frequency for one minute	140 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	0 - 3 min.- CO - 3 min.- CO
(g)	Control circuit voltage	220 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. The 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 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 the Saigon Substation.

(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 breaker:

(a) Rating plate

(b) Position indicating lamps; red and green

(c) One (1) 10-stage auxiliary switches

(d) Oil or air valves, pressure gauges and piping

(e) Pressure switches for oil pump or air compressor control, low pressure alarm, etc.

(f) SF_6 gas pressure gauges, pressure switches, valves and piping

(g) Space heater

(h) Operation counter

(i) Line terminal connectors of compression type to connect with the existing conductors

(j) Grounding terminals

(k) Supporting structures

(l) Dispatching number plate holder to be mounted on the supporting structure

(m) Mounting bolts and nuts

(n) Foundation bolts and nuts, and anchor setting plates

(o) Other necessary accessories

(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) SF_6 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) SF_6 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.

3.7.2 66 kV Disconnector

(1) Type

The disconnector shall be of three-pole, horizontal-break, local manual operated type for the static power capacitor circuit for the Saigon Substation.

The disconnector shall be provided with a supporting structure and grounding pad on each phase.

(2) Ratings

The disconnector shall be rated as follows:

(a)	Rated voltage	72.5 kV
(b)	Rated insulation level	
	- Full-wave lightning impulse 1.2 x 50 micro-second	325 kV
	- Power-frequency for one minute	140 kV
(c)	Rated normal current	1,250 A
(d)	Rated short-time withstand current	25 kA for three (3) seconds
(e)	Control circuit voltage	220 V DC

(3) Construction

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

All steel parts shall be hot-dipped galvanized.

(4) Operating mechanism

The disconnector shall be provided with a manual operating mechanism consisting of a manual operating handle, electrical and mechanical interlocks among the associated circuit breaker, disconnector and earthing switch(es), and a local control box with auxiliary switch for remote indication, an 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 disconnector:

(a) Rating plates for disconnector and earthing switch

(b) Position indicating lamps; red and green

(c) 6-stage auxiliary switches

(d) Line terminal connectors of compression type with the existing conductors.

(e) Grounding terminals

(f) Supporting Structures

(g) Dispatching number plate holder to be mounted on the supporting structure

(h) Mounting bolts and nuts

(i) Foundation bolts and nuts, and anchor setting plates

(j) Two (2) manual operating handles for each substation

(k) Other necessary accessories

(6) Spare parts

The following spare parts shall be furnished and quoted separately:

(a) 500% of actual use of indicating lamps and fuses

(b) One (1) set of indicating lamp lenses; red and green

(c) 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.

3.7.3 66 kV Current Transformers

(1) Type

The 66 kV current transformers shall be provided for replacement of the existing current transformer "772" and "777". Each current transformer shall be of single-phase, oil-immersed, outdoor use, hermetically sealed construction.

Each current transformer shall have four cores and shall preferably be constructed to suit the existing supporting structure.

(2) Ratings

The current transformers shall be rated as follows:

(a)	Highest system voltage	72.5 kV
(b)	Rated insulation level	
	- Full-wave lightning impulse	
	1.2 x 50 micro-second	325 kV
	- Power-frequency for one minute	140 kV
(c)	Rated current ratio	
	- "772"	1,200-600/5-5-1-1 A
	- "772"	1,200-800/5-5-1-1 A
(d)	Rated output	Not less than 30 VA
(e)	Rated short time thermal current	31.5 kA for three (3) seconds
(f)	Accuracy class	
	- for measuring	0.5
	- 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.to be supplied under Sections 4 and 6, 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 to connect with the existing conductors.

(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 66 kV Capacitor Voltage Transformers

(1) Type

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

for the 66 kV bus No. 1.

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 provided with a supporting structure.

(2) Ratings

The capacitor voltage transformers shall be rated as follows:

(a)	Highest system voltage	72.5 kV
(b)	Rated voltage ratio	110 kV/√3 : 110 V/√3 : 110 V/√3
(d)	Rated output	
	- for measuring	400 VA
	- for protective relaying	100 VA
(e)	Rated voltage factor	
	- for each winding	1.2 for continuous 1.5 for 30 seconds
(f)	Rated insulation level	
	- Full-wave lightning impulse 1.2 x 50 micro-second	325 kV
	- Power-frequency for one minute	140 kV
(g)	Accuracy class	
	- for measuring	1.0
	- for protective ralaying	3 P

(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 to connect with the existing conductors.

(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 66 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 proviede with a supporting structure.

