PART 6: TECHNICAL CONDITIONS

Section 6-2 TESTS

6-2-01 GENERAL

In addition to the manufacturer's standard tests, all equipment and material shall be tested according to the latest issue of the standard specifications adopted except where otherwise stated in these specifications.
The requirements of special tests on equipment or material are dealt with below. Unless clearly stated in these specifications, the nature procedure and details of these tests shall be in accordance with the latest standard s specifications adopted for this contract.
All tests shall be carried out in the presence and subject to the control of the inspecting engineer for tests at works and the REA engineer at site for tests in the field, except in specified or approved cases where test certificates ma be accepted.
The CONTRACTOR shall not be entitled to any payment whatsoever, or to any extension of time for delivery by reason of, or in respect of any such tests due to any failure during testing, or the rejection of any part of material of plant as a result of any test.
The acceptance of the CONTRACTOR's tender including his designs specifications and drawings shall not bind the REA to accept any of the contract work until they shall have passed the tests prescribed and have been a roved b the REA in writing.
The CONTRACTOR shall submit all type tests certificates for items of equipment where items of the same design and rating have been previously subjected to the required tests and the test results certified by recognized international test organization. In cases where such test certificates are submitted and acceptable to REA, the type tests at works required will be carried out and limited to a sin le unit of the item of equipment.

The CONTRACTOR shall perform at the various substation sites after completion of installation, all the prescribed site tests using his own personnel. The REA will provide free of charge, the HV-carriage for the HV-test and a regulating transformer for performing the primary and secondary injection tests. The CONTRACTOR without additional payment shall provide all other instruments required for the site tests.

6-2-02 EXPENSES

The expenses of all tests carried out during and after manufacturing at works shall be included in the F.O.B. price of the equipment. Also the tests at site after erection, which will be carried out by the CONTRACTOR, shall be born by the CONTRACTOR.
The costs of the tests at works and at site shall cover all expenses including cost of apparatus and instruments used (except as stated here above), equipment, labour required and generally all expenses necessary for the efficient carrying out of the tests.

6-2-03 TIME AT WHICH TESTS ARE MADE

The REA representatives in charge of the tests shall give the decision of the suitability of conditions for the starting of any test
After erection commences, the REA shall nominate to the CONTRACTOR the REA representatives who will be in charge of the site tests and sign the certificates.

6-2-04 CALIBRATION OF INSTRUMENTS

All instruments used for the purpose of testing shall be of approved type and shall have been calibrated by a recognized laboratory, which must be accepted by REA.
Particulars of the calibration shall be given on the test certificates.
Re-calibration of any instrument after testing shall be carried out at the request of the REA

6-2-05 GUARANTEED FIGURES

A guaranteed figure shall mean a figure contained in the guarantee tables signed by the CONTRACTOR or a figure which may be obtained by calculation or by interpolation from these figures, or by use of the correction curves supplied by the CONTRACTOR at the time of tendering.

6-2-06 TESTS AT WORKS

The following tests shall be carried out at works in accordance with the rules and procedures stated in the IEC standards or approved equivalent.

(1) TESTS ON MAIN AND AUXILIARY TRANSFORMERS

A. ROUTINE TESTS

These shall be applied on all the transformers in accordance with details as given in IEC publication NO. 76-1, 76-2, 76-3 (Last issue).
They shall include the following:
a. Measurement of winding resistance
b. Measurement of voltage ratio and check of voltage relationship (vector group)
c. Measurement of impedance voltage (principal tapping) short circuit impedance and load loss
d. Measurement of no load loss and current
e. Dielectric tests, including:
- One minute separate source voltage withstands test
- Induced over voltage withstands test
- Measurement of insulation resistance of each winding with respect to all other windings and tank.

B. TYPE TESTS

a. Full wave impulse voltage withstands test.
b. Temperature rises test.

C. TEST ON LOAD TAP-CHANGERS

Mechanical operating test to prove satisfactory operation.

(2) TESTS ON CIRCUIT BREAKERS

A. ROUTINE TEST

Routine tests on all units shall be performed as enumerated in IEC publication NO. 56 latest issue and shall include the following.

a. Power frequency voltage withstands dry tests on the main circuit.
b. Voltage withstands tests on control and auxiliary circuits.
c. Measurement of resistance of the main circuit.
d. Mechanical operating tests and measurement of operating times.
e. Design and visual check.

B. TYPE TEST

The type tests as detailed in IEC publication NO. 56 (Last issue) shall be carried out on circuit breakers from each type and rating as enumerated in Article 6-2-1 (Tests General) and shall include:
a. Impulse withstand voltage test with plus and minus I / 50 micro second impulse wave.

(3) TEST ON ISOLATING AND EARTHING SWITCHES

A. ROUTINE TESTS

The following tests as detailed in IEC publication No. 129 (last issue) shall be carried out on all of the isolators and earthing switches.
a. Power frequency voltage withstands dry tests on the main circuit.
b. Voltage withstands tests on auxiliary and control circuits.
c. Measurements of the resistance of the main circuit.
d. Mechanical operating tests to prove satisfactory operation.

B. TYPE TEST

The following tests as detailed in IEC publications No. 129 (last issue) shall be carried out on the isolators and earthing switches.

a. Impulse voltage dry tests.

(4) TESTS ON LIGHTNING ARRESTERS

The following tests as detailed in IEC publication NO. 99-4 (last issue) shall be carried out on all lightning arresters.

A. ROUTINE TEST

a. Measurement of reference voltage corresponding to the reference current specified by manufacturer
b. Lightning impulse residual voltage on the complete arrester or arrester unit.
c. Satisfactory absence from partial discharges and contact noise

d. Leakage checks.

