on the main transformer side.

(24) The Contractor shall submit the consumption amount of water and electric power to the Owner and the Engineer once a month.

(25) The Contractor shall be responsible for repair of the construction road and drainage system until the construction road and drainage system have been taken over by the Owner.

13. SAFETY

13.1 ENSURING SAFETY

The Contractor shall continuously take special care to ensure the safety and prevention of human and equipment accidents and maintain good sanitary conditions on and around the Site in accordance with the Labor Standards Law.

13.2 CONTRACTOR'S SAFETY ENGINEER

(1) The Contractor shall appoint a safety engineer for accident prevention, who shall work together with the Owner's safety engineer.

The Contractor shall submit in writing in the specified form the names and personal histories of the safety engineer and his staff in charge of accident prevention to the Owner and the Engineer prior to the commencement of the execution of Works, and this shall be approved by the Owner and the Engineer.

(2) The Contractor's safety engineer for accident prevention shall be constantly on the Works, and shall plan and conduct proper measures to prevent accident throughout the entire Works area in conformity with the provisions specified in the Specifications.

(3) Whenever the Contractor's safety engineer for accident prevention is off the Site on temporary leave or for other reasons, the Contractor shall assign a deputy and report this matter to the Owner and the Engineer in advance, and this matter shall be approved by the Owner and the Engineer.

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(4) The Contractor's safety engineer for accedent prevention shall wear the safety engineer mark on the Site for easy identification.

13.3 SAFETY FACILITIES

The Contractor shall install the following facilities in order to ensure the safety of the structures installed by the Owner on, in and around the Site.

(1) The Contractor shall install the facilities necessary to keep safe the structures of the Owner or the third party when the Works are executed in the vicinity of these structures.

(2) Walkways on the Site, such as catwalks, ladders and temporary bridges, shall be protected and shall be equipped with safety provisions for workers and materials.

(3) Slope protection works, nets, hole covers, fences and other protection works shall be installed at excavated areas and other places where an accident may occur.

(4) The Contractor shall in connection with the Works provide and maintain at his own cost all lights, guards, fencing and human watch when and where necessary or as required by the Owner and/or the Engineer or by any duly constituted authority for the protection of the works or for the safety and convenience of the public or others.

(5) Safety guide posts, marks, signs, etc., indicating falling stones and landslide, traffic sign posts when blasting, and other necessary guide posts shall be installed whenever and wherever they are necessary throughout the entire Site.

(6) The Contractor shall take sufficient measures so as not to

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cause any danger, hazard or obstruction to the public by installing work sign boards, traffic sign posts, lighting and protection facilities and/or other necessary safety devices whenever the works are executed in the vicinity of the public.

The Contractor shall maintain close communication with the police and the administrators of the roads and rivers in advance regarding traffic and other security measures.

(7) The Contractor shall install the road guard facilities in accordance with the standards of the police and the road administrators.

(8) The Contractor shall install any/all other proper guard facilities necessary for the execution of the Works in addition to above-mentioned facilities.

(9) Scaffolds and steps needed for work at/in high place shall be provided wherever necessary and possible. All measures shall be taken to prevent falling accidents, such as by preparing safety ropes, catch nets, etc.

(10) In case there are any holes or openings within the construction site into which workers may fall, safety measures against this shall be provided by covering the said area or by constructing handrails when the said holes or openings are not in use.

(11) All personel working at/in high places which may be dangerous shall wear life ropes, and preventive measures against the droppage of tools and materials shall be taken.

(12) A person in charge of safety shall be appointed for each

safety facility such as scaffolds, handrails, safety ropes, etc. The names and places where the persons in charge can be contacted shall be clearly indicated on/near/at the said safety facility.

(13) All work in the vicinity of equipment and facilities having live electricity shall be avoided whenever possible. However, when work in the vicinity such places is unavoidable, the area of danger shall be clearly indicated and the person in charge of safety shall be present at all times during the work.

(14) Before heavy equipment such as drum, transformers, generators, etc., are transported, sufficient investigation to ensure the strength of roads and road shoulders shall be carried out.

(15) For equipment such as cable conduits and cable pits which can not be inspected after installation, sufficient measures against damage shall be taken during construction.

13.4 MEASURES IN CASE OF ACCIDENTS

The Contractor shall carry out all necessary measures and submit the report to the Owner or the Engineer without delay when a human and/or facilities accident occurs or damage to the third party happens.

13.5 SAFETY PLANS

The Contractor shall submit to the Owner and Enmgineer plans on accident prevention in such manners as directed by the Owner.

13.6 ORDERLY SITE

The Contractor shall maintain an orderly Site and keep the Site in a clean, neat and easy workable condition for the safety of the Works.

14. DRAWINGS FOR TENDERING

The Drawings for Tendering shall be used as the drawings for detailed design by the Contractor who shall be responsible for the detailed design.

The site layout plan, the Substation and grid station buildings dimensions, and the figures such as dimensions, sizes and capacities stated in the Drawings for Tendering are the estimated ones for the equipment and facilities.

The Contractor shall make the final decision based on the actual design of equipment and facilities, but the Contractor shall submit the results of his designs to the Owner and the Engineer for approval.

However, as the site is narrow and rectangular, the main dimensions indicated in the site layout plan shall be kept within those indicated in the drawings so as to realize the construction of a well arranged substation with operation and maintenance ease.

As the dimensions and outlines of each major equipment will affect the size of the building and finally the layout each tenderer shall submit his drawings with the proposed layout and equipment layout in a design concept that satisfies the intention of the Owner and the Engineer.

These proposal drawings will be one of important items for evaluation at the evaluation stage.

14. OPERATION AND MAINTENANCE ADVISING WORKS DURING THE MAINTENANCE PERIOD

(1) The Engineer will provide the following services to the Owner during the maintenance period after taking over.

(a) Follow up and expedite rectification of any defects pointed out during the period.

(b) Provide advice and recommendations to the Owner regarding any trouble concering the performance of the Plant and/or equipment as and when required by the Owner.

(c) Provide specialists services for investigations of any problem or trouble as and when required by the Owner.

(2) The Contractor shall provide the works specified in Clause 19 in Section III, Volume 1, Book 1.

(3) The Contractor shall provide a necessary staff to advice and solve all matters related to defects, damages, troubles, etc., during the maintenance period.

(4) The Contractor shall provide the necessary data, drawing and reports concerning any defects, damages, troubles, etc., to the Owner and the Engineer.

(5) The Contractor shall exert his best efforts to asist the Engineer in all matters related to the Contractor's works.

(6) The Contractor shall prepare all reports and explanation sheets when so instructed by the Engineer.

15. DRAWINGS FOR TENDERING FOR THE CONTRACTOR OF LOT II-A

The Drawings for Tendering are as follows.

GENERAL		
WAT-1001	Site Layout	Site Layout Plan
1002	Ditto	Interface Between Existing and Planned Site Layout
Electrical		
WET-1001		West Wharf Substation Key Single Line Diagram
1002		West Wharf Substation Protection and Metering Single Line Diagram
1003		West Wharf Substation Arrangement of Substation
WET-1101		Baldia Grid Station 220 kV Single Line Diagram
1102		Baldia Grid Station 220 kV GIS Building Layout (Plan)
1103		Baldia Grid Station 220 kV GIS Building Layout (Section)
1104		Baldia Grid Station Control Building
WET-1201		Standard Cable Tray-1
1202		Standard Cable Tray-2
1203		Standard Cable Tray-3
1204		Standard Piping Scheme
Architectural		
WAT-1601	Substation Area	Architectural Drawing Sht-1
1602	Ditto	Architectural Drawing Sht-2
1603	Ditto	Structural Drawing Sht-1

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WAT-1604a	Substation Area	Structural Drawing Sht-2
1604b	Ditto	Transformer Yard Foundation
WAT-1615	Grid Station Baldia	Architectural Drawing
1615	Ditto	Structural Drawing
WAT-1618	Substation	Plumbing
1619	Ditto	A/C and Ventilation
1620	Ditto	A/C and Ventilation
1621	Grid Station Baldia	Ventilation
1622	Ditto	Ventilation

Under Ground Tonnel

WST-4001	Rout Plan (Plan)
4002	Rout Plan (Vertical)
4003	B.P. & Standard Section
4004	No. 1, No. 2 Man-Hole
4005	Turning Points
4006	Diverging Facility (1)
4007	Diverging Facility (2)
4008	No. 1 Ventilation (1)
4009	No. 1 Ventilation (2)
4010	No. 2 Ventilation

Foundation Arrangements

WST-1101	General Arrangement of Foundation at Baldia Grid Station
WLT-1105	Plan at the Place of Tower No. 1

PART II

SUBSTATION AND RELATED FACILITIES

SECTION I

SUBSTATION AND GRID STATION FACILITIES

SUBSTATION AND GRID STATION FACILITIES

CONTENTS

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1. GENERAL

The substation shall comprise a 220 kV and a 132 kV switchyard having two (2) sets of transformer.

The 220 kV switchyard will comprise the double bus system to improve the reliability of electric power supply. The electric power generated from the generator will be received by the switchyard and supplied to the KESC system through the transmission line. The 220 kV bus bar shall be connected to the 132 kV bus bar through the transformers.

The outgoing 220 kV transmission lines shall be connected to the Baldia Grid Station with two (2) circuits and the 220 kV substation shall be provided with two (2) circuits bays for future use. However, only the space for future bays shall be prepared.

The 132 kV switchyard shall comprise the double bus system and the electrical power shall be received by the switchyard from the 220 kV switchyard through interchange transformers. The bus will be connected to the the starting transformer and the two (2) sets of 132 kV/11 kV grid station transformers. The outgoing 132 kV transmission lines will be connected with the following seven (7) circuits.

- To S.I.T.E. : One (1) cct
- To MAULIPUR : One (1) cct
- To OLD TOWN : One (1) cct
- To GARDEN EAST : One (1) cct
- To QUEENS ROAD : Two (2) ccts
- To DEFENSE EIGHT : One (1) cct

2. SUBSTATION EQUIPMENT

The 220 kV / 132 kV substation equipment shall be provided for transmitting the electric power of West Wharf Thermal Power Station (2 x 200 MW) to the underground cable transmission lines.

2.1 220 KV AND 132 KV SF_6 GAS INSULATED SWITCHGEAR

2.1.1 APPLICABLE STANDARDS AND CODES

The following applicable standards and codes of the latest edition shall be applied.

International Electrotechnical Commission (IEC)

IEC-519 "Gas-Insulated Metal-Enclosed Switchgear For Rated Voltages of 72.5 kV and Above"

IEC-56 "High Voltage Alternating Current Circuit Breaker"

IEC-99 "Lightning Arresters"

IEC-129 "Alternating Current Disconnectors (Isolators) and Earthing Switch"

Other pertinent International Electrotechnical Commission (IEC) standards and international standards shall be applied for electrical machinaries and apparatuses.

2.1.2 SCOPE OF SUPPLY

The 220 kV / 132 kV substation equipment and accessories shall be provided, but shall not be limited to the following items.
The Contractor shall be responsible for the complete design, manufacture, pre-assembly and acceptance testing in the Contractor's workshop as well as the supply, delivery, unloading, erection, commissioning, trial operation and acceptance testing of each equipment.

(1)	One (1) set	220 kV SF_6 gas insulated switchgear (GIS) with accessories
(2)	One (1) set	132 kV SF_6 gas insulated switchgear (GIS) with accessories
(3)	Two (2) sets	220 kV / 132 kV interchange transformer with accessories
(4)	Two (2) sets	132 kV / 11 kV grid station transformer with accessories
(5)	One (1) set	220 kV line and bus control panel with accessories
(6)	One (1) set	132 kV line and bus control panel with accessories
(7)	One (1) set	220 kV line and bus protective relay panel with accessories
(8)	One (1) set	132 kV line and bus protective relay panel with accessories
(9)	One (1) set	400 V switchgear and distribution panel with accessories
(10)	One (1) set	DC220 V battery and battery charger with accessories
(11)	One (1) set	Telecommunication equipment with accessories
(12)	One (1) set	Lighting system with accessories
(13)	One (1) set	132 kV CV (XLPE) cable with accessories
(14)	One (1) set	11 kV CV (XLPE) cable with accessories
(15)	One (1) set	Lightning arrester

2.1.3 TECHNICAL INFORMATION

2.1.3.1 DESIGN AND PERFORMANCE

The design and performance of the metal enclosed switchgear shall comply with these Specifications and the latest revisions of the relevant IEC and other equivalent international standards. The switchgear shall be of modular construction, wholly metal enclosed

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and shall offer maximum flexibility from the point of view of design, operation, maintenance and repair. Insulating medium shall be SF_6 gas.

The equipment offered shall comply with the following design principles.

a) Similar parts shall be strictly interchangeable without special adjustment or individual fittings.

b) The design shall be such that malfunctions will not occur due to ingress of foreign matter, dust or moisture or to variations in temperature within the normal limits of switchgear design.

c) The performance of the equipment and its individual components shall be adequately proven by tests carried out under normal operating conditions and at conditions above and below normal so as to confirm that adequate margins are available to cover manufacturing tolerances and all service conditions.

d) Prior to shipping, routine tests shall have been performed to ensure that the equipment has been completely assembled and that all components are functioning correctly.

e) All mechanical parts and linkages shall have longlife use and shall require only minimum maintenance.

f) Where the tenderer offers a design not specifically designated but well proven in service, he shall draw attention to any component, major or minor, which may be newly designed.