(2) Rating

The surge arresters shall be rated as follow:

(a)	Rated voltage	84 kV or more
(b)	Max. continuous operating voltage (line to ground)	46 kV or more
(c)	Nominal discharge current	10 kA
(d)	Residual voltage level (RVL) defined as follows: $RVL = \frac{\text{Residual voltage at 10kA (kV crest)}}{\text{Rated voltage (kV rms)}}$	Not more than 2.7
(e)	Rated insulation level	
	- Full-wave lightning impulse 1.2 x 50 micro-second	325 kV
	- Power-frequency for one minute	140 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 to connect with the existing conductor

vii) Mounting bolts and nuts

viii) Foudation 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 15 KV DISCONNECTORS

(1) Type

The disconnectors shall be of outdoor use, three-pole, horizontal installation type designed for three-phase manual operation by a manual operating handle. Each disconnector shall be provided with a supporting structure.

(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	1,250 A
(d)	Rated short-time withstand current	25 kA for three (3) seconds

(3) Accessories

The following items shall be provided for the outdoor disconnectors:

(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.

3.5 66 kV STATIC POWER CAPACITOR

(1) General

One (1) bank of the static power capacitor shall be provided on the 66 kV circuit of the Saigon Substation in addition to the existing four (4) banks. The static power capacitor bank shall have a rated bank capacity of 10,000 kvar and shall consist of single-phase capacitor units, series reactors, discharge coils, insulating transformers, insulated 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	72.5 kV
(b)	Nominal operating voltage	66 kV
(c)	Rated insulation level	
	- Full-wave lightning impulse 1.2 x 50 micro-second	325 kV
	- Power-frequency for one minute	140 kV
(d)	Number of phase for capacitor unit	Single-phase

(e) Number of phase for bank — Three-phase

(f) Rated capacity of bank — 10,000 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, single-phase, oil-immersed, film type, hermetically sealed construction with a stainless steel container.

The series reactor shall be provided on each phase at a neutral point of the bank that shall not be grounded. The series reactor shall be of outdoor use, single-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 mounted on the insulated racks.

(3) Accessories

The following accessories shall be provided:

(a) For capacitor bank

i) Rating plate and connection diagrams with full details

ii) Insulated racks complete with steel supporting structures, supporting insulators, foundation bolts and nuts, etc.

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 SYSTEM 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 system equipment to be installed in the Da Nhim Power Station and the Saigon Substation.

4.1.1.1 Scope for Da Nhim Power Station

(1) One (1) set of duplex type, main control and relay boards for the following equipment and circuits:

(a) Four (4) turbine and generator units

(b) Four (4) 13.2/230 kV main transformers "1T", "2T", "3T", "4T"

(c) Four (4) house-service transformers "11T", "12T", "13T", "14T"

(d) One (1) 230 kV transmission line

(e) One (1) 230 kV bus-tie circuit

(f) One (1) 230/121 kV transformer "9T"

(g) Two (2) 110 kV transmission lines

(h) One (1) 13.2/66 kV transformer "5T"

(i) Two (2) 66 kV transmission lines

(j) One (1) 31.5/13.2/6.6 kV transformer "6T"

(k) One (1) 31.5 kV feeder

(l) Three (3) 6.6 kV feeders

(2) Four (4) programmable controllers for generating unit control

(3) One (1) set of supervisory computer system, consisting of:

(a) One (1) operator console

(b) Two (2) minicomputers

(c) Two (2) color visual display units

(d) Two (2) keyboards

(e) One (1) hard copy unit

(f) Three (3) logging printers

(g) One (1) power distribution panel

(h) Other necessary peripheral equipment

(4) One (1) set of automatic synchronizing device

(5) One (1) set of manual synchronizing panel

(6) One (1) fault locator

(7) One (1) set of AC distribution panels

(8) One (1) set of DC distribution panels

(9) One (1) set of station batteries

(9) One (1) battery charger

(10) One (1) DC - AC investors

(11) One (1) surge tank water level gauging system

(12) One (1) lot of spare parts and accessories for supervisory control system

4.1.1.2 Scope for Saigon Substation

(1) One (1) set of duplex type, main control and relay boards for the following equipment and circuits:

(a) Two (2) 230 kV transmission lines

(b) One (1) 230 kV bus-tie circuit

(c) Three (3) 230/115/11 kV main transformers "1T", "2T", "8T"

(d) Eight (8) 66 kV transmission lines

(e) One (1) 66 kV bus-tie circuit

(f) Five (5) static power capacitor banks

(g) Three (3) 69/22 kV transformers "3T", "4T", "9T"