B. ACCEPTANCE TESTS

Carried out on nearest lower whole number to the cube root of number of arresters to be supplied.

a. Measurement of power frequency voltage on the complete arrester at the reference current.
b. Lightning impulse residual voltage on the complete arrester or arrester unit.
c. Partial discharge test.
d. Measurement of power losses
e. Other manufacturer's recommended tests

(5) TESTS ON CURRENT TRANSFORMERS

A. ROUTINE TEST

The following routine tests shall be carried out on all current transformers according to IEC publication No. 186 (last issue)

a. Verification of terminal marking
b. Power frequency tests on primary windings and measurement of partial discharges
c. Power frequency tests between sections of primary and secondary windings and on secondary windings and on secondary windings
d. Inter-turn over voltage test
e. Tests for accuracy

B. TYPE TEST

The following type tests shall be carried out on cording to IEC publication No. 185 (last issue) one current transformer a - Impulse test on primary windings.

a. Impulse test on primary windings

(6) TEST ON VOLTAGE TRANSFORMERS

A. ROUTINE TEST

The following routine tests shall be carried out on all voltage transformers according to IEC publication N0186 (Last issue).
a. Verification of terminal markings
b. Power frequency tests on primary windings and measurement of partial discharges
c. Power-frequency tests between sections of primary and secondary windings and on secondary windings
d. Tests for accuracy

B. TYPE TEST

The following type tests shall be carried out on one voltage transformer according to IEC publication No 186 (last issue).

a. Impulse test on primary windings

(7) TEST ON INSULATORS

1) TESTS ON POST INSULATORS

The following tests shall be carried out in accordance with IEC publication NO. 168 (Last issue) and as enumerated in part 6-2-1 (TESTS GENERAL)

A. SAMPLE TEST

a. Visual inspection and verification of dimensions
b. Temperature cycle test
c. Power frequency puncture voltage test
d. Porosity test
e. Galvanizing test

B. TYPE TEST

a. Dry impulse voltage withstand test
b. Dry one - minute power frequency voltage withstand test

2) TESTS ON CAP. AND PIN INSULATORS

The following tests shall be carried out in accordance with IEC publication NO. 383 (Last issue) and as enumerated in part 6-2-I (TESTS GENERAL)

A. SAMPLE TESTS

a. Visual inspection and verification of the locking system
b. Verification of dimensions
c. Temperature cycle test
d. Electromechanical failing load test
e. Mechanical failing load test
f. Thermal shock test
g. Puncture test
h. Porosity test
i. Galvanizing test

B. TYPE TEST

a. Dry impulse voltage withstand test
b. Dry one - minute power - frequency voltage withstand test

(8) TESTS ON WALL BUSHINGS

The following tests shall be carried out in accordance with IEC publication NO. 1 37 (Last issue).

A. ROUTINE TESTS

a. Measurement of the dielectric dissipation factor tan delta and the capacitance at ambient temperature
b. Dry power frequency voltage withstand test
c. The measurement of the partial discharge quantity
d. Tests of the tap insulation
e. Tightness test on liquid: filled and liquid - insulated bushings
f. Tightness test at the flange or other fixing device

B. TYPE TEST

The dry lightning impulse voltage withstand test

(9) TEST ON CONTROL PANELS FOR HIGH VOLTAGE SWITCHGEAR, MEDIUM VOLTAGE SWITCHBOARD CUBICLES

a. Check of all wiring according to wiring diagram of the panels
b. Voltage test on the secondary wiring without relays and instruments connected
c. Function test of all relays and instruments using relay testing equipment

(10) TEST ON RELAYS

Routine tests as detailed in IEC 255 (Last issue) on one sample of each offered type of protection relays to verify the design, operation, performance curves and figures.

(11) TEAT ON MEASURING INSTRUMENTS AND SUPPLY METERS

Routine tests on one sample of each offered type of the measuring instruments and supply meters.

(12) TEST ON ACCUMULATOR BATTER

Visual inspection

(12) TEST ON CABLES

1) Routine tests
2) The following tests as detailed in IEC publication NO. 502 (Last issue) shall be carried out
a. Conductor resistance test
b. High voltage power frequency test
c. Dielectric power factor test at ambient temperature
d. Measurement of the cable inductance and capacitance where applicable

6-2-07 TESTS AT SITE

The following tests shall be performed at the site.

(1) TEST ON TRANSFORMERS

a. Dielectric strength of oil
b. Function test of on load tap changer
c. Measurement of winding resistance
d. Measurement of voltage ratio and check of voltage vector relationship

(2) TEST ON HIGH VOLTAGE SWITCHGEAR

a. One minute high voltage test on circuit breakers, isolating switches, bus bar assemblies complete with auxiliary connections as well as low tension connections
b. Remote and local operation of circuit breakers and isolating switches and check of interlocking scheme
c. Function test of control and relay boards working together with 66 kV switchgear equipment

(3) TEST ON MEDIUM VOLTAGE SWITCHGEAR

a. Function test of medium voltage switchgear
b. One minute high voltage test on completely assembled switchgear

(4) TEST ON CABLE

High voltage test on all medium voltage, 0.4 kV, DC and lighting cables after laying and jointing. The test voltage shall be direct current 2.5 times the rated voltage, maintained for ten minutes on each core, the other cores being earthed.

(5) TEST ON RELAY

All relays shall be tested for correct performance, and the supplied operation curves shall be verified.

Note: In general the tests to be carried out on the different equipment shall be fixed by REA after the erection.

PART 6: TECHNICAL CONDITIONS

Section 6-3 PENALTY AND REJECTION

6-3-1 REJECTION OF MATERIAL

If, during inspection, tests at the works or at the site attended by the Inspector any material is found to be defective or not manufactured according to the specifications agreed upon, the Inspector shall have the right to reject such material if he is not convinced that it can satisfactorily repaired.
In such case the contractor shall be obliged to replace the defective material without being entitled to any extra payment whatsoever or to any extension of time of completion.

6-3-2 PENALTY AND REJECTION FOR INCREASED TEMPERA RISE

If the temperature rise of any transformer exceeds the specified limits then newly determined maximum continuous rating of the transformer should be considered as that at which the temperature rise is in accordance with the specified limits. A penalty of one percent of the total cost of that transformer shall be imposed for every one percent or fraction of one- percent decrease in maximum continuous rating as defined above.

If the maximum continuous rating as determined above is lower by more than ten percent than the specified value, the R.E.A shall have the right to reject such transformers.

6-3-3 PENALTY AND REJECTION FOR DECREASED EFFICIENCY

The contractor should keep the iron and / or the copper losses to be within the guaranteed values.
If the loss values measured from the works tests exceed the allowable tolerances in the IEC or approved equal standards then the R.E.A shall have the right to reject the transformer (s) with such losses.

However, the measured losses deviate from the guaranteed figures but lie within the allowable tolerances, then the excess losses shall be evaluated as per the following formula and the contractor shall be penalized accordingly.

$PW = K \times 8760 \times c\ [dwi + (LSF)(P^2)\ dwcu]\ LE$

Where,	PW:	Present worth (LE) of annual capitalized cost of losses at 16.25 % rate of interest over 20 years
	K:	Present worth factors 16.25 %, interest over 20 years: 5.85355
	C:	Cost per kWh: 0.162 LE (liable to be adjusted at the time of evaluation of the penalty
	LSF	Loss factors for the load: 0.40
	dwi:	Excess iron losses in kW at normal voltage and main tapping
	dwcu	Excess copper losses in kW at full load of the rating of the transformers 95°C at main tapping
	P	Peak load in PU = 1.10 Full load Rating: 25.0 MVA

No credit shall be given for any decrease in the value of losses below the guaranteed.