The equipment shall be designed to ensure unrestricted, reliable operation continuously at a maximum ambient temperature of 50 ^{o}C,

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with possible temperature fluctuations of 25°C (day/night) and a relative humidity of 90%. No air conditioning shall be provided for the substation building, but an air ventilation system shall be installel. The maximum temperature rise shall not exceed 50°C for the conductors and 35°C for the enclosures.

The design of the 220 kV and 132 kV switchgear and the coordination of the protection equipment with the corresponding equipment of the power supply network shall ensure that faults of any kind in the 220 kV and 132 kV networks shall not lead to fault or damage to any part of the installation or operating personnel.

The installations at the substation shall be equipped with appropriate grounding switches, grounding studs and all other necessary protective features to ensure that at the time of repair and maintenance the switchgear will exhibit no danger to personnel or equipment under any circumstances.

Control and supervision of the 220 kV and 132 kV switchgear shall be exercised from the control rooms of the substation as well as the local control panels of the switchyard. The generator transformer circuits on the 220 kV GIS and the starting transformer circuit on the 132 kV GIS shall be controlled and supervised from the central control room in the main power house. All switchgear, control and measuring devices shall be equipped with auxiliary contacts, etc., as required.

The painting sheme of the switchgear and the control and protection panels shall be decided at a later date.

The type of enclosure for the local control and protection system panels shall be IP 32 of IEC 529 (Enclosures for Electrical Apparatus). The cabling inside the control and protection panels of the SF_6 switchgear shall conform to relevant IEC standards and other equivalent international standards. The panels shall be verminproof, weatherproof and resistant to ingress of moisture.

All switchgear and panels shall be installed on subframes specially provided for this purpose and supplied by the Contractor.

2.1.3.2 LAYOUT

The switchgear shall be of the SF_6 gas insulated metal enclosed type suitable for indoor installation in the substation building of the West Wharf Thermal Power Station, and shall be capable of continuous operation under the climatic conditions at the site.

The switchgear shall be designed to permit the removal and extension of any part without unnecessary outages or disturbance to adjacent items of plant, and it shall be possible to maintain a supply from one section of busbar while extending the other. The Contractor shall ensure that the offered equipment layout, whether main or alternative, satisfactorily complies with the substation layout.

If necessary, the Contractor may, upon approved by the Owner/

Engineer, modify the layout, provided that the basic bus configuration with couplers and the correct number of switchbays are retained.

The Contractor shall offer a design and layout that is consistent with regard to the available space in the switchyard building, and shall ensure that operation, maintenance, repair and safety aspects are not compromised.

The Contractor shall set out in writing any departures from these Specifications with respect to the equipment offered. Full particulars of any deviations and shortcomings in respect of the specified requirements for operating, erection, testing, maintenance or dismantling of the equipment shall be provided together with a statement of the advantages and disadvantages of any alternative arrangement offered.

2.1.4 COMMON FEATURES

2.1.4.1 RATING

	220 kV	132 kV
Rated voltage (kV) :	220	132
Maximum working voltage (kV):	245	145
Rated frequency (Hz) :	50	50
Rated short-time current(kA):	40	31.5
Impulse withstand voltage (peak) (kV) :	950	650
Power frequency withstand voltage (kV) :	395	215
Insulation medium :	SF_6 gas	SF_6gas

		220 kV	132 kV
Rated busbar current (A)	:	3,150	2,500
Bus configuration	:	Double bus system	Double bus system
Busbar enclosed tubing	:	Single phase	Single phase
Star point	:	Solidly grounded	Solidly grounded

2.1.4.2 CONSTRUCTION

(1) SF_6 Gas Pressure

The rated working pressure of the SF_6 gas inside the switchgear shall be kept as low as possible to minimize leakage of gas, and shall be at least 15% above the minimum value necessary to ensure safe and continuous operation of the switchgear. Dependable operation of the switchgear shall be ensured at the maximum possible pressure of the gas.

(2) SF_6 Gas Monitoring and Alarm Circuits

Each compartmented section of the GIS shall be equipped with temperature compensated gas density/pressure monitoring devices. The characteristics of the monitoring devices shall be shown on the gas vapour graph. The gas monitoring device shall be fitted with electrical contacts for alarm and automatic tripping purposes and shall be set in two stages. The first stage shall operate an alarm to warn that the gas density/pressure is falling to a critical level to indicate the need of adding gas to the particular section.

If the density/pressure of the gas drops to a level below which the insulation of the gas is insufficient, a second

stage shall initiate automatic isolation of the gas section concerned by tripping associated circuit breakers and isolators as required. Tripping shall be wired into main protection circuits, and shall only be initiated when both alarm and trip conditions exists. The gas density/pressure alarms shall be generated in the control room and at local control panels.

(3) SF_6 Gas Treatment

Under normal operating conditions, treatment of the SF_6 gas shall not be necessary between major overhauls. A self-sealing vacuum coupling shall be provided on each separately compartmented section to allow renewal and filling of SF_6 gas.

To minimize the moisture content of SF_6 gas, moisture absorbers shall be installed in each compartmented section of the switchgear. All the insulators in each section of the gas shall be manufactured from a material whose surface remains entirely unaffected by the corrosive acids formed due to reaction of the decomposition products of the SF_6 gas with the traces of moisture.

Permanent filters shall be installed in the quenching chambers of the circuit breaker to remove SF_6 gas decomposition products produced due to arcing. The filters shall remain fully effective for the period between overhauls.

(4) Enclosure

The material and design of the switchgear enclosure shall be

provided to ensure safe and satisfactory installation.

Each separately compartmented section of the enclosures shall be provided with an automatic pressure relief device to release the gas in case of increased internal pressure developed due to internal arcing. These devices shall be so designed that exhaust is discharged away from operating personnel. The minimum time required for the pressure relief device to operate shall be less than the time specified below for burning-through/puncturing of enclosure.

The Contractor shall ensure that no burning-through/ puncturing occurs on metal cladding of the switchgear due to an arc formed by the rated breaking current of the installation within a time of 200ms (minimum), and that the total trip time of the first-stage protection is less than 150ms.

Suitable measures shall be employed between the individual sections of the switchyard to compensate for thermal expansion of equipment and building structure.

Each separately compartmented section of the installation shall be grounded separately. The enclosures shall be of gas tight construction with gas tight flanges. The various parts of enclosures shall be electrically interconnected with each other to avoid development of dangerous potential differences in case of faults.

The enclosures shall be designed to withstand the earthquake stresses specified in Part I of these Specifications.

(5) Maintenance

For operating safety, reliability and ease of maintenance, the following minimum requirements shall be provided.

- o Maintenance of any circuit breaker in the installation, e.g. the changing of contacts, shall be possible without having to switch-off any other outgoing feeders of the installation.
- o In the event of extensions made to the switchgear, one of the two bus bar systems shall always remain serviceable.
- o In the event of damage to one of the bus bar systems, it shall be possible to replace it without having to switch-off any other sections of the switchgear.
- o During the whole of the repair time, it shall be possible to continue operating the switchgear with the remaining bus bar system.

(6) Gas Sealing

The Contractor shall describe the principles and materials of his sealing arrangements in his tender.

The maximum annual gas loss and the total gas loss which still allows trouble-free operation shall be quoted in the tender.

(7) Bus Bar and Conductors

The installation shall have double bus bars, and plug-in contacts shall be provided for interconnecting the individual sections of the bus bars and other parts of the switchgear. Silver-plated copper shall be used as the

contact material.

The bus bars and all other conductors shall be able to withstand the stipulated rated currents, thermal and initial short-circuit currents without a dangerous temperature rise or other damage.

The maximum conductor temperature at the rated current shall not exceed the values stipulated in IEC-56 at the condition of 50°C ambient temperature.

(8) Type of GIS

The primary components of 220 kV GIS, except the main bus bar, shall be segregated from primary components of other phases. The main bus bar shall be of the three phase common enclosure type.

All primary components of 132 kV GIS shall be of the three phase common enclosure type.

2.1.5 CIRCUIT BREAKER

The circuit breakers shall be of the single-pressure puffer type designed and tested for the following ratings.

2.1.5.1 RATING

		220 kV	132 kV
Nominal system voltage, kV	:	220	132
Maximum design voltage, kV	:	245	145
Rated frequency, Hz	:	50	50
Rated normal current, A	:	1250/3150	1250/2500
Rated short circuit breaking current, kA	:	40	31.5
Rated short circuit making current, kA	:	100	80
Rated maximum breaking time, msec.	:	50	50
Rated out-of-phase breaking current, kA	:	10	8
Rated operating sequence	:	0-0.3 sec-CO-3min-CO	
Rated line charging breaking current, A	:	125	50
First pole-to-clear factor	:	1.3	1.3
Rated transient recovery voltage for terminal faults (for 2.0 kV/micro sec. rate of rise), kV	:	365	215
Rated transient recovery voltage for short line faults (for 2.0 kV/micro sec. rate of rise), kV	:	280	166
Rated power frequency withstand voltage kV, r.m.s. (one minute)	:	395	215
Rated lightning impulse withstand voltage kV, (peak)	:	950	650
Rated control voltage, V, (D.C.)	:	220	220

The circuit breaker shall meet the following transmission line

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characteristics for any type of fault or fault location, and shall be suitable for line charging and dropping when used in the 220 kV effective grounding system.

Double Circuit 220 kV Overhead Lines

Line length	24.0 km (Tower No. 1 - BALDIA G/S)
Conductor configuration	Vertical, double circuit
Material	ACSR/AS 330 mm^2 Cross-sectional area
No. of sub-conductors	2
Dia. of sub-conductor	25.3 mm
Phase-to-phase spacing	6.4 meters

Double Circuit 220 kV Underground Lines

Line length	1.1 km (WEST WHARF S/S - TOWER NO. 1)
Material	Oil-filled cable
Size	1,200 mm^2 x 1C

2.1.5.2 CONSTRUCTION

(1) The circuit breakers shall meet the following switching requirements.

(a) The circuit breakers shall be suitable for single shot, high speed, three pole automatic reclosing.
Provision shall also be made for single pole reclosing on 220 kV breakers only.

(b) The circuit breakers shall be suitable for switching on transmission lines and transformers for any type of fault.

(c) Circuit breaking shall be made possible without restriking with the overhead lines off load.

The interrupting time at 25% of the interrupting current rating under the applied normal control voltage shall not exceed the rated interrupting time.

(d) No restrikes at the main contacts shall be permitted under any operating phase.

(e) The circuit breakers shall be capable of making and breaking currents associated with out of phase switching, auto reclosing and the switching of magnetizing or capacitance currents without sustaining damage and without generating transient over-voltage in excess of 2.5 times the peak value of the rated phase to neutral before the switching operation.

(f) The circuit breakers shall be capable of handling short line fault conditions associated with line switching in accordance with IEC Publication 56-2 Clause 8.

(2) The circuit breakers shall meet the following constructional requirements.

(a) The circuit breakers shall be electrically and mechanically trip free.

"Pumping" of the circuit breakers shall be prevented by suitable measures.

(b) All similar contacts of three-pole circuit breakers shall close or open within a period of one half of a cycle or less with respect to each other, except where single pole operation is required.

(c) The circuit breaker operating mechanism shall be of the spring/hydraulic/pneumatic type.

(d) The operating mechanism shall be capable of performing the specified duty cycle.

(e) All circuit breakers shall be able to perform an O-CO switching cycle when the auxiliary voltage is lost.

(f) Hand operation shall be made possible in emergencies.

(g) The mechanism shall be able to operate satisfactorily at direct voltage between 170 and 270 volts.

(h) The design of operating mechanism shall be capable of normal synchronized three pole operation during multi-phase faults.

(i) The design of the operating mechanism shall permit selective single pole tripping and reclosing of any of the three phases for phase-to-ground faults. The 132 kV GIS shall be three phase reclosing only.

(j) Electrical tripping facilities for the operating mechanism of each pole shall be duplicated to include, but not necessarily limited to, the following.

a) Two electrically independent and identical trip coils for each pole of the breaker arranged such that the probability of the failure of one trip coil affecting the operation of the second trip coil is minimal.

b) Two electrically independent and identical sets of wiring, terminals and protecting equipment for connection to two 220 V D.C. independent control/and/or tripping power circuits.

(k) Each circuit breaker shall be equipped with a sufficient number of auxiliary contacts for annunciation locally,

to the control room and for all necessary interlocks.

(1) The following indications shall be provided for each circuit breaker.

The SF_6 gas density in the circuit breaker section shall be constantly indicated by a gauge and monitored by a density monitor on each pole of the circuit breaker. The density shall be detected in two stages. The first stage (gas density low) shall initiate an alarm at the control switchboard. The second (gas density too low) shall prevent closing or tripping of the breakers, and shall issue visual and audible annunciation on the control switchboard. Closing or tripping of the breakers shall be avoided, should the density drop too low after the closing or tripping operation has started. The design shall make known the identification of the breaker pole having low SF_6 gas density, and no damage shall be caused to any component of the circuit breaker in case of low gas density.

(3) Spring charged mechanisms

The circuit breakers fitted with power spring operated closing mechanisms shall meet the following requirements.

(a) The mechanism shall be charged automatically, for further operations, as soon as the circuit breaker has completed a closing operation. The time required to power charge the spring shall not exceed 30 seconds.