(h) Thirteen (13) 15 kV distribution lines

(i) Two (2) synchronous condensers

(j) One (1) 22(15)/0.4 kV house-service transformer

(k) One (1) 11/0.4 kV house-service transformer

(2) One (1) set of data logging and event recording system, consisting of:

(a) One (1) minicomputer

(b) One (1) color visual display units

(c) One (1) keyboard

(d) Three (3) logging printers

(e) One (1) power distribution panel

(f) Other necessary peripheral equipment

(3) One (1) set of manual synchronizing panel

(4) One (1) set of AC distribution panels

(5) One (1) set of DC distribution panels

(6) One (1) set of station batteries

(7) One (1) battery charger

(8) One (1) DC - AC investors

(9) One (1) fault locator to be located in the Long Binh Substation

(10) One (1) lot of spare parts and accessories for supervisory control system

4.1.2 Overall Scheme

4.1.2.1 Overall Scheme for Da Nhim Power Station

The main control board shall be provided for remote manual control, automation, protection and alarm management for the plants with the aid of the programmable controllers for the generating units.

The supervisory computer system with man-machine interface equipment shall be provided in the control room to perform supervisory control of the plant and data processing to accomplish a complete database for operation management.

The supervisory computer system and the programmable controllers shall be linked by the dataway for high-speed data transfer to permit data exchange among them.

The control system shall include the following functions:

(1) Generating unit automatic/manual control

Indication, start and stop control, power and frequency control, voltage control, synchronizing control, shutdown of operating unit, and alarm for each generating unit.

(2) Station common control

Indication, ON/OFF switching control of circuit breakers, protection and alarm for house-service equipment

(3) Outdoor switchgear control

Indication, ON/OFF switching control, and alarm for the switchgear for 230 kV, 110 kV, 66 kV, 31.5 kV and 6.6 kV circuits

(4) Indication of surge tank water level

(5) Data logging and event logging

Automatic listing and manual printing of measured values and meter readings such as electrical quantities, temperatures, water levels, etc., and automatic listing of all operations and spontaneous events in their correct sequential order.

(6) Provision for interface with the SCADA system to be established in the future.

4.1.2.2 Overall Scheme for Saigon Substation

The main control board shall be provided for remote manual control, automation, protection and alarm management for the plants.

The control system shall include the following functions:

(1) On-load tap-changing transformer control

Indication, automatic/manual tap-changing control, protection and alarm for each transformer

(2) Outdoor switchgear control

Indication, ON/OFF switching control and alarm for the switchgear for 230 kV, 66 kV (110 kV), 15 kV (22 kV) and 11 kV circuits

(3) Synchronous condenser control

Indication, start and stop control, voltage control, shutdown of operating unit, and alarm for each generating unit.

(4) Station common control

Indication, ON/OFF switching control of circuit breakers, protection and alarm for house-service equipment

(5) Data logging and event logging

Automatic listing and manual printing of measured values and meter readings such as electrical quantities, temperatures, etc., and automatic listing of all operations and spontaneous events in their correct sequential order.

(6) Provision for interface with the SCADA system to be established in the future.

4.1.3 Requirements for Design

The schemes of control, indication, protection and alarm for each equipment and circuit shall be similar to the design concept of the existing ones, except the protective relaying scheme for the 230 kV transmission line.

The equipment to be provided under this section shall be highly reliable and long-lived and

shall be basically of solid-state design suitable for continuous operation.

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

The control system shall have the following features:

(1) Reliability

The system shall work satisfactorily under any service condition with the ambient air temperature of not exceeding 40°C and the relative humidity of not exceeding 95%. The system shall be protected against external interference such as electrical noise and possible surges caused by switching operations, lightning stroke and the like. In the event of internal fault and loss of power supplies, the system shall not interfere with the controlled process and shall ensure no damage to the plant.

The main function of the system shall employ a dual redundant (hot standby) system, as applicable.

(2) Availability

The system equipment shall be of modular design for high availability.

In the event of internal fault, the system shall provide to the operator an immediate alarm and an accurate indication of the fault. The system shall be possible to resume operation in a controlled manner by a single module exchange.

(3) Serviceability

The system shall be duly serviceable design to permit on-line diagnosis and repair of malfunctions under normal control execution without making an effect on the system availability.

The Contractor shall prepare arrangement and detailed drawings, equipment lists and wiring diagrams based on the requirements for meters, relay, control switches, indicators and other devices including those to be supplied under other sections.

It shall be the Contractor's responsibility to properly design the electrical control, protective relaying, alarm and indication schemes related to all plants in the Da Nhim Power Station and the Saigon Substation. The design of the control system shall be carried out under intimate coordination with the existing plants and the plants to be rehabilitated and replaced under the other chapters.