6-3-4 REPLACEMENT OF REJECTED MATERIAL AND EQUIPMENT

If according to the above articles, any material or equipment is rejected, the CONTRACTOR shall be obliged to replace it without extra payment. The rejected equipment shall remain in use by R.E.A until it has been replaced.

PART 6: TECHNICAL CONDITIONS

Section 6-4 66 kV SWITCHGEAR

6-4-1 LAYOUT

The layout of the 66 kV indoor switchgear shall follow the most modern engineering practice, and shall ensure maximum continuity and reliability of supply, as well as safety for the operator.
The offered 6.6 kV indoor switchgear shall comprise all apparatus and instruments necessary for the efficient working, control and protection of the transformer station.
The design of the switchgear shall fulfill the following conditions.

a. Simple and suitable for the prevailing atmospheric conditions and all apparatus, instruments and accessories shall not be subject to excessive inherent heating.
b. Facility of access to the different sections, so as to enable routine cleaning and repair of any section without interruption of service, and with due safety to maintenance personnel.
c. Entire security of the staff running the stating, bearing in mind, that all switching operations will be carried out by semi-skilled labourers.
d. Careful and methodical connections of the different parts of the switchgear, so that all the different circuits can be easily followed. Different colours shall be given for the different phases.
e. The clearance between any two live parts shall be not less than 90 cm, between live parts and the earth should be not less than 70 cm. The clearance between live conductors and ground or platform or access ways or from the nearest conductor of one section to the points on the conductors in an adjacent section at which work may be carried out, when the former conductor is alive should not be less than 320 cm.
f. The minimum leakage path for all the indoor equipment shall be not less than 3.0 cm per kV and for the outdoor equipment shall be not less than 4.5 cm per kV based on line voltage 66 kV. g. The 66 kV indoor equipment shall be able to successfully withstand the mechanical forces and thermal effects based on maximum conditions of a short circuit current of 31.5 kA r.m.s. symmetrical for one second without any damage to the installation. The insulation of bus bars and connections shall withstand 10 % higher test voltages.

6-4-2 BUS BARS AND CONNECTIONS

Bus bars and connections shall be made of electrolytic copper conductors which may be either stranded wire or copper tubes to withstand current rating of 1250 A.
The bus bars cross section shall bc capable of carrying thc loads corresponding to the transformer ratings and max transmitted loads on the lines, the normal current rating shall be as proposed in the single line drawings as attached.
The temperature rise of the bus bars at the normal bus bar current and at 45°C ambient temperature shall not exceed 25°C.
The general construction of bus bars, connections and their insulated supports shall be strong mechanically, so as to withstand the stresses, which may be imposed upon them in ordinary working, due to vibration, change of temperature, short circuit and other cases.
No material used for bus bars, connection or for supporting the connections shall be stressed to more than one forth of its breaking load, or one third of its elastic limit, whichever is less.

Rigid or tension bus bars may be used. Provisions shall be made for the expansion and contraction of bus bars and connections, to take into account the change in temperature. In case rigid bus bars are utilized, the expansion fittings, fixed bus bar supports and slip type bus supports shall be carefully located. In case tension bus bars are utilized, the TENDERER shall offer T-connectors of approved good quality and design, that would minimize overheating troubles due to aging and reduction in size of bus bars under tension.

The bus bars and connections shall be so arranged and supported, so that in no circumstances, including short circuit conditions, shall the clearance between phases and between live metal and earth be less than those specified in item 6-4-I (Layout).

The two bus bar system shall not be placed one above the other in order to safeguard the maintenance staff or those taking care of routine inspection of one bus bar system, while the other is live. For the same reason the arrangement utilizing two circuits per bay shall preferably not be used, unless adequate safety measures are provided and approved.

The spacing of all supports for both rigid and flexible conductors shall be required the approvals of the INSPECTOR.

All clamps and other fittings required to attach the bus bars and connections to bus bars and transmission lines and bare copper terminals on bushing insulators shall be included as part of this contract. Where dissimilar metals are connected approved means shall be provided to prevent electrochemical action and corrosion. All joints shall be of approved design and surfaces of copper alloys shall be tinned.

6-4-3 INSULATORS, FITTINGS AND WALL BUSHINGS

All offered insulators shall be of brown glazed porcelain designed for highest voltage of 72.5 kV having a leakage path not less than 3 cm per kV for indoor insulators and 4.5 cm per kV for outdoor insulators. The insulators shall be so designed as to facilitate their periodical cleaning and maintenance. The insulation levels and factor of safety for all offered types of insulators must be in accordance with the latest issue of IEC.

The offered wall bushings shall be oil filled condenser type made of brow glazed porcelain and fulfill all requirements of insulation level, leakage path and factors of safety mentioned in 6-4-1 (Layout) and IEC.

They shall be provided with magnetic oil level gauges legible from ground level and power factor test taps. All bushings shall be designed to withstand the mechanical and thermal shocks.

6-4-4 ISOLATING SWITCHED

A. GENERA L

The three-phase isolating switch shall be of gang or rotary (single break) type, the three phases shall open and close simultaneously. It shall be mounted on a galvanized steel frame. The operation shall be possible from the control board and from the switch location.

Each overhead transmission line feeder isolator, (that can be identified in the appended single- line diagram) shall be provided with an earthing switch that is interlocked with its associated isolator mechanism.

Leakage path of the isolating switch shall not be less than 3.0 cm per kV based on line voltage 66 kV.

B. RATING

Required rating shall be as follows.

- Rated voltage:	66 kV
- Highest voltage:	72.5 V
- Rated current:	1250 A for circuit breaker
	1250 A for bus tie breaker
	1250 A for lightning arrester
- Rated frequency:	50 Hz
- Rated short time withstands current for one second:	3 1.5 kA
- Rated dynamic withstands current:	80 kA
- Lightning impulse withstands voltage to earth:	325 kV
- One-minute power frequency withstands voltage to earth and between poles (wet):	140 kV

C. OPERATING MECHANISM

The operation shall be through motor-driven mechanism and manual operation.
The isolating switch must be provided with all the necessary auxiliary switches for indication, control, as well as suitable electric interlocking devices as safeguard against faulty operation and protected by dust and water proof covers.
The operating gear shall be self locked in both of the open and closed positions so that the isolating switch shall not be affected by force caused by the fault currents passing the switch.