(b) The spring shall be fully charged before it can be released to close the circuit breaker, and it shall not

be possible for the breaker to close whilst the spring is being charged.

(c) Spring closing mechanisms shall be designed so that it is not possible for the fully charged spring to be released inadvertently due to external shock or vibration caused by the breaker opening under short circuit conditions or any other cause.

(d) The mechanisms shall be provided with means for charging the spring by hand. This operation shall be carried out with the doors of the cubicle opened. During this process, no electrical or mechanical operation of the mechanism shall endanger the operator or cause damage to the equipment.

(e) A mechanical indicating device shall be provided to indicate the state of charge of the spring, and shall be made visible with the doors of the cubicle closed.

(f) An alarm shall be provided at the local control panel and in the main control room to indicate any spring failing to be charged by a pre-set time after circuit breaker closing.

(g) The spring mechanism shall be fitted with a local manual release, preferably by a shrouded push button, to avoid inadvertent operation.

Measures shall be provided for discharging the spring when the circuit breaker is in the open position without the circuit breaker closing.

2.1.6 ISOLATORS

2.1.6.1 RATING

	220 kV	132 kV
Nominal system voltage, kV :	220	132
Maximum design voltage, kV :	245	145
Rated lightning impulse withstand voltage		
Across the isolating distance, kV (peak) :	1050	750
To ground and between poles, kV (peak) :	950	650
Rated power frequency withstand voltage (1 sec)		
a) Across the isolating distance, kV rms. :	460	315
b) To ground and between poles, kV rms :	395	275
Rated frequency, Hz :	50	50
Rated normal current, A :	1250/3150	1250/2500
Rated short time withstand current, kA :	40	31.5
Rated duration of short circuit, Sec. :	1.0	1.0
Rated peak withstand current, kA :	100	80

2.1.6.2 CONSTRUCTION

All isolators shall be provided with motor-driven operating mechanisms which shall work reliably from a direct voltage of 170-270 volts, and shall open and close all three phases simultaneously.

It shall not be possible for the isolators to open or close in-

advertently due to forces which may occur in service or under short-circuits.

The operating mechanisms shall be capable of being locked and secured by padlock in the open or close position.

In the event of driving motor failure, measures for hand operation shall be provided.

Each isolator shall be provided with a window for visual inspection of contact positions.

For isolators having three mechanisms (i.e. one per phase), it shall be possible to electrically interlock all three phases to ensure that they open or close if any one phase is to be electrically operated either by remote or local means. Such isolators shall be provided with a time delayed discrepancy alarm having normally open, potential free contact to indicate that one or more phases have failed to operate correctly. All isolators shall be fully interlocked with associated circuit breakers, isolators and grounding switches to ensure safe operation of the equipment under all service conditions.

Full electrical interlocking shall be required for maintenance and operation. Mechanical interlocking shall be required for maintenance purposes only. The insulation level for the isolating distance between isolator contacts shall be able to withstand 115% of the impulse withstand voltage as specified by IEC.

In the event of gas leakage, the isolator shall be capable of withstanding twice the phase to ground voltage at normal atmospheric SF_6 gas pressure. Alternatively, automatic

means shall be provided to electrically isolate the faulty isolator.

The isolators shall be capable of switching load currents when shunted by parallel path and capacitance charging currents associated with open bus bars, bushing and capacitor voltage transformers. Isolators to comply with the required switching functions with the isolating medium at atmospheric pressure shall be automatically blocked out of operation.

The contacts shall be of the high pressure type and shall open and close positively, but shall not cause galling of the contact surfaces. Full contact and current carrying capacities shall be secured during reasonable overtravel or undertravel of the mechanism.

Gravity, vibration, reasonable shock or accidental handling of the connecting rods of the operating mechanism shall not cause isolators or grounding switches to be released from their open or close position.

All main contacts, male and female, shall be silver plated or shall have silver inserts.

2.1.7 GROUNDING SWITCH

The switchgear shall be equipped with two different types of grounding switches.

High speed grounding switches

Working grounding switches

2.1.7.1 RATING

	220 kV	132 kV
Nominal system voltage, kV :	220	132
Maximum design voltage, kV :	245	145
Rated lightning impulse withstand voltage, kV (peak):	950	650
Rated power frequency withstand voltage kV, r.m.s. (1 sec.) :	395	275
Rated frequency, Hz :	50	50
Rated short-time withstand current, kA :	40	31.5
Rated duration of short circuit, sec. :	1.0	1.0
Rated peak withstand current, kA :	100	80
Rated making current, kA :	100	80

2.1.7.2 CONSTRUCTION

The grounding switches integrally mounted with isolators or separately mounted shall be provided for grounding already isolated sections of gas insulated switchgear so as to ensure maintenance safety.

The grounding switch, when in the closed position, shall have a short-time current withstand as specified with a minimum duration of three seconds.

No burning or welding of contacts shall occur.

All grounding switches shall be interlocked with associated circuit breakers and isolators so that it shall not possible to close a grounding switch in a live circuit or to make the circuit alive when the grounding switch is closed.

(1) High speed grounding switches

High speed grounding switches shall have motor operated mechanisms. The motor shall work reliably from a direct voltage of 170 to 270 volts. It shall be possible to close the switch manually even when the auxiliary voltage has failed. An interlock between the manual and power operated drive shall be provided so that when the manual operation is being carried out the motor operated drive shall not operate.

Grounding switches shall be capable of operation in a live circuit and suitable for high speed operation. It shall be made impossible to close all grounding switches slowly.

High speed grounding switches shall be capable of interrupting induced currents as may be necessary where the grounding switch is used for grounding one out of two or more long parallel circuits with mutual coupling.

High speed grounding switches shall have a position indicator mechanically connected to the operating mechanism of the switch. The switch position shall be indicated at the local control panel and in the control room.

All grounding switches shall be in accordance with the requirements for maintaining working grounding switches.

(2) Working grounding switches

Working grounding switches shall have a hand operated mechanism. These grounding switches shall be mechanically interlocked with the associated isolators and electrically interlocked with the other isolators.

2.1.8 CURRENT TRANSFORMER

The current transformers shall be of the dry type design using epoxy resin as insulation, and shall comply with the latest revisions of IEC 185 and of these Specifications.

Facilities shall be provided for primary injection it current transformers are installed in SF_6 filled chambers.

The current transformers shall be installed in the exact positions indicated in the Drawings.

Where multi-ratio current transformers are required, the various ratios shall be obtained by changing the effective number of turns on the secondary winding.

Rating and diagram plates shall be provided. The information to be supplied on each plate shall be as specified in the relevant IEC specifications, which shall be given for the tapping for which the rated performance is specified and for each transformer core.

The position of each primary terminal in the current transformer SF_6 gas section shall be clearly marked by two plates permanently fixed to the metal cladding at each end of the current transformer section.

The beginning and end of each secondary winding and all secondary taps shall be wired to suitable terminals accommodated in a terminal box mounted directly on the current transformer section of the SF_6 switchgear.

Provision shall be made for the grounding of all secondary windings inside the terminal box.

External mounted current transformers, if offered by the Contractor in his protection scheme, shall be provided.

The ratings, ratios and number of cores of different current transformers shall be as shown in the table below.

The Contractor shall, however, make detailed calculations to determine the ratios and burden ratings most suitable for protection and metering.

		220 kV	132 kV
Number of secondary cores	:	4	4
Rated transformation ratio	:	Refer to drawing	Refer to drawing
Accuracy class			
Measuring core	:	Class 0.2	Class 0.2
Protective core	:	5P 20	5P 20
Rated burden, VA			
Measuring core	:	30	30
Protective core	:	30	30

Core 1 shall be designed for measuring, while cores 2, 3 and 4 shall be designed for protective relaying.

Core 4 shall be used for differential protection.

2.1.9 VOLTAGE TRANSFORMER

The voltage transformers to be installed in SF_6 gas insulated metal clad switchgear shall be of the inductive type and shall comply with the latest revisions of IEC 186 and of these Specifications.

The voltage transformers shall be connected line-to-ground. The beginning and end of each secondary winding and all secondary taps shall be wired to suitable terminals accommodated in a terminal box mounted directly on the voltage transformer section of the SF_6

switchgear.

Secondary outputs shall be taken out via HRC fuses in the terminal box. The ratings of the voltage transformers for 220 kV shall be as follows.

		220 kV	132 kV
Rated secondary voltage (L-L), V, rms.	:	100	100
Number of secondary windings	:	2	2
Rated output of each winding, VA			
a) Measuring core	:	200	200
b) Protective core	:	75	75
Rated voltage factor			
a) Continuous	:	1.2	1.2
b) 30 seconds	:	1.5	1.5
Burden power factor	:	0.8	0.8
Accuracy class			
a) Measuring core	:	0.2	0.2
b) Protective core	:	3P	3P

2.1.10 LOCAL CONTROL PANEL AND MONITORING

Separate local control panels shall be provided for each 220 kV / 132 kV bay for local control and monitoring of the 220 kV / 132 kV switchgear in the substation building.

The local control panels shall be of sheet steel and of free-standing construction, and shall be supplied directly from the factory ready-wired.

Local control panels shall contain the following minimum equipment.

- Control switches for circuit breakers, isolators and high speed grounding switches.
- Mimic diagrams with position indicators for all circuit breakers, isolators, high speed grounding switches and working grounding switches, control switches and positions indicators for all circuit breakers, isolators, etc., and preferably combined in the form of push-buttons.
- All alarm and indicators associated with SF_6 gas monitoring, protection tripping, circuit breaker trip, power supply failure, etc.
- All auxiliary relays, contactors, MCBs with necessary auxiliary contacts, fuses, etc., for control monitoring, remote control, protection and interlocking circuits.
- Terminal strips each with 15% spare capacity after handover for connection of measuring, control and interlocking circuits, etc., and the DC/supply and other connections to switchgear and substation control room.

It shall be made possible to exercise complete control and supervision of the equipment from the control room and local control panels. Clearance for local switching operation shall be given from the control room by interlocking switch.

2.1.11 AIR COMPRESSOR EQUIPMENT

Air compressor equipment shall be provided for control of the air source for gas insulated switchgear e.g. circuit breakers, if required, and isolators for 220 kV and 132 kV GIS.

2.1.11.1 TYPE

Indoor use, oil-less, reciprocating, belt-driven, self-cooled, vertical type.

2.1.11.2 CONSTRUCTION

The air compressor equipment shall consist of an air compressor, air tank, reduce pressure valve, safety valve, drain valve, pressure gauge, piping, control panel, etc., and shall have a capacity of generating compressed air of high dryness.

(1) AIR COMPRESSOR

The air compressor shall be designed to automatically start and stop at a prescribed pressure. Terminal voltage of the driving motor shall be 3-phase, 380 V, 50 Hz.

(2) AIR TANK

The air tank shall be of a vertical cylinder type and made of welded carbon steel plate. The air tank shall have sufficient strength against the maximum working pressure and have a drain valve at the lower part.

(3) PIPING

For the piping, seamless copper pipes shall be applied, and the piping shall be mutually connected with various equipment.

(4) VALVES

Reduce pressure valves, safety valves and drain valves shall be fitted.

(5) PRESSURE SWITCH

Pressure switches for low pressure annunciator and start and stop of the air compressor shall be provided as required.

(6) CONTROL PANEL

The control panel shall be of a self-standing type and shall enable precise supervision and control of the air compressor equipment.

2.2 POWER TRANSFORMER

2.2.1 APPLICABLE STANDARDS AND CODES

The following standards codes of the latest edition shall be applied.

International Electrotechnical Commission (IEC)

IEC-76 "Power Transformers"

IEC-137 "Bushings" for Alternating Voltage Above 1,000V"

IEC-296 "Electrical Insulating Oil"

Other pertinent International Electrotechnical Commission (IEC) standards and/or equivalent international standards shall be applied for electrical machineries and apparatuses.

2.2.2 SCOPE OF SUPPLY

Two (2) sets 220 kV/132 kV interchange transformer with complete accessories

Two (2) sets 132 kV/11kV grid station transformer with complete accessories

2.2.3 TECHNICAL INFORMATION

2.2.3.1 TYPE

(1) 220 kV/132 kV interchange transformer

Outdoor, oil immersed, oil natural, air-natural (ONAN), oil-forced, air-forced-cooled (OFAF), three-phase, two (2) windings, delta tertiary winding, auto-transformer

(2) 132 kV/11kV grid station transformer

Outdoor, oil immersed, oil-natural, air-natural (ONAN), oil-forced, air-forced (OFAF), two (2) winding

2.2.3.2 RATING

(1) 220 kV/132 kV interchange transformer

Capacity	250,000 kVA/160,000 kVA (ONAN)
Class of rating	Continuous
Voltage	
Low tension side	132 kV
High tension side	220 kV
Tertiary winding	11 kV
On/load voltage tap Changer	+7.5% (6 steps) -20% (13 steps)
Frequency	50 Hz
Vector group	YNynO
Connection	
Low tension side	Cable and fittings with protecting tunnels
High tension side	SF6 gas ducts conductor
Common neutral	Direct grounding
Impedance voltage	14% (at rated MVA base)
Insulation class	A
Insulation level	
Low tension side winding	BIL 650 kV (Full wave)
High tension side winding	BIL 950 kV (Full wave)

(2) 132 kV/11 kV grid station transformer

Capacity	30,000 kVA
Class of rating	Continuous
Voltage	
Low tension side	11 kV

High tension side	132 kV
On/load voltage tap	+10% (8 steps)
Changer	-20% (16 steps)
Vector group	YNyn0 (d1)
Frequency	50 Hz
Connection	
Low tension side	CV (XLPE) with sealing end,
High tension side	SF6 gas ducts conductor
High tension neutral	Direct grounding
Low tension neutral	Direct grounding
Impedance voltage	10% (at rated MVA base)
Insulation class	A
Insulation level	
Low tension side winding	BIL 110 kV (Full wave)
High tension side winding	BIL 650 kV (Full wave)

2.2.3.3 SHOP TEST

The shop tests shall be as follows, but shall not limited to the items listed below. The tests shall be carried out in the presence of the Owner and/or the Engineer.

Construction test

Withstand voltage test

Induced voltage test

Applied voltage test

Impulse voltage test (with oscillograph), (No. 1 Interchange Transformer and No. 1 Grid Transformer only)

Measurement of winding resistance
Measurement of transformer ratio

Measurement of transformer ratio

Polarity test

Angular displacement test

Impedance test

Temperature test

No load test

Measurement of tan δ

Operation test to show the correct function of all devices

Meggering

Noise measurement

Efficiency test

Auxiliary machine power consumption test

2.2.4 CONSTRUCTION

The transformer and all component parts shall be capable of withstanding mechanical and thermal stresses caused by short circuits, and shall be in accordance with IEC 76.

2.2.4.1 STEEL CORE MATERIAL AND CONSTRUCTION

The cold rolled directional silicon steel plates excellent in magnetic characteristics shall be applied. Measures required to reduce not only exciting current loss but also winding eddy current loss and stray load loss shall be taken.

Complete magnetic and mechanical connections shall be provided, and the no load current and noise shall be reduced.

The transformer core ground connection shall be provided to prevent damage to core winding due to core faults.

2.2.4.2 WINDING MATERIAL AND CONSTRUCTION

For the component wire of the winding, sufficiently headtreated, high purity electrolytic copper shall be applied.

The winding shall be sufficiently insulated at the portion between the component wires and shall be transposed.

Consideration shall be given to insulation between layers and ground.

As a countermeasure against surge voltage, the internal potential distribution of the winding shall be made uniform, and care shall be taken to prevent internal potential vibration.

2.2.4.3 INSULATING MATERIAL AND CONSTRUCTION

For the insulator, the materials which are excellent in dielectric strength, oil-proof and corona-proof properties, and have large heat conductivity, mechanical strength and impulse ratio shall be applied.

Sufficient consideration shall be given to prevent entrance of dust and moisture during the manufacture.

2.2.4.4 TANK

The tank shall be of a steel plate welded construction having appropriate reinforcement materials. It shall withstand external shocks, internal vacuum and internal pressure rise produced during normal operation. The pipings shall be of a construction that will prevent loosening due to vibration, temperature change and other undesirable effects.

Tank base shall be of the shoe type.

2.2.4.5 ON LOAD TAPCHANGER

(1) General

The on load tapchanger shall be of the Jansen type design having an oil immersed tap selector, an arcing or transfer switch with current limiting resistors contained in a separated pressure tight oil filled vessel inside the transformer tank, motor operated mechanism and controls, and shall be in accordance with IEC Publication 214 (1976). The on load tapchanger shall have current rating (*) as specified, and shall be suitable to withstand mechanical and thermal stresses. At all taps of the on load tapchanger, the transformer winding shall be capable of withstanding the impulse test voltage and the power frequency test voltage specified.

(2) Construction

(a) The on load tapchanger shall permit high speed change over with long life-span, high switching and short-circuit performance, and shall be mechanically long lasting. The spring operated energy stored diverter switch shall transfer with rapid action the power circuit from one tap to the next while two adjacent taps are bridged without the possibility either for a portion of the transformer winding to be short circuited, except through the current limiting resistors or open circuits. The main contacts shall be faced with suitable alloy for extending their working life. Diverter switch shall be designed to

permit easy removal and installation in the tank. Suitable guides shall be provided for correct alignment of diverter switch and contacts.

(b) Diverter components shall be easily renewable and enclosed in a separate oil-filled vessel fitted with drain valve, oil level indicator, relief vent and a gas alarm relay of suitable type and design with two contacts. The connection of the separate oil-filled vessel to the conservator shall be via an easily replacable filter and such that fouled oil can be tapped off while the transformer is in service and is automatically replaced with fresh oil from the conservator, or alternatively, the conservator may be divided into two compartments separated by a filter, for connection to the main tank and the tapchanger compartment.

(c) An operation counter shall be provided to register the accumulated number of tapchanges performed.

(3) Control

(a) The tapchanger shall be remote controlled manually from the substation control room.

It shall also be possible to operate the tapchanger locally. A local/remote switch shall be provided in the tapchanger control cabinet to select the point of operation. A crank for hand operation of the drive mechanism shall be provided, and shall be electrically interlocked to prevent operation of the motor while the

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hand crank is engaged.

(b) The motor drive control shall follow the step by step principle, i.e. after energization, the switching operation is automatically and irrevocably accomplished. If after a voltage dropout during the running time of the motor drive the voltage is present again, the motor drive shall automatically restart in the direction in which it had previously started. A safety connection shall be provided to interrupt the supply voltage in case of false phase sequence.

(c) The tapchanger shall be equipped with an emergency stop switch. Mechanically operated electric limit switches and mechanical stops shall be provided in the driving mechanism to prevent over-travel beyond the maximum raise and lower position.

(4) Position indicator

Two position indicators shall be provided, one shall be installed on the control board in the control room and the other on the transformer. The remote indicator shall be fitted with adjustable maximum and minimum indicating stops. The local indicator shall be so located that it can be read while operating the tapchanger. The remote indicator shall be of the servo type. The position indicators shall be marked as follows.

The principal tap shall be marked on the dial center line, and shall be indicated by the letter N. The range for raising the voltage of the LV winding with respect to the HV

winding shall be on the right hand side of the dial, and this range shall be marked with an arrow and the letter R. The lower range shall correspondingly be on the left side and marked with the letter L. The tap position numbers shall also be marked on the dial in smaller figures. The markings shall correspond to the tap numbers given on the rating plate.

(5) Housing

The control equipment and the drive mechanism shall be housed in a sheet steel or cast aluminium verminproof, well ventilated weather and corrosionproof cabinet. The doors shall have lift-off type hinges and be fastened by integral handles with provision for locking.

Identification labels on the outside of the doors shall be provided.

2.2.4.6 OIL CONSERVATOR

The oil conservator shall be of an atmo-seal system and shall be led to the atmosphere through a breather. The breather shall consist of a moisture absorbing chamber and an oil filter chamber, and shall be easy to handle. Exchange of moisture absorbing materials from aboveground and supervision of moisture absorbing conditions shall be made easy. In addition, the insulation oil level shall be made easy to supervise from aboveground, and shall have an alarm contact.

2.2.4.7 COOLING SYSTEM

The cooling system shall consist of a removable radiator composed of a unit radiator, a header, a oil pump and a fan. The

removable radiator shall have welded flanges attached on the main tank through packings, and a spare removable radiator shall be mounted on the transformer as a standby unit. An indicating type shut off valve shall be mounted on the tank side to enable removal of each radiator.

An oil pump and an oil indicator shall be fixed to the oil pump, and the pump shall be of a construction enabling supervision of normal oil flow direction.

A totally enclosed motor shall be used for the cooling fan. The fan shall be excellent in cooling performance and generate as little noise as possible.

The rating of the above oil pump and fan motors shall be AC 380V.

2.2.4.8 BUSHING

(1) High tension side bushing

The high tension side bushing shall be provided for each phase independently, and the bushing oil shall be charged separately.

The high tension side bushing shall be connected to the SF_6 gas bus duct.

The flanges to connect the SF_6 gas bus duct shall be provided.

The bushings shall be able to withstand the voltage rising of sound phases after one phase grounding.

(2) Low tension side bushing

The bushing in the oil and that in the air cable head, as well as each terminal at elephant parts shall not be

included in the scope of work, but the leads between the bushing in the oil cable head and the transformer side bushing in the oil shall be provided.

The elephant shall be provided for each phase independently, and the bushing oil shall be charged separately.

The high tension side bushing shall be an elephant type with porcelain and connected CV (XLPE) cable.

The bushing shall be able to withstand the voltage rising of sound phases after one phase grounding with the condition of salt contamination at 0.03 mg/cm^2 when the humidity of the air around bushings is 100%.

The following accessories shall be attached on the elephant parts.

Oil conservator

Pressure relief device

Valves

N_2 pressure meter

(3) Neutral side bushing

The neutral lead side bushing shall be drawn out together with each phase, and shall be connected together with three-phase at the bushing terminal by means of copper band. The neutral lead shall be supported by an insulator pulled down up to the lower part of the transformer.

The neutral CT shall be attached on each phase and wired up to the terminal cabinet.

2.2.4.9 ACCESSORY

The following accessories shall be provided.

(1) Oil level gauge

The oil level gauge shall be of the dial type enabling ample supervision from the floor, and shall have an alarm contact.

(2) Oil temperature indicator

The oil temperature indication of the dial type shall be provided to measure the temperature in the upper part of the tank.

A bar thermometer shall be attached to enable easy supervision from the floor.

A temperature alarm device with variable adjuster and a maximum temperature indicator shall be provided for the indicator.

An alcohol thermometer shall be provided for the bar thermometer, and shall be of a construction not easily damaged by outside shocks.

The measuring sensor of the dial type oil temperature indicator shall be of double construction which enables easy exchange of the measuring sensor, and care shall be taken to prevent insulating oil from leaking.

(3) Winding temperature indicator

The winding temperature indicator shall be used to equivalently indicate the winding temperature by means of a temperature compensator, and shall have a construction enabling easy supervision from the floor.

The measuring sensor shall be of double construction

enabling easy exchange of the measuring sensor, and care shall be taken to prevent insulating oil from leaking.

(4) Sudden pressure relay

The sudden pressure relay shall be designed to function in accordance with sudden internal pressure rise due to arcs in oil produced at the time of trouble inside the transformer. The sudden pressure relay shall have an alarm contact shaft but shall not function in case of slight change during normal operation. The relay shall be of a construction to enable easy testing of its operating condition from outside.

(5) Gas detecting device

The gas detection device shall serve as a relay, and shall have an alarm contact which will function by catching the buoyancy of gas and the oil flow.

The gas detection shall have a construction which enables easy detection of the gas collecting condition and sampling.

(6) Pressure relief device

The pressure relief device shall be used for releasing abnormal high pressure inside the tank into the atmosphere at the time of trouble of the transformer.

The pressure relief device shall be drawn out from the upper part of the tank to the lower part, and shall consist of a bursting plate with alarm contact which operates at the designated pressure at the time of abnormal condition.

The bursting plate shall not function at the time of oil face change during normal operation.

(7) Miscellaneous valves

The sampling valve, oil filter valve and drain valve shall be of flange type with gasket construction to enable easy attachment to outside piping. Blind covers shall be provided for each valve.

(8) Terminal cabinet

The terminal cabinet shall serve as an accessory electrical device of the transformer, and shall be used for connection of outside cable which shall be attached to the transformer body. The terminal cabinet shall be of the outdoor waterproof steel plate type with a door at its front. All cables shall be drawn out from the lower part and the inside shall be of a construction which enables the power circuit and control circuit to be separated.

(9) Ladder

A ladder for inspection shall be mounted at the side of the transformer body, and a handrail shall be set up on the top. The ladder shall be locked with steel plates and a "Do Not Enter" sign shall be attached to prevent use by unauthorized personnel.

(10) Steel plate platform with handrail

The steel plate platform with handrail shall be provided around the tap changer for safety of maintenance and operation.

(11) Grounding lug

Two (2) grounding lugs shall be mounted along the diagonal line of the tank. A brass clamp having four (4) fixing bolts shall be provided.

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As the grounding terminal and the tank are connected by different kinds of metals, sufficient welding shall be provided. The grounding terminal shall not be painted.

(12) Anchor bolts and nuts, foundation base

The anchor bolts and nuts, and foundation base shall not be damaged when the conditions described in "Design Conditions" in Part I overlap.

(13) Lifting lug, jack boss, pulling hole, etc.

Careful attention shall be paid to the fixing positions of the lifting lugs, jack bosses, pulling holes, etc., so that transportation and installation can be easily provided.

(14) Piping and wiring

Wiring between the accessory electrical devices of transformer and the terminal cabinet shall be provided, and shall have thick steel conduit tubes.

(15) Name plate

The name plate shall be fixed at a position easy to see from the floor.

The materials corresponding to SUS shall be applied.

The name plate shall have the following items recorded on them and these items shall not be erased under any atomspheric condition.

Name

Code No.

Name of manufacturer

Manufacture No.

Date of manufacture

Rated capacity

Frequency

Phase

Rated voltage

Tap voltage (including tap indication)

Rated current

Vector

Connecting diagram

Impedance voltage

Type of cooling

Insulation class

Insulation level

Total weight

Quantity of oil

Indoor or outdoor type

Temperature

Noise

2.2.5 ELECTRICAL INSULATION OIL

The electrical insulation oil shall have sufficient insulation strength, and shall be excellent in heat conductivity, low in viscosity and pour point and high in flash point. The oil shall not cause any corrosion to insulation materials and structural materials of electrical equipment, and shall be chemically stable for long years of use.