D. CONSTRUCTIONAL REQUIREMENTS

The switch contacts shall be manufactured to operate satisfactory under the prevailing climatic conditions and to provide self-cleaning contacting surfaces.
The blades of each phase of the isolating switches shall be one unit and not two parts.
The material of the contacts and plates (disconnecting blade) shall be of copper or a corrosion resistance copper alloy having a sufficient mechanical strength and thermal radiation area, and shall be wear resistant for use over a long period of time.
The contact area shall be silver plated and shall maintain sufficient pressure by compression spring so that the contact pressure will not change over a long period of time.
The blade consists of a rotating mechanism and is installed on the center of rotating insulator.
The contacts shall be released before the blade's travel. The disconnecting switch shall also be able to operate easily and smoothly.

6-4-5 66 kV CIRCUIT BREAKERS

A. GENERAL

The 66 kV circuit breakers shall be of SF 6 gas insulated three-phase type.
The leakage path shall not be less than 3.0 cm / per kV r.m.s. based on 66 kV system voltage. The circuit breaker shall be adopted for three phase automatic re-closing.

It shall have the full breaking capacity and guaranteed breaking time at the first as well as the second break.
The circuit breaker shall be capable to fully interrupt low power factor currents without arc re-ignition, and it shall successfully interrupt near by faults.
The rate of rise of transient recovery voltage is not to exceed 0.75 kV per microsecond according to IEC.
The circuit breakers shall be of a single pressure type (puffer type).
Heaters for the SF 6 gas are not required.
The arc interruption performance shall be constant over the entire operation range from line charging currents to full short circuit currents.

B. RATINGS

The required rating shall be as follows.

- System voltage:	66 kV
- Highest voltage:	72.5 kV
- Frequency:	50 Hz
- Normal current	1250 A
- Short circuit breaking current:	31.5 kA
- Withstand of short circuit:	1 sec
- Maximum breaking time:	3 cycles
- Rated making current:	80 kA
- Dry lightning impulse withstands voltage:	325 kA
- Wet power frequency withstands voltage (1 min)	140 kA
- Operating sequence (three phase re-closing)	
	O-0.3 sec – CO – 15 sec -CO

C. OPERATING MECHANISM

Operating mechanism must be of the motor wound spring type.
It shall be possible to operate the breakers and to set the operating spring also manually.
The circuit breaker shall be fitted with two separate tripping coils, it shall be fitted with operation counter.
Rated auxiliary DC. shall be 220 V, with allowable variation not less than 0.75 rated DC. voltage where the mechanism shall operate successfully.

D. CONSTRUCTION REQUIREMENT

The breaker shall be equipped with a separate controlling panel containing fuses or (miniature circuit breaker), links selector switches for local and remote operation.
In addition to the auxiliary contacts require for normal control and interlocking, the mechanism shall be equipped with six auxiliary contacts easily convertible from normally open to normally closed and vice versa.
The terminal block shall be moisture proof as well as anti-flammable.
The circuit breaker shall have monitoring system in order to ensure that all circuit breaker poles are

either open or closed.
The TTENDERER is requested to state the accessories they recommend for the circuit breakers. They shall also submit a list of the special accessories necessary for carrying out maintenance work such as transport and dismantling of breakers.
The name plate of circuit breaker shall state in English the data required by IEC 56 and the serial number, year of manufacture, and etc.

6-4-6 CURRENT TRANSFORMERS

A. GENERAL

Current transformers shall be of the small oil volume type three-wire, for indoor use, with separate secondary for metering and protection.

B. RATINGS

- Highest operation voltage under normal conditions:		72.5 kV
- Rated primary currents (In):		2 x 600 A for lines and bus sectionalizer 2 x 300 A for transformer
- Rated secondary currents:		1/1/1/1 A
- Rated continuous thermal current in both connections:		1.2 x (In)
- Rated burden:		30/60/30 VA
- Accuracy classes:		0.5 / 5 P15 / 5 P15 / 5 P15
- Rated short time thermal current in both connections:		31.5 kA for 1 sec
- Rated dynamic current in both connections:		80 kV
- Lightning impulse withstands voltage:	325 kV	
- One-minute power frequency withstands voltage:		140 kV

C. CONSTRUCTION REQUIREMENTS

a. The current transformer shall be capable withstanding the dynamic and thermal forces of short circuit corresponding to the breaking current of circuit breakers (31.5 kA) without suffering any damage or change in their characteristics.
b. Internal insulation shall be moisture proof in a secure and durable manner.
c. The windings shall be made of copper.
d. The current transformer shall have a terminal box for the secondary terminals, a plate with easily legible data of the transformer and marking of the windings.
e. Leakage path should not be less than 3.0 cm per kV based on line voltage 66 kV.

6-4-7 POTENTIAL TRANSFORMER

A GENERAL

Potential transformers shall be of the small oil volume type, single-phase indoor use.

B. RATINGS

- Type: Single-phase indoor voltage transformer
- Rated voltages: $66{,}000/\sqrt{3} : 110/\sqrt{3} : 110/\sqrt{3}$:
- Rated frequency: 50 Hz
- Rated burden of the measuring and protective winding ($110/\sqrt{3}$ V): 300 VA
- Rated burden to the open delta winding ($110/\sqrt{3}$ V): To be provided by the TENDERER
- Accuracy class of the measuring and protective windings: 0.5 and 3 P
- Lightning impulse withstands voltage of the primary: 325 kV
- One-minute power-frequency withstands voltage (wet) of the primary: 140 kV

C. CONSTRUCTION REQUIREMENTS

- The windings of the potential transformer shall be made of copper.
- Internal insulation shall be moisture proof in a secure and durable manner.
- The potential transformer shall have a terminal box for the secondary terminals, a plate with easily legible data of the transformer and marking of the windings.
- Means to protect potential transformer against ferro-resonance oscillations shall be adopted.
- Leakage path should not be less than 3.0 cm per kV based on line voltage 66 kV.

6-4-8 66 kV LIGHTNING ARRESTERS

A, GENERAL

Substation equipment shall be protected against lightning and switching over voltages by installing lightning arresters on the 66 kV line feeders. Lightning arresters are used to clear the incidental over voltages without being affected.
The arresters shall be zinc oxide type. It shall confirm with the prescribed climatic conditions.
It shall comply with IEC – N0. 99 - 4 / 1991.

B. RATINGS

- Nominal voltage of the system: 66 kV
- Highest system voltage: 72.5 kV
- Nominal discharge current for impulse wave form 8/20 microsecond: 10 kA
- 100 % impulse spark over voltage at wave with 1.2/50 microsecond: 325 kV
- Rated voltage of the arresters (min.): 60 kV
- Rated protective level of the arresters (max.): 325 kV
- Leakage path at 66 kV: 4.5 cm / kV
- Rated frequency: 50 Hz

C. CONSTRUCTION REQUIREMENTS

The arresters shall be equipped with a guard ring in addition to a discharge counter to record the number of operations performed.
The arrester housing shall be made of porcelain or ceramic insulators hermetically sealed at both

ends by non-aging elastic seals. All metal parts shall be galvanized.
The lightning arrester shall be equipped with a pressure-relief device, and the arrester stack shall be adequately insulated from ground so that the discharge will pass through the counter.

6-4-9 CONTROLLING PANELS

The purpose of these is to accommodate all the control cables from the control room to the 66 kV switchgear apparatus.
In front of each 66 kV bay there shall be one control panel where the cables are neatly terminated and labeled.
Name plates and labels for the control switches shall be provided according to the respective wiring diagrams.
Each panel shall be fitted with one 25 A, single phase socket outlet, one lamp 60 watt controlled by on/off switch and all other auxiliary materials.
One copy of the cable termination diagram is to be fixed to the inner side of the panel door and protected by plastic cover.
The control panels shall be constructed from hot dip galvanized sheet steel, they shall be dust proof totally enclosed and provided with padlocks.
The entering cables shall be fixed to the bottom plate compression glands.
The control panels shall be provided with earthing terminal preferably to be mounted in front of the bays.
The panels should have a system of numbering to match their numbers on the respecting diagrams.
A three-phase, 380 V socket should be installed on the outside of at least three control panels.

PART 6: TECHNICAL CONDITIONS

Section 6-5 MAIN TRANSFORMER

6-5-1 TYPE

The transformer shall be of the three-phase, two winding, oil immersed, natural-forced air-cooled type by built-in fans suitable for outdoors-tropical conditions.

6-5-2 STANDARD SPECIFICATIONS

All transformers shall comply with IEC 76 last edition unless otherwise specified herein. The pertinent IEC recommendations shall apply to the auxiliaries and fittings.

6-5-3 RATINGS

The rating of the transformer shall be as follows.

- Rated Power: for use on natural cooling: 20 MVA
  for use on forced air cooling: 25 MVA
- No load voltage at the middle tap: primary voltage: 66 kV
  secondary voltage: 11.86 kV
- Frequency: 50 Hz
- Winding insulation levels for 66 kV:
  Lightning impulse withstands voltage (1.2/50 microsecond), peak: 325 kV
  One-minute power frequency withstands voltage, r.m.s: 140 kV
- Winding insulation levels for 11 kV:
  Lightning impulse withstands voltage (1.2/50 microsecond), peak: 75 kV
  One-minute power frequency 28 kV withstands voltage, r.m.s:28 kV

6-5-4 MAXIMUM CONTINUOUS POWER RATING

The transformer shall be able to deliver for unlimited period of time at the main tapping of the tap changer, the maximum continuous power rating (20 MVA natural cooled and 25 MVA forced air-cooled) without exceeding the allowable temperature rise limits.

6-5-5 SHORT TIME RATING

The transformer shall be capable of carrying 10 % overload for two hours, following continuous running at maximum rated load of 25 MVA under forced air cooling without exceeding the specified limits of temperature rise, which mentioned in article 6-5-7 hereinafter.
Also the transformer shall withstands 100 % overload from continuous running for three minutes without injury.

The TENDERER shall state in guarantee tables appended the overload capacity which the transformer can carry and its duration time after the transformer have been full loaded for an unlimited period of

time with 10 %, 20 %, 30 %, 50 %, 70 % arid 100 % of its maximum continuous power rating without exceeding the limits of temperature rise mentioned in article 6-5-7.

6-5-6 CAPABILITY OF WITHSTANDING SHORT CIRCUITS

All transformers shall be capable of withstanding without damage the thermal and mechanical effects of a short circuit to the terminals of any winding for three seconds.
The short circuit levels at the 66 kV and 11 kV networks are 31.5 kA and 26.3 kA respectively.
The CONTRACTOR will be required to submit certified type test reports for short circuit tests on the winding.

6-5-7 LIMITS OF TEMPERATURE RISE

The transformer shall be able to deliver its maximum continuous ratings with the tap changer set at middle tapping of the primary winding, without exceeding the temperature rise limits.
The temperature rise shall be limited and guaranteed to the following values.

- Oil temperature rise measured by thermometer at top level: 40°C
- Winding temperature rise measured by resistance method: 50°C
- Core temperature rise: 50°C

For other parts of the transformer, the temperature rise shall in no case reach value that will injure the core itself, metallic parts or adjacent materials.
The above temperature rise limits shall be based on the ambient temperature of 45°C.

6-5-8 IMPEDANCE VOLTAGE

The impedance voltage of the transformer at full load and normal ratio shall be 10 %.

6-5-9 TRANSFORMER LOSSES

The transformer shall be designed for minimum losses.
When comparing between different tenders, the present worth of the annual capitalized cost of guaranteed losses in the transformers shall be add according to the following formula.

$$PW = K \times 8760 \times C\ [Wi + (LSF)(p^2)Wcu] \qquad (LE)$$

Where, K: Present worth factor (LE) based on 16.25 rate of interest over 20 years: 5.85355 C: Cost of kWh which can be assumed to be 0.162 (LE)
LSF: Loss factor for the load: 0.40
Wi: Iron losses in kW at rated voltage and main tapping
Wcu: Copper losses in kW at full load (25 MVA) at 95°C
P: Peak load (P.U): 1.10
Full load rating: 25.0 MVA

6-5-10 HARMONICS

The percentage deformation, appearing in the voltage wave of one winding of a transformer, when the other winding is energized from a source of pure sine wave should not exceed 5 % (five percent) of the fundamental wave amplitude.

6-5-11 VIBRATION AND NOISE LEVEL

The transformer shall be capable of operating continuously at specified outputs and at a highest system voltage at any tapping, without vibration and noise.
The noise level measurement shall not exceed 67 dB measured according to German Standard (DIN 42 508) or equivalent standard.

6-5-12 CONNECTION

The winding connection group of the transformer shall be delta on the primary side and star on the secondary side in accordance with the vector group DYN 11, as specified in IEC 76 (last edition).

6-5-13 NEUTRAL POINT EARTHING

The neutral of the secondary winding (11 kV side) of the transformer shall be grounded through earthing resistors and isolating switch and protected by lightning arrester.