2.2.6 COOLER CUBICLE

The cooler cubicle shall be installed around the main transformer.

A cooling control device for the transformer, molded type air circuit breaker, control PT, fault indicator, etc., shall be attached on the cubicle.

The cooling fan and oil pump shall start automatically and simultaneously by current relays.

The power source of the cooler shall consist of two (2) systems, one for normal operation and the other for emergency use. The power source shall automatically be changed over to emergency power source at the time of fault in normal power source. All faults shall be indicated by the fault indicator and by alarm from the re-annunciation system to the substation control room.

2.2.6.1 TYPE

Outdoor, self standing, metal clad

2.2.6.2 CONSTRUCTION

The cooler cubicle shall have a door at its front and a panel inside the cubicle. The control switch, molded type air circuit breaker, changeover switch and signal lamp to be mounted at the front of the panel shall be of a construction enabling supervision from outside. A base plate shall be set up under the cubicle. The cubicle shall be of convection ventilation construction, and care shall be taken to prevent intrusion out of rain water, dust and insects.

2.2.6.3 RATING

Power voltage	AC 3φ	380 V	50 Hz
Control voltage	AC 1φ	220 V	50 Hz
	DC	220 V	

2.2.6.4 SPACE HEATER

A space heater having appropriate capacity shall be provided to prevent moisture from forming inside the cubicle.

2.2.6.5 LIGHTING, SWITCHES AND WORKING PLUG SOCKET

Fluorescent lamps, snap switches and plug sockets shall be provided for inspection of the cubicle inside.

2.2.7 NOISE

The indicating sound level meter shall be provided to measure the noise of the transformer, and shall be in accordance with "Measurement of Transformer and Reactor Sound Level" (IEC-551).

2.2.8 TRANSPORTATION

Packing shall be provided for transportation to prevent damage due to outside shock, rain and dust. If required, the electrical insulating oil shall be removed from the tank, and N_2 gas shall be filled.

In this case, an N_2 gas pressure gauge shall be attached for supervision, and the pressure value shall be clearly indicated.

The electrical insulating oil shall be put in a drum which shall be completely sealed to shut out rain water and dust.

2.3 CONTROL ROOM EQUIPMENT

2.3.1 LINE CONTROL PANEL

2.3.1.1 APPLICABLE STANDARDS AND CODES

The following standards and codes of the newest edition shall be applied.

International Electrotechnical Commission (IEC)

Also, International Electrotechnical Commission (IEC) shall generally be applied for Electrical Machineries and Apparatuses.

2.3.1.2 SCOPE OF SUPPLY

The following line control panels and accessories shall be supplied.

One (1) set	220 kV line and bus control panel
One (1) set	132 kV line and bus control panel

2.3.1.3 TECHNICAL INFORMATION

The line control panels shall be mounted in the substation control room on the second floor of the substation building.

The line control panels shall be applied so as to enable supervision and operation of the 220 kV, 132 kV transmission line and the 220 kV, 132 kV bus and 220 kV / 132 kV interchange transformer. The control room shall be air conditioned so as to maintain the room at a uniform temperature and humidity.

(1) TYPE

Indoor use drip-proof, self-standing, metal-clad.

(2) MANUFACTURER TESTS

Construction test

Meggering

Withstand voltage test

Sequence test

Watt-hour meter construction test

Tolerance test (error test)

Starting test

Creeping test

2.3.1.4 CONSTRUCTION

The construction of line control panels shall be in accordance with the following.

Dimensions

Height : 2,300 mm

Width : 1,000 mm and 700 mm

Depth : 1,500 mm

The panel shall be an operation panel having a mimic bus, meters, control switches, signal lamps and an annunciator at its front, and at its rear part, auxiliary relays for annunciators and watt-hour meters for respective circuits. The synchroscope panel shall be of a swing type and operated by remote control.

2.3.1.5 OTHERS

(1) Relays to be attached

The relays to be attached shall all be of a draw-out type.

The relays for annunciators shall be of a transistor type and shall be attached on the back of the panels.

(2) Electrical apparatus to be attached

(a) 220 kV and 132 kV bus panel

AC voltmeter for synchronizing	2 sets
AC voltmeter for 220 kV bus voltage	2 sets
Frequency meter for synchronizing	2 sets
Synchroscope	1 set
Frequency and 220 kV bus voltage recorder	1 set
Changeover switch	3 sets
Push button for annunciator (Bell stop, flickering stop, lamp reset, lamp test)	1 set
Test terminal of CT, PT	1 set each
Annunciator window	1 set
Buzzer (AC operated)	1 set
Bell (DC operated)	1 set
Synchronizing swing motor with limit switch	1 set

(b) 220 kV and 132 kV transmission line panel

Watt meter	1 set
Var meter	1 set
Voltmeter	1 set
Ammeter	1 set
Power factor meter	1 set

Annunciator window	1 set
Full-operated control switch with red, green and white lamps	1 set
Watt-hur meter	1 set
Pull-operated control switch with green and red lamps	4 sets
Removable handle type changeover switch	1 set
Ammeter changeover switch	1 set
Reclosing changeover switch	1 set
Carrier test push button and white lamp	1 set
Test terminal of CT and PT	1 set each
Push button for synchronizing panel	2 sets

(c) Transformer panel

The electricl apparatus to be attached for the transformer panel shall be the same as that indicated in above item (b).

(3) Connection to line relay panel

The annunciators, PT, CT and the interlock circuit applied for connection from the line and bus protective relay panel to the line control panel shall be provided.

2.3.2 LINE AND BUS PROTECTIVE RELAY PANEL

2.3.2.1 APPLICABLE STANDARDS AND CODES

The following standards and codes of the newest edition shall be applied.

International Electrotechnical Commission (IEC)

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Also, other pertinent International Electrotechnical Commission (IEC) and/or other international standards applied for electrical machineries and apparatuses.

2.3.2.2 SCOPE OF SUPPLY

The following protective relay panels and accessories shall be supplied.

Line protective relay panel	Two (2) sets
Bus protective relay panel	Two (2) sets

2.3.2.3 TECHNICAL INFORMATION

The protective relay panel shall be mounted inside the substation control room on the 2nd floor.

The line protective relay equipment shall be installed in order to protect the 220 kV direct ground system, two circuits and two terminal transmission lines to be connected to the West Wharf Thermal Power Plant and the Baldia Grid Station.

For line protection, the non-metallic optical cable shall be applied so as to protect the transmission line between the West Wharf Thermal Power Plant and the Baldia Grid Station.

For bus protection, differential voltage equipment shall be applied so as to protect the bus for 220 kV and 132 kV switchyard. Protective relays for the West Wharf Thermal Power Plant shall be of identical manufacture as those used for the Baldia Grid Station.

Air conditioning equipment shall be installed in the control room so as to maintain the room at a uniform temperature and humidity.

(1) TYPE

Indoor use, drip-proof self-standing, metal clad

(2) MANUFACTURER TESTS

Construction test

Meggering

Withstand voltage test

Sequence test

Primary and secondary relay test

2.3.2.4 PROTECTION SYSTEM

(1) BASIC SPECIFICATIONS

All protective relays shall be of the flush mounted, back connected withdrawable type. Relays shall be in accordance with IEC Standard Publication No. 225, Electrical Relays, and shall be suitable for operation with 100V sec. voltage transformers and 1 amp. current transformers. Relays shall be suitable for operation in the DC 220V system.

All parts of installation shall be covered by two high speed protection schemes which will, as far as practicable, be independent so as to avoid common mode failures.

The cabinets shall be completely equipped with the necessary protective and auxiliary devices and terminal strips, and shall be supplied fully wired.

The protective relays shall be divided into two groups so that the relays of group 2, for instance, represent the back-up for the relays of group 1.

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Fully automatic relay testing equipment shall be coordinated with this separate grouping of the protective relays, and shall be capable of performing relay testing without interruption of normal functioning, i.e. one relay group shall remain fully operative throughout.

The protective settings shall be carried out by the Contractor in accordance with the requirements of the existing network.

Only static relays shall be used for transmission line protection.

In service test facilities shall be provided so as to check and test the operation of relays. It shall be possible to test the relays by an external source from the appropriate test set by means of test plugs provided for this purpose. In no case shall it become necessary to remove or open control and protection wiring for the purpose of performing the necessary checks and tests. All trip circuits shall be individually isolated by test links so that test operation of a relay can be carried out without tripping the circuit breakers. Trip circuit supervision shall be provided.

In built tripping indication shall be provided in relay casing with alarm signals locally displayed.

Distance relays shall have local indications for starting element operation and zone of operation. Back up over current and ground relays for line protection shall have independent local indications.

(2) TRANSMISSION LINE PROTECTION

First main distance protection shall comprise solid state ultra high-speed non-switched distance relays having multizoned directional distance characteristics for phase and ground faults.

These relays shall have the following features.

a. Directional comparison, permissive under-reach/over reach transfer tripping and directional comparison blocking modes via non-metaric optical cable line carrier

b. Power swing blocking

c. Single and three phase auto-reclosing relays

d. Detection of all types of phases and ground faults

e. Broken conductor detection

f. Suitable for close in and evolving faults

g. Immunity to CT Saturation, swings, switching surges, etc.

h. Signalling contacts for starting elements, time step element tripping, tripping blocked, tripping from remote station, supply module ready to operate, and relay ready to operate

i. Built in test functions including diagnostic module, self-monitoring functions and power supply monitoring

j. Second main distance relays shall be solid state, high-speed distance relay having multizoned direction distance characteristics for phase and ground faults. A switched scheme may be considered for second main,

but this shall be approved by the Owner/Engineer.

The protection system shall have the same features as described above for first main distance protection.

In case of tripping by these protection devices, the breakers of the remote grid station of the overhead line system shall trip via carrier impulse.

Fault locator associated with distance relay to provide digital output (LED display and printed output) to indicate location of fault in the transmission line shall be provided.

a) Overcurrent time delay protection (Definite time) and IDMT relay for ground faults

b) Auto-reclosing protection for single and three phase faults through synchro-check relay

The protection cabinets shall be installed as follows.

220 kV transmission line protection	Control room
Busbar protection	Control room
Transformer protection	Control room

(3) BUSBAR PROTECTION

Short circuit and ground circuit fault protective devices for the 220 kV and 132 kV double bus system shall be provided with the following protective relays.

a. Bus protective relay

High impedance current differential relay operating at high speed at the time of a fault in the short circuit and ground circuit for the bus, for both A and B buses

b. Under-voltage relay

Under-voltage relay together with respective bus protective relays to ensure precise operation of the bus protective relay

c. Bus lock-out relay

Bus lock-out relay operated by means of action of bus protective relay and under-voltage relay, and the corresponding circuit breaker shall all be tripped. For the lockout relay contacts with necessory numbers shall be provided.

(4) 220 kV/132 kV INTERCHANGE TRANSFORMER

The following protection scheme shall be provided.

a. Differential protection

b. Buchholz protection (transformer tank and tap changer)

c. Overcurrent protection (primary and secondary) with instantaneous high set element and separate timer continuously adjustable between 0.1 and 1 sec.

d. Overload protection (primary and secondary as contact thermometer)

e. Restricted ground fault protection

(5) 132 kV/11 kV GRID STATION TRANSFORMER

The following protection scheme shall be provided.

a. Differential protection

b. Buchholz protection (transformer tank and tap changer) overcurrent protection (primary and secondary) with instantaneous high set element and separate timer

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continuously adjustable between 0.1 and 1 sec.

c. Overload protection (primary and secondary as contact thermometer)

d. Ground leakage protection

2.3.3 400V SWITCHGEAR

2.3.3.1 APPLICABLE STANDARDS AND CODES

The following applicable standards and codes of the latest edition shall be applied.

International Electrotechnical Commission (IEC)

IEC-157 "Low Voltage Switchgear and Control Gear"

Other pertinent International Electrotechnical Commission (IEC) and/or equivalent shall be applied for electrical apparatuses.

2.3.3.2 SCOPE OF SUPPLY

The switchgear and accessories described hereunder shall be supplied. However, other than the power source equipment for auxiliary machines to be decided by the Contractor, the control center unit indicated in the attached drawing shall be installed as the power source equipment for auxiliary machines in the substation.

One (1) set	Indoor type, 400V control center assembly

2.3.3.3 TECHNICAL INFORMATION

(1) TYPE

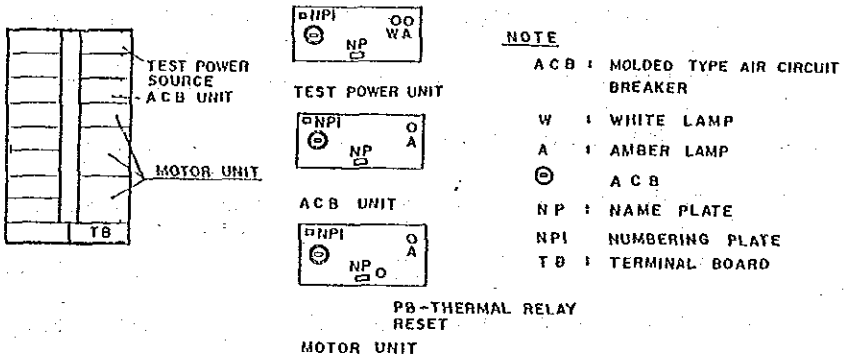
Indor use, self-standing, metal clad, vertical section type

(2) RATING

400V control center

Voltage	600 V
Frequency	50 Hz
Phase and wire	3φ3W
Bus current	400 A
Interrupting current	15 kA

(3) TYPICAL FRONT VIEW OF CONTROL CENTER



(4) MANUFACTURER TESTS

The following tests shall be carried out but shall not be limited to the items below.