A. THE EARTHING RESISTOR

It should be capable to withstand all specified climatic conditions without developing high resistance joints.
The value of the earthing resistor should be regulated 12 to 15 ohm in 5 steps, 0 to 500 amp, 6,350 volt able to carry the fault current for 10 sec.
The neutral point shall be led out of the transformer by means of bushing insulator. Current transformers 1,500 / 5 / 5 amp for the connection of the restricted earth fault relay shall be provided for the neutral point.
Each resistor shall have remote indication by one ammeter on the control board.

B. ISOLATING SWITCHES

The isolating switch shall be single phase, out door type for vertical or horizontal mounting and complete with driving mechanism. The operation shall be through motor driven mechanism and manual operation.
The isolating switch must be provided with all the necessary auxiliary switches for indication control, as well as suitable electric interlocking devices as safeguard against faulty operation and protected by dust and water proof covers.
Rating of the isolating switch will be as follows.

- Rated voltage: 11 kV
- Highest voltage: 12 kV
- Rated current: 630 A

- Rated frequency: 50 Hz
- Rated short time withstands current for 3-second: 26.3 kA
- Rated dynamic withstands current: 60 kA
- Lightning impulse withstands voltage to earth: 75 kV
- One-minute power frequency withstands voltage to earth and between poles (wet): 28 kV

C. LIGHTNING ARRESTER

The neutral of the transformer shall be protected against switching over voltages by installing lightning arresters on the 11 kV side with earthing resistors.
The arresters shall be metal oxide type. Its housing shall be made of porcelain or ceramic insulators hermetically scalded. All metal parts shall be galvanized.
The Ratings of the lightning arresters shall be as follows.
- Nominal voltage of the system: 11 kV
- Highest system voltage: 12 kV
- Nominal discharge current for impulse wave form 8/20 microsecond: 10 kA
- Leakage path of 11 kV: 3.5 cm per kV
- Rated frequency: 50 Hz
- Minimum energy discharge capability in (kJ/kV) of maximum continuous operating voltage (MCOV): 4.5 kJ/kV

6-5-14 TAP CHANGING GEAR

The transformer shall be equipped with on-load tap changing gear on the high voltage side, which will be operated from the transformer terminal cabinet as well as from the control room.
A device for indicating tap position shall be provided on both the transformer terminal cabinet and the high voltage control panels.
Voltage regulation will be affected in 8 steps of + 10 % above rated voltage and 8 steps of – 10 % below rated voltage as the main offer.
The main arcing contacts or tap selector contacts shall have a minimum contact life of 200,000 operations to reduce maintenance requirements.
All movable parts of the tap changing mechanism shall be located in an oil compartment that is separate and sealed from the main transformer tank.
Provision of transformer parallel operation shall be made

6-5-15 TRANSFORMER PARALLEL OPERATION

Similar Transformers shall work satisfactory in parallel under the various loading conditions. Similarly rated transformers shall be exact replaces of each other.

6-5-16 AUXILIARY VOLTAGES

The power supply for the driving motor of the tap changer, tap position indicator, fan motors as well as for the electric heating shall be 380 / 220 V four wires, 50 Hz AC system.

6-5-17 TRANSFORMER CONSTRUCTION

The TENDERER shall submit full detailed specification design, drawings, maintenance and operating catalogues of the offered transformers.

6-5-18 TERMINALS

All winding leads shall be brought out through bushings. The bushings shall have electrical and mechanical characteristics suitable for service voltages specified and shall comply with IEC 137.
The Insulation levels for bushings shall be at least equal to those of the windings. The bushings on the high voltage side of the transformer shall be of the outdoor type, designed for 72.5 kV and have a leakage path of not less than 3.5 cm per kV at 66 kV.
All bushings shall be designed such that there will be no excessive stressing of any parts due to temperature changes and adequate means shall be provided to accommodate conductor expansion.
Bushings of same voltages shall be interchangeable between transformers.
The bushing insulators shall be of the oil filled condenser type, with means to indicate oil level. The bushing shall be fitted with approved lifting devices.
A cable sealing end box shall be provided for the secondary side of the transformer. Terminations shall be furnished by the TENDERER for a minimum of four single cores
XLPE copper conductor cable of 400 mm2 per phase.

6-5-19 CORE

The core shall be made of low loss steel laminations which are made from cold rolled grain oriented, annealed, high permeability, non aging, silicon steel type with thickness less than 0.35 mm for each lamination.
The core, framework, clamping arrangement and general structure shall be mechanically robust to withstand any shocks to which they may be subjected during transport, installation service and faults.
The core construction shall provide efficient cooling of its internal parts.
The core joints shall be properly interleaved. Precautions shall be taken to eliminate noise and vibration in the core when loaded and to diminish harmonic voltage as far as possible particularly the third and fifth harmonics.

6-5-20 WINDING

The winding conductor shall be made of best quality high conductivity electrolytic copper, complying with the requirements of the IEC standard.
The winding shall be clamped effectively so that they withstand chocks and vibrations during transport and forces produced by the most severe short circuit current persisting for at least three seconds.
The terminal end turns and tapped coils shall be provided with reinforced insulation.
The insulation level shall be according to the IEC relevant standard. The insulation to earth at the neutral point of the secondary windings shall be the same, as at the line end, graded insulation is not accepted.
The TENDERER shall give full particulars of the transformer windings, the arrangement of the coils, full description of insulation material and the method of insulation shall be given in the tender.

6-5-21 TRANSFORMER COOLING

The transformer shall be cooled naturally by the thermo-siphon effect up to 20 MVA of full load output, without exceeding the maximum temperatures mentioned in article 6-5-7 above,
and up to 25 MVA forced air draught equipment will be used in two steps, where the cooling system shall be divided into two completely independent groups. Each cooler group shall consist of a heat exchanger assembly complete with its fans.
The forced air draught equipment shall operate automatically upon exceeding the preset maximum temperature of the transformer oil. Meanwhile push button operation of the cooling fans shall be possible both from the transformer terminal cabinet, and from the control room.
The number of cooling fans is recommended to be eight, and start up and shut down temperature shall be adjustable. The TENDERER shall give full description of the design, operation and maintenance of the offered air-cooling system.

6-5-22 OIL FOR TRANSFORMERS

The TENDERER shall supply the necessary oil for the first filling of transformer.
The oil shall be of the best quality, high breakdown strength, low viscosity, and high resistance to oxidation and shall not deteriorate under all loading conditions.
The TENDERER shall submit with their tenders full specifications and characteristics of the transformer oil.

6-5-23 DRYING OF TRANSFORMERS

The transformers shall be dried out at the manufacturer's works, and no further drying shall be carried out at site.

6-5-24 TANK, ACCESSORIES AND FITTINGS

The transformer tank shall be made of best quality boilerplate steel and reinforced from all sides. The tank and valves shall be designed to withstand full vacuum.
The tank shall be rigid enough to withstand the mechanical stresses due to expansion of oil and those occurring during transport.
The tank shall be provided with cast iron wheels provided with locking arrangement. The base of the tank shall be so designed that when the wheels are detached it shall be possible to move the complete transformer with oil on rollers or jacks in any direction. The tank shall be provided with detachable cooling elements and valves.
The transformer cover shall be bolted to the transformer tank and a ground pad shall be welded on the tank wall near the neutral bushing.
The connection between the tank and radiators shall be made by means of shut off valves, which can be locked in either open or closed positions placed immediately adjacent to the main tank.
The TENDERER shall submit full information about material of transformer tank and thickness of steel plates used in different components of the transformer
The tank shall be provided with the following fittings.

a. Detachable rollers
b. Lifting tackles to be used for the removal of the cores and windings

c. Oil level indicator with low oil level alarm contact
d. Flanged oil drain valves
e. The tank cover shall be provided with manhole and devices
f. Oil sampling cocks at the top and bottom of the tank
g. Flanged valves at the bottom and top of tank for connection to oil filtering apparatus
h. Thermostats and thermometers with special pocket for the measurement of the transformer oil and windings temperatures at different points (thermal image) with remote indication contacts
i. On load tap changer
j. Silica gel breather
k. Earthing terminals, diagonal to the tank
l. Buchholz relay with two contacts
m. Relief valve of an approved type
n. Nameplate which indicating the vector group and wiring diagram and tap data

6-5-25 OIL EXPANSION VESSEL

The oil expansion tank shall have an adequate capacity to allow for extreme changes in the oil level i. e. when the transformer is switched off at 0℃ and when the transformer is at full loaded at 45℃ ambient temperature.
It shall be equipped with oil level indicator visible from round level and includes remote indication contacts.

6-5-26 TERMINAL CABINET

A terminal cabinet made of sheet steel, totally enclosed, dust proof and water tight type shall be provided to each transformer for the termination of the multi-core control cables, and for the accommodation of the temperature indicators, cooling units control gear and on-load tap changer remote operating equipment. Access doors with pad locks shall be provided.

6-5-27 PAINTING

All surfaces of the transformer shall be thoroughly cleaned before painting. The interior surfaces of the cases above the low oil level shall be finished with 2 coats of light coloured oil resistant paint or enamel. The paint used for the finished coats shall have special heat, oil, and weather resisting properties. A11 finish metalwork shall be suitably wrapped or otherwise protected from damage during transportation and installation.

6-5-28 REMOTE TEMPERATURE INDICATOR AND ALARM DEVICES

The transformer shall be provided with suitable, and reliable devices which will produce a thermal image of the winding and the transformer oil.

6-5-29 BUCHHOLZ PROTECTION

Each transformer shall be fitted with two gas detecting relay of the Buchholz type for the winding and the tap changer. The relays shall be mounted in an approved manner in the oil connection pipe

between the transformer tank, tap changer vessel and the expansion vessel, in such way as to be easily accessible for maintenance and repair.
The gas protection system shall be provided with an approved bypass, so that the relay may be maintained and repaired without interrupting the oil flow from the tank to the expansion vessel. The relay shall include a test cock to test gases inside the relay without dismantling.
The Buchholz protection shall be designed to do the following operations.

a. Give an alarm signal in case a slow fault occurs in the transformer giving rise to local over heating and the appearance of gas bubbles or in case of decrease of oil level below a certain level indicating leakage of oil.
b. Give a tripping signal to the transformer circuit breaker and isolate the transformer in case of serious fault occurring inside it and giving rise to heavy gas formation and violent oil flow to the expansion vessel or in case a serious drop in the oil level is detected
c. Be able to accumulate the formed gasses and thus determine the cause and position of the fault by colour or chemical analysis of the gasses.

PART 6: TECHNICAL CONDITIONS

Section 6-6 11 kV SWITCHGESRS

6-6-1 General Description

The 11 kV Switchgears shall be divided into two parts, the first part is installed in the 11 kV Switchgear room of the main substation building, and the second part is installed in the Auxiliary Substation room of the No. 7 Pumping Station Building.
The first is named as 11 kV Distribution Panel and the second is 11 kV Power Receiving Panel.

6-6-2 TYPE AND ARRANGEMENT

A. 11 kV DISTRIBUTION PANEL

The panel shall be of the 3 phase indoors, single bus bar system with bus-tie breaker, metal clad, totally enclosed, truck withdrawable type, and the cubicles shall be of the unit construction, factory assembled, so as to form a homogeneous structure.
The switchboard shall also be fitted with approved seals as dust proof.
The panel shall be installed in the Main substation building.
The panel shall consist of the following units as shown on the drawings.

a. 4 units of Neutral Grounding Panel
b. 4 units of Cable Termination Panel
c. 4 units of VCB (Vacuum Circuit Breaker) Panel
d. 4 units of 11 kV Feeder Panel
e. 2 units of Lightning Arrestor Panel
f. 1 unit of Bus Tie Panel

B. 11 kV POWER RECEIVING PANEL

The panel shall be of the 3 phase indoors, metal clad, totally enclosed, truck withdrawable type, and the cubicles shall be of the unit construction, factory assembled, so as to form a homogeneous structure.
The switchboard shall also be fitted with approved seals as dust proof.
The panel shall be installed in the No. 7 Pumping Station building.
The panel shall consist of the following units as shown on the drawings.

a. 2 units of Cable Termination Panel for 12 x 500 mm^2, Single core, 11 kV, XLPE cables
b. 2 units of VCB (Vacuum Circuit Breaker) Panel
c. 2 units of 11 kV PT (Potential Transformer) Panel

6-6-3 CUBICLE CONSTRUCTION

The unit type cubicles shall have the following features.

a. The system shall satisfy the requirements of IEC 298, and it shall totally prevent contact with live parts under all operating and service conditions.

b. The cubicle shall consist of a withdrawable truck carrying the circuit breaker, a separate compartment for the bus bars with the fixed contacts, the instrument transformer compartment and the cable terminals with earthing switch accommodated in a separate compartment accessible from the rear. Another compartment located at the front is to be confined for low voltage devices.

c. Each cubicle shall be a self-supporting construction of sheet steel with folded edges. The cubicles are to be bolted together with sheet steel partitions fitted in between. The freestanding switchboard when assembled shall be covered from the back and the two ends with sheet steel plates. An earth copper bar at the bottom of the switchboard shall be provided.

Pressure relief vents have to be provided to the switchboard, so that the expanding gas developed in case of a short circuit shall be directed in a safe direction in order to prevent injury to persons standing near the board.