All tests shall be conducted in the presence of the Owner and/or the Engineer.

1) Control center

Construction test

Meggering test

Withstand voltage test

Sequence test

2) Air circuit breaker

Construction test

Meggering test

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Withstand voltage test

Operating test

2.3.3.4 CONSTRUCTION

(1) STATIONARY STRUCTURE

The stationary structure shall be of welded or frame assembled construction using steel plates having thicknesses of 1.6 mm to 3.2 mm, and consist of a motor combination starter unit, an Air Circuit Breaker (ACB) unit, current limiting reactor compartment, bus compatment, terminal compartment, etc. Each component shall be of a completely separated construction with no exposed parts. The stationary structure shall have a hinged panel with stopper and handle with key for each unit at its front, and shall be of a construction which facilitates operation of the ACB and thermal reset from outside. At its back, the stationary structure shall have a door hinged with fastening bolts which shall be mounted at each vertical section.
For each power circuit, cable supporters for the outside cable and inside wiring shall be provided.
Cable supporters shall be provided for the outside cable for the control circuit.

(a) Unit compartment

The unit compartment for each unit shall be constructed so that, in the case of accident, no spreading of any influence to other units shall

occur.

The compartment shall have a guide with stopper for inserting and drawing out the unit.

(b) Buses

For the bus conductor, insulated copper or aluminium bar shall be applied.

The bus conductor shall consist of a horizontal bus conductor and a vertical bus conductor, and the contact surfaces of the joint part shall be silver plated. The joint part shall be firmly jointed mechanically and electrically, and insulated.

The contact surfaces of the vertical bus conductor connecting with each unit shall be silver plated. For the bus supporter, mechanically and electrically excellent insulating materials shall be applied, and shall sufficiently withstand electromagnetic force at the time of short circuit of the bus.

(c) Terminal

The terminals for power and control circuit shall be attached in each vertical compartment to be provided at each vertical section.

The power circuit shall be installed at the rear side of the terminal compartment, and the control circuit at the front side of the terminal compartment.

The the above short circuit current shall be decided by giving consideration to its motor contribution. The reactor shall be connected with the bus conductor by insulated wire, and shall be of a construction enabling reduction, wherever practicable, of the electromagnetic force produced on both side cable (for power source and load) of the reactor at the time of short circuit. The front door and rear door shall be the hinged type with stopper and handle with key.

(d) Cable entry

Drawing the cable outside shall be provided from the upper or lower part of the control center, and the following terminals shall be supplied.

Terminal for power cable, wherever required, shall be supplied.

Compression type for more than 125 mm^2

Crimp type for 125 mm^2 and less

However, in case the cable is drawn out from the upper part, it shall be connected to the cable tray with a vertical shaft.

(e) Auxiliary relays and wiring

All auxiliary relays for outside interlocking shall be attached at the rear side of the control center, and shall not be attached inside the control center.

(f) Grounding terminal

One each of grounding teminals shall be provided at both sides of the stationary structure. The size shall be 50 mm^2.

(2) UNIT

(a) Motor feeder unit

The motor feeder unit shall consist of a molded type air circuit breaker with alarm contact magnetic contactor, trouble indicating lamp, thermal relay, transformer for control circuit, signal lamp, auxiliary relays, wiring, etc. For reversible type unit, electrical and mechanical intelock shall be provided.

Each unit shall be of a draw-out type. The primary power circuit shall be connected to the vertical bus on the stationary structure by a grip type connector. The secondary power circuit and the control circuit shall be connected with a connector, and shall have a construction facilitating easy drawing out of the unit for maintenance and repair.

Each motor feeder unit shall be of a construction enabling operation test through a different power source while the circuit breaker is open without drawing out the unit from the stationary structure.

Units, such as fans and blowers, from among the motor feeder units having a large GD^2 shall be coordinated by means of a saturation reactor or a time relay as required.

(b) Molded Type Air Circuit Breaker (ACB) Unit

The ACB unit shall consist of a molded type air circuit breaker with alarm contact, signal lamp and wiring, and shall have the same construction as that for the motor feeder unit.

(3) NAME PLATE

Name plates and number plates shall have the following items indicated at the prescribed positions.

(a) Name plate

The name plates shall be placed on the front door and rear surface of each unit.

(b) Unit number plate

The panels shall be numbered 1, 2, 3, ..., counting from the incoming panel side and A, B, C, ..., counting from the upper level. (Each panel shall be numbered 1A, 2A, ...)

(4) SPARE UNIT

Two (2) sets of a compelte spare unit shall be provided for motor feeder unit and ACB unit, and shall correspond to each capacity in each control center.

2.3.4 DISTRIBUTION PANEL

2.3.4.1 APPLICABLE STANDARDS AND CODES

The following standards and codes of the newest edition shall be applied.

International Electrotechnical Commission (IEC)

IEC-76 "Power Transformers"

Also, other pertinent International Electrotechnical Commission (IEC) and/or other international standards shall be applied for electrical apparatuses.

2.3.4.2 SCOPE OF SUPPLY

The following distribution panel and accessories shall be supplied.

One (1) set	AC 380 - 220 V substation distribution panel
One (1) set	DC 220 V distribution panel

2.3.4.3 TECHNICAL INFORMATION

The distribution panel shall be provided to supply power for instruments, control equipment, site work, etc., of the power station.

(1) TYPE

Indoor use, drip-proof, self-standing, metal clad

(2) RATING

(a) 380 - 220 V substation distribution panel

Panel

Voltage	380 - 220V
Phase and wire	3ϕ 4W
Bus current	400A

Molded type air circuit breaker	
Number	*
Rating	600V, 2P, 3P
Transformer	
Type	Dry
Capacity	30 kVA
Voltage	
High tension side	400V
Low tension side	380 - 220V
No-load, no-voltage tap	420 - 400 - 380V
Insulation class	H

(b) DC 220V substation distribution panel

Panel	
Voltage	220V
Bus current	400A
Molded type air circuit breaker	
Number	30
Rating	600V, 2P, 100A

(3) MANUFACTURER TESTS

Manufacturer tests shall be as follows, but shall not be limited to the items below. All tests shall be carried out in the presence of the Owner and/or the Engineer.

(a) Panel

Construction test

Meggering

Withstand voltage test

Circuit test

(b) Transformer

Withstand voltage test

Measurement of winding resistance

Measurement of transformer ratio

Polarity test

Angular displacement test

Impedance test

Temperature test

2.3.4.4 CONSTRUCTION

(1) AC DISTRIBUTION PANEL

The AC distribution panel shall be provided, and shall consist of a distribution panel with a built-in molded type air circuit breaker and a cubicle with a built-in transformer.

(a) Distribution panel

The distribution panel shall be of an assembled construction on the basis of 1.6 - 3.2 mm thick steel plate and frame, and shall have built-in bus conductor and molded type air circuit breaker with alarm contact.

The distribution panel shall have a hinged door with stopper and handle with key at its front, and the rear part shall be of a removable bolt type.

A protective plate shall be attached inside

the panel in order to separate the bus conductors, and the distribution panel shall be of a construction which facilitates easy operation of the molded type air circuit breakers.

For the bus conductors, insulated copper or aluminum bar shall applied, and the contact surfaces of the joined parts for the bus conductor shall be silver-plated. The conductor shall be firmly joined mechanically and electrically.

Insulation materials excellent in mechanical and electrical properties shall be applied for the bus conductor supports, and the supports shall firmly hold and sufficiently withstand the electromagnetic force produced at the time of bus short circuit.

The terminal board shall be mounted inside the rear side of the panel, and insulated wire shall be applied between the terminals and the molded type air circuit breakers.

The cable shall be drawn out from the upper part and shall be connected with the cable tray by means of a vertical shaft.

For the teminal for the cable, a compression type terminal of more than 125 mm^2 and a crimp type terminal of 125 mm^2 or less shall be

provided wherever required. One set each of grounding terminals of 50 mm^2 shall be provided on both sides.

(b) Transformer cubicle

The transformer cubicle shall have a built-in transformer for the distribution panel.
The cubicle shall have a construction in consideration of heat radiation.
The cubicle shall have at its front door a handle with key and stoppers. The door shall be of a construction facilitating supervision from outside of the transformer winding temperature meter, and the cubicle shall have a removable plate at its rear part.
Inside the cubicle, a guide rail with stopper lug for drawing in and drawing out the transformer, and a supporter for the high tension side cable shall be provided.

(c) Transformer

The transformer shall be connected with the 400 V control center. The transformer shall supply power to the respective distribution panels.
Construction of the main components of the transformer shall be in accordance with the following.

a) Construction of steel core material

For the steel core materials, cold rolled directional silicone steel plate excellent in magnetic property shall be applied.
The exciting current loss shall be reduced wherever practicable, and measures shall be taken to reduce winding eddy current loss and stray load loss.

b) Construction of winding material

For the component wires, high purity electric copper sufficiently heat treated shall be provided.
Sufficient insulation between the component wires and transposition shall be provided, and sufficient consideration to insulation between layers and layers, winding and grounding shall be given.
As a measure against surge voltage, the internal potential distribution of the winding shall be kept at a uniform level, and consideration shall be given to the prevention of internal potential vibration.

c) Insulation material

The insulation material shall be excellent in dielectric strength, corona-proof property, heat-proof property, moisture-proof property and dust-proof property.

Material having large heat conductivity and large mechanical strength shall be applied, and sufficient attention shall be paid at the time of their manufacture.

d) Tap changer

The tap changer shall be a no-load, no-voltage type, and applied for easy and precise changeover of taps inside the cubicle.

The tap changer shall have sufficient mechanical and electricl strength, and shall have a tap position indicator.

e) Connection

The high tension side of the transformer shall have a construction facilitating easy connection of the outside cable. The low tension side of the transformer shall be directly connected with the distribution panel by means of a bus bar, and it shall have a construction enabling absorption of vibration of the transformer.

f) Accessories

The following accessories shall be supplied as required.

Winding temperature indicator

The winding temperature indicator shall be of a dial type, and shall be attached

at a position enabling supervision from outside of the cubicle.

Grounding

For grounding lug, one (1) set of 50 mm^2 crimp type terminals shall be mounted on the transformer structure.

Lifting lugs

Sufficient attention shall be given to the mounting position of the lifting lugs so as to facilitate easy transport and installation of the transformer.

(2) DC DISTRIBUTION PANEL

The DC distribution panel shall have built-in molded type air circuit breakers with alarm contact.

The construction of the distribution panel shall be the same as that of the AC distribution panel.

(3) NAME PLATE

The following name plates and number plates shall be placed at the prescribed positions.

(a) Name plate

The name plate shall be placed on the upper side of the front and rear surfaces of the doors for distribution panel and the molded type circuit breakers.

(b) Number plate for molded type air circuit breaker

The circuit breakers shall be numbered 1, 2, 3, ..., continuous from the left side and A, B, C, ..., continuous from the upper side.

(4) SPARE CIRCUIT BREAKER

Five (5) sets of spare circuit breakers shall be attached.

2.3.5 BATTERY AND BATTERY CHARGER

2.3.5.1 APPLICABLE STANDARDS AND CODES

The following applicable standards and codes of the latest edition shall be applied.

International Electrotechnical Commission (IEC)

IEC-335-2-29 "Particular Requirement for Battery Charger"

Other pertinent International Electrotechnical Commission standards (IEC) and/or equivalent shall be applied for electrical apparatuses.

2.3.5.2 SCOPE OF SUPPLY

The following battery, battery charger and accessories shall be provided, but shall not be limited to the following items.

One (1) set	DC 220V station battery and battery charger with accessories for substation

2.3.5.3 TECHNICAL INFORMATION

As the station battery is used as a power source for the control of 220 kV and 132 kV substation equipment as well as power source for emergency lighting, sufficient

care shall be paid to design and fabrication of the station battery.

(1) TYPE

(a) Battery

Indoor, stationary, nickel-cadmium type

(b) Battery charger

Indoor, three-phase, full wave, silicone rectifier, drip-proof , self-standing, metal clad

(2) RATING

DC 220V Station battery for substation

(a) Battery

Voltage	220 V
Number of unit cell capacity	160 - 172 *Ah (at 5 hour rate)
Nominal voltage of cell	1.4 V ±1%
Minimum voltage of cell	1.2 V
Self-discharge capacity	Less than 0.5%/day
Maximum temperature of electrolyte	45°C
Specific gravity of electrolyte when fully charged	1.200 - 1.230 (at 20°C)

(b) Battery charger

Rectification system	Three-phase, full wave
Class of rating	Continuous
Cooling system	Self-air cooled
Input (AC side)	
Phase	3φ

	Frequency	50 Hz
	Voltage	380 V
	Output (DC side)	
	Voltage	220 V
	Current	* A
	Voltage adjustment range	
	Automatic floating charge	210 V - 240 V
	Automatic equalizing charge	240 V - 270 V
	Manual	195 V - 320 V
	Current adjustment range	0 - 100%
(c)	Counter cell	
	Current	* A

(3) BASIC CIRCUITS

Drawing

(4) SHOP TEST

The shop tests shall be as follows, but shall not be limited to the items below. The tests shall be carried out in the presence of the Engineer.

(a) Battery

Construction test

Measurement of voltage for each cell

Measurement of specific gavity for each electrolyte cell

Capacity test

(b) Battery charger

Construction test

Meggering

Withstand voltage test

Sequence test

Voltage and current adjustment test

Constant voltage characteristic test

2.3.5.4 CONSTRUCTION

(1) BATTERY

The battery shall consist of positive plate, negative plave, separator, cell, and exhauster, and each component shall have excellent corrosion-proof and mechanical properties. All materials shall be of the finest quality in every respect. An exhauster capable of preventing explosion and foaming of the gas generated inside the battery shall be provided, and the battery shall be sealed completely with the compound,

packing, etc., so that no gas shall be discharged through parts other than the exhauster. Each part shall have a construction enabling stable performance for a long period of time, causing no damage or dropping of reacting agents even in case of short circuit current, and shall be made easy for maintenance and inspection.

(a) Plate

a) Plate

The positive plate and negative plate shall have excellent properties and uniform surfaces. The plates shall not contain any harmful foreign matter. The plates shall have a construction causing no dropping of reacting agents, and shall endure long periods of use.

b) Terminal

The terminal shall be made of lead alloy, and shall be completely and uniformly welded to the plates. The terminals shall have such a construction that they can be easily mounted.

(b) Cell

The transparent cell made of alkali-proof synthetic resin shall be applied for the cell. The cell shall be uniform in thickness, shall have sufficient strength with no cracks

or cuts, and shall not deteriorate after long years of use.

An electrolyte level indicating line shall be attached to the cell at a position easy to supervise.

For the cell, a cover of material having sufficient strength, with no cuts or cracks, shall be provided.

The cell shall be of a construction facilitating easy injection of electrolytes and measurement of gravity.

(c) Separator

For the separator, the materials made of alkali-proof synthetic resin shall be applied.

(d) Electrolyte

Electrolyte corresponding to potassium hydroxide shall be applied, and the specific gravity shall, in principle, be 1.200 - 1.230 (tolerance 1.160 - 1.250) at 20°C when the battery is completely under a charging condition.

(e) Exhauster

The exhauster shall have an explosion-proof and spray-proof function so that any battery outside fire shall not cause ignition or explosion inside the battery. The exhaust shall have a construction so that acidic mist generated inside the battery shall not be

dispersed into the atmosphere.

(f) Packing and compound for sealing

Various packings to be used at places requiring sealing shall be made of synthetic rubber, etc., of excellent quality, and the packings shall not be dissolved or expanded due to the electrolytes for long periods of use, and shall ensure complete sealing.

(g) Pilot cell

The pilot cell shall be of a construction enabling permanent enclosure of the gravity meter and thermometer, and shall be made easy to measure from outside. In regard to quantity, at least two (2) units of the pilot cells shall be provided for one set of batteries.

(h) Connection method and conductor

The battery shall be connected, in principle, with connecting bolts and nuts by tightening the conductor having sufficient sectional area against discharge current with the positive terminal and negative terminal.

The conductors and connecting bolts and nuts shall be in conformity with the following.

a) Conductor

Copper to be applied for the conductor and terminal shall be lead-plated. For insulation

sheathing, synthetic rubber or other alkali-proof synthetic resins shall be used.

b) Connecting bolts and nuts

The connecting bolts and nuts shall be made of copper, with lead-coating or lead-sheathing provided on the surfaces.

(i) Polarity mark

For polarity marks, "+" and "-" shall be indicated clearly and firmly at the corresponding positions of the battery, and the marks shall not be erased.

(j) Mounting structure

The mounting structure shall be made of steel, and complete acidproof painting shall be provided. The structue shall be capable of accommodating a complete set of batteries, and all batteries shall be mounted in a one stage arrangement.

The insultors shall be made of porcelain of excellent quality, and shall have sufficient strength.

(k) Spare battery

At least two (2) sets of spare battery shall be provided on the mounting structure.

(2) BATTERY CHARGER

The battery charger shall consist of a rectifier, a transformer for the rectifier, an automatic

constant voltage device, accessories and a cubicle for housing the above, and it shall have a construction easy to handle for maintenance and inspection. In regard to the layout of the battery charger, control center and distribution panel, refer to Item 3.6.3.3.

(a) Rectifier

The rectifier shall consist of silicone devices and other required accessories. The silicone devices shall be uniform in quality, of a construction causing no loosening at the tightened places of accessories, and shall facilitate easy replacement of rectifier parts as required. The devices shall be constructed so as to provide the required heat radiation.

(b) Transformer for rectifier

The transformer for the rectifier shall be a two-winding transformer, and shall have 400V, 380V and 360V no-load, no voltage tap chargers on the primary side.

(c) Voltage rgulator

The automatic voltage regulator shll be of a static type, and it shall be highly sensitive, quick in response and highly stable. The regulator shall be in conformity with the following.

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a) It shall be possible to be changed over to either manual or automatic operation.

b) In case of automatic operation, the regulator shall be capable of continuously regulating the DC side voltage within the regulating range prescribed in Item 6.1.3.2 (2)(a).

The setting voltage regulator for the floating and equalizing charge shall be mounted on the panel. The changeover switch to enable selection of floating charge or equalizing charge shall be mounted on the panel.

c) In case of manual operation, the regulator shall be capable of regulating the DC side voltage to the step voltage of less than 2V in accordance with the regulating range prescribed in Item 6.1.3.2(2)(a).

(d) Counter cell

The counter cell shall be provided for compensating the load voltage when an equalizing charge is used.

The counter cell shall be designed to be operated both automatically and manually.

(e) Cubicle

The cubicle shall be made of 2.3mm or 3.2mm thickness steel plate, and shall be of the self

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standing type. The cubicle shall have at its front meters, changeover switches, adjustment dials, signal lamps, etc.

The cubicle shall have a construction enabling manual operation of the molded type air circuit breaker with an alarm contact.

The cubicle shall also have a construction giving consideration to heat radiation of the transformer rectifier, etc.

The rear part shall be composed of a removable type plate, and the power and control terminals for the outside cable shall be provided inside the cubicle.

(3) MAINTENANCE ACCESSORIE

(1)	Syringe hydrometer	Four (4) sets
(2)	Hand type DC voltmeter with lead wire	Four (4) sets
(3)	Jug	Four (4) sets
(4)	Filling syringe	Four (4) sets
(5)	Funnel	Four (4) sets
(6)	Eye dropper with temperature meter and gravity meter	Four (4) sets
(7)	Box for attachment	One (1) set
(8)	Other necessory materials	One (1) set

2.4 TELECOMMUNICATION EQUIPMENT

2.4.1 APPLICABLE STANDARDS AND CODES

The following standards and codes of the latest edition shall be applied.

International Electrotechnical Commission (IEC)

Other pertinent International Electrotechnical Commission (IEC) standards and equivalent international standards shall be applied for electrical machinaries and apparatuses.

2.4.2 SCOPE OF SUPPLY

The following telecommunication equipment shall be provided. These equipments shall be installed at both the West Wharf Substation and the Baldia Grid Station.

Non-metallic optical cable system

Teleprotection equipment

Telecontrol equipment

Telephone equipment

Power supply equipment

Energy supply, cables and auxiliary equipment

RTU

VHF radio communication equipment

2.4.3 TECHNICAL INFORMATION

The purpose of the telecommunication system is to transmit via 220 kV overhead lines all necessary information and orders between the power station, grid stations and the KESC load dispatching center so as to facilitate optimal operation and protection of the power station and grid stations in the KESC

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grid in accordance with the load and network configurations.
The system shall be complete in every respect and suitable for satisfactory and reliable operation.
Non-metallic optical cable communication facilities shall be provided for telecommunication and protection signaling for the 220 kV double circuit transmission lines between the 220 kV West Wharf Substation and the Baldia Grid Station.
The two (2) circuits of non-metallic optical cable shall be led and connected with OPGW along the following routes.

	From	To	Distance
1.	Terminal box at tower No. 1	Optical line terminal equipment at West Wharf Substation	about 1.2 km
2.	Terminal box at gantry	Optical line terminal equipment at Baldia Grid Station	about 0.1 km

The type of non-metallic optical cable shall comprise single mode step index type optical fiber.
The OPGW on the 220 kV overhead transmission lines shall be provided by the Contractor of Lot II B.

2.4.4 TELECOMMUNICATION EQUIPMENT

The equipment shall be supplied for full integration into the existing KESC PLC system, and shall be fully compatible and properly interfaced with existing carriers, protection signalling and switching equipment at other grid stations with which it is required to work in conjunction.
The purpose of this system is remote monitoring and control of the KESC grid from the load dispatching center. The grid stations

shall be equipped with the necessary telecontrol devices so as to facilitate transmission of the following data via the optical fiber cable carrier system.

(1) Remote indication

Voltage and frequency	per busbar
Current, active and reactive power	per generator-transformer
Voltage, current, active and reactive power	per OHL system and coupling transformer

(2) Remote control

All isolating switches	
All circuit breakers, including position indication	(except generator synchronizing circuit breakers)

(3) Remote alarm

Common alarm and fault alarms from the substation.

(4) Transmission of tripping impulses

Intertripping for distance protection

Interlocking of the off-impulse of signal comparison protection. As auto-reclosing is only single-phased, the protection tripping impulses shall operate in the same way.

(5) In the design of the telecontrol equipment the following shall be considered.

a. New devices shall be compatible to the existing BBC equipment (Indactic, NSD) with regard to structure of the information, works, number of bits, codes, transmitting speed, bandwidth, frequency, etc.

b. Measuring values shall be transformed from analogic to

digital impulses and shall be transmitted cyclically to the load dispatching center for storage and display on data monitors.

The flow direction of active and reactive power measurements shall be indicated by ±sign.

The transmission and input of remote control impulses and alarm shall take place spontaneously. This shall also apply for the protection impulses, but these shall have priority over all other signals and information. The transmitting speed for protection impulses shall be less than 20 ms.

At this stage, the load dispatching center shall only be equipped for measuring values; extension for remote control and alarms will follow later.

(6) The optical fiber carrier equipment shall be provided in order to transmit and receive the following signals at the West Wharf Substation and the Baldid Grid Station.

Telecontrol

Telesignaling

Telemetering

Transmission line protection

The optical fiber carrier equipment shall comprise the multiplexer with synchronizer, optical line terminal equipment including optical transmitter/receiver, bipolar-to-unipolar converters, alarm control unit, power supply unit, service data interface unit, code/speed converters, orderwire equipment, service data interface unit, digital distribution frame, line switchgear and line supervisory equipment.

All equipment, including measuring transformers, shall be supplied in factory-finished condition, mounted in cabinets (IP32), wired to the terminal strips erected, connected up and put into operation.

The miscellaneous equipment shall include the following.

- telecontrol equipment
- telesignaling equipment
- telemetering equipment
- protection impulse transmission equipment

This equipment shall be installed together with the appropriate optical fiber cable transmitter channels and receiver channels in common cabinets.

The electronic modules shall be equipped as follows.

a. Telecontrol modules
   - With all required command receiver sets for the reception of command impulse telegrams from the transmission system.
   - With all necessary command output sets and onward transmission to circuit breakers or isolating switches.
   - The necessary peripheral sets, power supply, etc.

b. Telesignaling modules
   - With all necessary signaling input sets for input of signals in the data acquisition system with the aid of programmed signals in the form of signal telegrams having the specified number of bits (pulses).
   - With all necessary signaling transmitter sets (impulse

transmitter, encoder, modulator, etc.) for forming the pulse train and onward transmission of the signal to the load dispatching center.

- All necessary peripheral sets, power supply, etc.

c. Telemetering modules

- With all necessary measuring signaling input sets for input of measured values, coupled with analog/digital converter.
- With all necessary measuring signaling transmitter sets (impulse transmitter, encoder, modulator, etc.) for forming the pulse train and onward transmission of the cyclically scanned measured values to the load dispatching center.

d. Protection impulse transmission modules

- With all necessary protection impulse transmitter and receiver sets for the transmission of the switching-off impulse through the system. The associated circuit breakers shall be connected directly to the assemblies so that the switching-off impulse from the protective device can be triggered without delay and without selection.

(7) Remote terminal unit (RTU)

Remote Terminal Unit (RTU) shall be housed in dustproof, vermin-proof indoor cabinets. Cable access shall be through top and/or bottom. All RTU assemblies, including test panels and power supplies, shall be mounted fully enclosed inside the cabinet.

With the exception of RTU cabinet lights and utility outlets that shall operate from AC mains, the equipment shall be fed from remote battery supplies rated 48 V DC nominal with a tolerance range of 42 V/58 V. The equipment shall operate with positive side grounded battery.

The equipment shall be protected against voltage transients originating from other equipment connected to the same battery. Similarly, normal operation of RTU shall not introduce any voltage transient in the DC distribution circuits greater than 0.75 V peak to peak.

Electrical and mechanical grounding shall be entirely separated in the equipment. It shall be possible to connect both circuits through the same ground point. Isolation shall be 500 V 50 Hz during one minute.