The cubicles shall have IPH 6 level of protection according to IEC.

d. The breaker carrying truck shall be of a robust design having a chassis. Carry the circuit breaker provided with four wheels of reasonable size to facilitate the movement of the truck.

The truck with its circuit breaker shall be provided with electrical and mechanical interlocks to prevent faulty operation such as withdrawing the circuit breaker unless it is tripped. Shutter shall be provided to isolate automatically the live parts in the cubicles when the circuit breaker is withdrawn. The shutters shall be provided with padlocks.

Earth continuity to the truck shall be secured by suitable means till the truck is completely withdrawn from the cubicle.

e. The measuring instruments and relays shall be of the flush type mounted on the hinged door on the front of the cubicle.

f. Special interlock prevents disconnection of low voltage plug while the breaker truck is in operating position.

g. Interlock is to be provided to prevent closing the cable earth switch except when the cable terminals are dead.

h. Sealing ends and cable clamping materials for the outgoing feeders shall be provided. It is to be noted that the 11 kV cables used in the network are XLPE type, size and number of cables are as shown on the attached drawings, with copper conductors. All cables will be entering from the bottom and proper provision shall be made to get the cables passing through the bottom plate vermin proof.

i. A mimic diagram shall be provided on the switchboard front panel indicating the positions of the circuit breakers and earthing switches.

j. The control, instrumentation and interlock circuits between the truck and the cubicle shall be connected by means of flexible wires drawn through flexible metallic house and ended by multi-pin plug and socket of suitable size. All wiring used in the switchboard shall be of copper conductors PVC insulated or rated voltage not less than 1,000 V.

k. The mechanical strength of the switchboard shall be capable to withstand short circuit current of 26.3 kA, for duration of 3 second.

l. All contacts shall be silver plated.

m. The metal clad structure shall be painted with a primary coating (rust resisting) followed by two coats of heat-treated light green paint.

n. The phases of the bus bars and the connections shall be marked with red, yellow and blue colours. Earth connections shall be marked with black colour.

o. All bus bar supports shall be of white porcelain or equivalent dielectric support.

6-6-4 BUS BARS

A. 11 kV DISTRIBUTION PANEL

The panel shall comprise a single sectionalized bus bar of 2500 amp current rating; it shall be made of best quality high conductivity copper.
The conductors shall include the necessary flexible and expansion joints that accommodate the system shown in the drawing.
The cross section of the bus bar shall bc designed and chosen for maximum allowable temperature rise at maximum load conditions 25℃ above 45℃ ambient temperature. The bus bars shall pass from one cubicle to another through bushings or any other dielectric supports.

B. 11 kV POWER RECEIVING PANEL

The panel shall comprise a single sectionalized bus bar of 2500 amp current rating; it shall be made of best quality high conductivity copper.
The bus bars shall be connected to 11 kV, 3-Phase, 3000 A Bus Duct, which installed by the other contract to supply power to the pumping station.
The conductors shall include the necessary flexible and expansion joints that accommodate the system shown in the drawing.
The cross section of the bus bar shall bc designed and chosen for maximum allowable temperature rise at maximum load conditions 25℃ above 45℃ ambient temperature. The bus bars shall pass from one cubicle to another through bushings or any other dielectric supports.

6-6-5 CIRCUIT BREAKERS

The 11 kV circuit breakers shall be of vacuum or SF 6 type mounted on withdrawable trucks.
Breaking capacity of circuit breaker shall be 26.3 kA, symmetrical, rated current shall be as follows.

A. 11 kV POWER DISTRIBUTION PANEL

The following circuit breakers shall be installed.

- 3000 amp for outgoing feeders to the 11 kV Power Receiving Panels in the No. 7 Pumping Station
- 630 amp for outgoing to the auxiliary transformers in the main power substation
- 1600 amp for 25 MVA power transformers
- 3000 amp for bus sectionalizer

These circuit breakers shall be equipped with electrical motor spring charged control device, operated by 220 V DC.
It shall have two coils for tripping and closing. Operating spring can be manually charged too. It shall include operation counter.

In addition to auxiliary contacts required for normal control and interlocking, the mechanism shall be provided with four auxiliary contacts easily convertible from normally open closed and vice versa.

B. 11 kV POWER RECEIVING PANEL

The following circuit breakers shall be installed.

- 3000 amp for outgoing feeders to the Auxiliary Substation of the No. 7 Pumping Station

The circuit breakers shall be equipped with electrical motor spring charged control device, operated by 220 V DC.
It shall have two coils for tripping and closing. Operating spring can be manually charged too. It shall include operation counter.
In addition to auxiliary contacts required for normal control and interlocking, the mechanism shall be provided with four auxiliary contacts easily convertible from normally open closed and vice versa.

6-6-6 INSTRUMENT TRANSFORMERS

11 kV instrument transformers shall be of the dry type. The windings are made of copper with a rating sufficient for the burden of the connected instruments and relays. Each transformer shall have a plate with easily readable data and marking of the winding.
They shall have a terminal box for the secondary terminal with earth terminal. The accuracy of the secondary of instrument transformers for metering shall be of class 0.5 and of class 5 P 10 of protection.
Current transformers shall have two cores, one for metering, the other for protection except the current transformer for the incoming feeder, which shall have three cores, one for measuring and the other two cores for protection. They shall be short circuit proof and capable for withstand 26.3 kA of shoe circuit current for 3 seconds.
Current transformer ratios are as shown as follows.

a. For 11 kV Power Distribution Panel
1) Current transformer ration is as shown as follows
- 2500 / 5 / 5 A for bus section
- 1500 / 5 / 5/ 5 A for main transformer feeders
- 3000 / 5 / 5 A for outgoing feeders to No. 7 Pumping Station
- 50 / 5 / 5 A for auxiliary transformer feeders

2) Voltage transformer ratios are as shown as follows.
- 11 kV/$\sqrt{3}$, 0.11 kV/$\sqrt{3}$, 0.11 kV/$\sqrt{3}$

The measuring cell of each sections of bus bars the following.
a. 1 3-phase isolating switch
b. 3 single-phase potential transformer protected by HRC fuses
c. One voltmeter with selector switch

d. 3 single-phase lightning arresters rated as 12 kV, 10 kA for the bus bars

a. For 11 kV Power Receiving Panel

1) Current transformer

- 3000 / 5 / 5 A for outgoing feeders to Auxiliary Substation of the No. 7 Pumping Station

2) Voltage transformer ratios are as shown as follows.

- 11 kV/$\sqrt{3}$, 0.11 kV/$\sqrt{3}$, 0.11 kV/$\sqrt{3}$