A test cable shall be supplied with quick disconnect connectors to interface with the communication panel at the control center and at modem interfaces at the RTU.

The Contractor shall provide all special test equipment necessary to test and maintain the RTU equipment and master station computer, and shall provide a complete list of the equipment to be offered.

Modems

A 200 Baud FSK modem shall be provided with RTU for the Baldia Grid Station.

A 600 Baud FSK modem shall be provided with each RTU for the West Wharf Substation.

The modem shall be installed inside the RTU equipment

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cubicle.

The modem shall be equipped with all necessary facilities for the testing and setting up of the modem.

The precise frequencies of operation of each modem will be defined at the detailed design stage.

Each terminal shall be equipped with a transit filter to transmit data through to adjacent terminals. The precise frequency allocations for the transit filters will be defined at the detailed design stage.

The characteristics of the modems shall be as follows.

General

Standards	CCITT, or equivalent
Data rate	Field strappable 200/600 bits/sec.
Modulation	FSK
Operating mode	Half or full duplex
Construction	Solid state card
Line impedance	Balanced 600 ohms
Line filters selectivity	< ± dB for parallelling 5 equipments on speech plus band
Controller interface	CCITT V 24
Line interface	4 wires with adaptative and protective circuits relevant to the line

Construction facilities shall be provided for convenient connection of test equipment at modem interface points at either the analog or digital side.

Transmitter

Center frequency	< ± 4 Hz for 200 Bauds
drift	< ± 8 Hz for 600 Bauds
Center frequency	< ± 6 Hz for 200 Bauds
accuracy	< ± 12 Hz for 600 Bauds
Transmitted level	Adjustable between 0/-26 dBm on 600 ohms

Receiver

Received nominal level R shall be adjustable to the prevailing transmission lines and data rate. Receiving shall operate correctly within international standardized ranges for level distortion and central frequency drift. The Contractor shall state the performances offered for each category of data transmission rate. The Contractor shall state, according to his proposed data transmission circuits, whether automatic equalization is required for correction of delay distortion.

(8) Control console desk

The control console desk shall be provided in the substation control room and shall serve for controlling the paging system, public and station telephone system, and interphone system.

The load dispatch telephone shall be provided.

The desk shall be of the bench board type, and the following devices shall be provided.

Public telephone	One (1) set
Station telephone	Two (2) sets
Paging handset	One (1) set
Monitor speaker	One (1) set
Monitor volume control	One (1) set
Load dispatch telephone	Two (2) sets
Interphone	One (1) set
Alarm	One (1) set

a. Public telephone set

The public telephone set shall be of the dial-in type, and provided for emergency use at the time of a failure in the PABX in the power plant.

b. Station telephone set

The station telephone shall be connected with the PABX.

c. Paging handset

The paging handsets shall be provided as dispatching devices. One (1) set of the paging handset shall be provided. In case of calling with this handset, the monitor speaker on the control console desk shall be in the "off" position.

d. Monitor speaker and volume knob

The monitor speakers shall be used for the paging system and the volume shall be adjustable by means of the volume knob.

e. Load dispatch telephone

Two (2) sets of load dispatch telephone with related accessories shall be provided on the control console

desk.

f. Interphone

One (1) set of interphone shall be provided.

This interphone shall be for the central control room in the main power house.

2.4.5 VHF RADIO COMMUNICATION SYSTEM

2.4.5.1 SCOPE OF SPECIFICATIONS

These Specifications cover the design, manufacture, preassembly and acceptance testing in the Contractor's workshop as well as the supply, delivery, unloading, erection, adjusting, commissioning, trial operation and acceptance testing of all VHF radio communication equipment for the West Wharf Thermal Power Station.

2.4.5.2 DESIGN CRITERIA

The VHF radio communication equipment shall provide speech communication between the West Wharf Thermal Power Station and the Elander Road Grid Station in Karachi, Pakistan, a distance of approximately 10 kM. Karachi is situated on the Arabian Sea and is at longitude 67^{o} East and latitude 25^{o} North.

2.4.5.3 FACILITIES REQUIRED

Duplex communication is required between the West Wharf Thermal Power Station and the Elander Road Grid Station. Selective call facility shall be provided. The quality of communication

equipment shall ensure clear and undistorted speech under all conditions.

Three frequencies shall be allocated to the VHF radio communication system which shall be detailed at a later date.

All equipment shall be provided with sufficient and convenient test points to facilitate measurement, alignment and maintenance procedures. Standardized modular design shall be preferred for ease of maintenance and spare parts.

Channel scan and channel guard shall be provided on all VHF equipment.

2.4.5.4 VHF RADIO COMMUNICATION EQUIPMENT

VHF radio communication equipment complete with antennas and RF (coaxial) cable shall be provided for the West Wharf Thermal Power Station and the Elander Road Grid Station.

The radio communication equipment shall include, but not be limited to, the following items.

Transmitter

Receiver

Antenna system and tower

Co-axial cable

Duplexer

Selective call facility

Battery and battery chargers for 12 hours continuous operation without charging.

2.4.5.5 GENERAL REQUIREMENTS

The general requirements and characteristics of equipment

shall be as follows.

(1) General

Power supply	220V AC, + 30%, -15% 50 Hz
Operating Voltage	12 - 14V DC
Speech Band	0.3 to 3 kHz
Frequency Band	146 - 174 MHz
Capacity	6 channel capacity
Operation methods	On simplex as well as double frequency simplex with 5 MHz frequency. separation in TX & RX
Temperature range	$-10^{o}C$ to $60^{o}C$
Construction	Robust, shockproof

(2) Transmitter characteristics

RF Power output	25W minimum rms (adjustable)
RF output impedance	50 ohm
Modulation deviation	0 to $\pm$5 KHz
Audio distortion	2%
Conducted spuricus and harmonic distortion	75 dB below carrier
Frequency separation (max)	2 MHz for 148 - 174 MHz
Frequency stability	$\pm$0.0005%

(3) Receiver characteristics

RF input impedance	50 ohm
Sensitivity	Better than 0.3 uv at 20 dB quieting
Selectivity	75 dB for duration- $\pm$25 KHz from tuned frequency
Frequency stability	$\pm$0.0005%
Modulation acceptance	$\pm$7 KHz

Frequency separation (Max)	1 MHz for 148 - 174 MHz
Spurious and image rejection	-100 dB
Channel spacing	25 KHz
Intermodulation	-85 dB
Switching bandwith	±2% of the mean frequency
Audio output power	1.5 - 3 W (300 - 3000 Hz)
Selective calling option	

(4) Antenna

Suitable broadband gain antennas shall be provided for the West Wharf Thermal Power Station and the Elander Road Grid Station.

This tower already exists at the Elander Road grid station. For the West Wharf Power Station, a tower shall be provided by the Contractor, with details for mounting of the antennas to be provided at a later date.

The antennas shall be able to withstand winds and earthquake stresses specified in Part I of these Specifications.

The antenna characteristics shall be as follows.

Frequency range	144 - 174 MHz
Gain	9 dB
VSWR	1.5 to 1 or less
Maximum power input	500 watts
Vertical pattern beamwidth (half power points)	16^{o}

(5) Cable

Co-axial cable used as RF feeder shall be the low-loss foam dielectric type or the air dielectric type, and shall conform to the following minimum specifications.

Characteristics impedance	50 ohm
Velocity of propagation	89%
Minimum bending radius	250 mm
Attenuation dB/100 m	
at 150 MHz	1.57 dB/100 m
450 MHz	2.89 dB/100 m

(6) Duplexer

The duplexer shall be supplied complete with all necessary cables and connections for connection to antennas and VHF radio equipment.

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2.5 LIGHTING

2.5.1 APPLICABLE STANDARDS AND CODES

The following standards and codes of the newest edition shall be applied.

IEC 309 Plugs, Socket-outlets and Couplers for Industrial Purpose

Also, other pertinent and/or International Electro-technical Commission (IEC) standards and international standards shall be applied for electrical apparatuses.

2.5.2 SCOPE OF SUPPLY

The following lighting fixtures, lighting distribution panels and accessories shall be supplied.

One (1) set	For substation building
One (1) set	For substation control room
One (1) set	For power transformer area
One (1) set	For outdoor equipment at No.1 tower area
One (1) set	For inside of cable tunnel between substation and No.1 tower

2.5.3 TECHNICAL INFORMATION

The Lighting shall consist of normal lighting and emergency lighting, and shall be used for lighting for indoor and outdoor equipment, offices and roads.

The power source shall be supplied from the 380-220V substation lighting distribution panel.

The emergency lighting shall be capable of automatically providing lighting for safety at the time of a power source failure in the normal lighting system.

The power source shall be supplied from the AC 220V in the lighting distribution panel, but the lighting system shall be so designed as to changeover the power source to the DC 220V power source, in case of emergency.

2.5.4 DESIGN

2.5.4.1 ILLUMINATION LEVEL

The normal and emergency illumination level shall be in accordance with the following. However, the Contractor shall submit the layout, quantities, etc., of the fixtures to the Engineer for approval.

	Illumination level (lx)
Normal lighting	
Substation control room	500
Substation building	100
Transformer area	20
Inside cable tunnel	10
Emergency lighting	
Central control room	5

2.5.4.2 LIGHTING CIRCUIT

(1) LIGHTING DISTRIBUTION PANEL

The lighting distribution panel shall be installed in the substation control room.

The panel shall be made of steel plate with thickness 1.6 mm to 2.3 mm, and shall be of a wall mounting type or a wall embedded type. The panel shall have a 3-phase 220V bus for the normal

lighting and a single-phase 220V bus for the normal emergency lighting, and shall serve for supplying the power to each fixture through the molded type air circuit breaker. The panel shall have an automatic timer for outdoor lighting.

(2) AC-DC CHANGEOVER PANEL

The AC-DC changeover panel shall feed power to the emergency lighting fixtures.

Under normal conditions, the power source shall be from the AC 220V lighting distribution panel.

However, should the above power source fail, the power source shall be automatically changed over to DC 220V.

(3) INDOOR LIGHTING

The indoor lighting shall be designed to be manually switched on and off by means of the lighting distribution panel.

(4) OUTDOOR LIGHTING

The outdoor lighting shall be designed to enable automatic switching on and off by means of an automatic timer built into the lighting distribution panel as well as manual switching on and off by means of a changeover switch.

2.5.4.3 LIGHTING FIXTURES

The lighting fixtures shall be provided as follows.

(1) FLUORESCENT LAMP

Fluorescent lamps shall be of a rapid-start type,

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and the stabilizer shall be of a high power factor constant voltage type. Fluorescent lamps shall be used for the substation control room, inside of cable tunnel, etc.

(2) INCANDESCENT LAMP

Incandescent lamps shall be used for local lighting and emergency lighting.

(3) MERCURY VAPOR LAMP

Mercury vapor lamps shall be used for the power transformer area lighting, the operating floor in the substation building and outdoors. For the stabilizer, the high power factor constant voltage type shall be applied.

For the poles to be used for power transformer area lighting, the hot-dipped galvalized pipes shall be provided. The pipes shall have a built-in stabilizer with a cut-out switch, and shall have a construction easy for inspection.

(4) EXIT SIGN LIGHT

Exit sign lights shall be mounted above the access ways, stairs, exits, etc., of the substation building and inside cable tunnel.

The lights shall have a battery with a rectifier with a capacity of more than 30 minutes.

(5) POWER RECEPTACLE

The AC 220V, 15 A, 2-phase power receptacle with an adapter and a grounding terminal shall be provided

in each room and each floor of the substation area.

The power receptacle to be used for the outdoor area shall be of a waterproof type.

All power receptacles shall be 16 A, 220V and three (3) pin type in accordance with IEC-309.

2.6 CV (XLPE) CABLE
(CROSS LINKED POLYETHYLENE INSULATED VINYL SHEATH)

2.6.1 APPLICABLE STANDARD AND CODES

The following standards and codes of newest edition shall be applied.

Intenational Electrotechnical Commission (IEC)

IEC-287 "Calculation the Continuous Current Rating of Cable"

Other pertinent International Electrotechnical Commission (IEC) standards and international standards shall be applied for electrical apparatuses.

2.6.2 SCOPE OF SUPPLY

The following CV cable shall be provided.

One (1) set	132 kV CV cable, with accessories for 132 kV circuit of 220 kV / 132 kV interchange transformer
One (1) set	11 kV CV cable, with accessories for 11 kV circuit of 132 kV / 11 kV grid station transformer

2.6.3 TECHNICAL INFORMATION

The 132 kV CV cable shall be provided between the interchange transformer (250 MVA) and 132 kV GIS so as to transmit step down power from 220 kV bus.

The 11 kV CV cable shall be provided between grid station transformer (30 MVA) and existing 11 kV grid station incoming circuit breaker so as to transmit step down power from 132 kV bus.

2.6.3.1 TYPE

Cross linked polyethylene insulated vinyl sheath cable

2.6.3.2 RATING

	132 kV	11 kV
Rated voltage	145 kV	11 kV
Impulse withstand voltage	650 kV (Full wave)	110 kV (Full wave)
Transmitting capacity	250 MVA	30 MVA
Temperature rise	90°C	90°C
Ambient temperature	50°C	50°C
Number of circuit	2	2

2.6.3.3 MANUFACTURE TESTS

The manufacturer tests shall be as follows, but shall not be limited to the following items. All tests shall be conducted in the presence of the Owner and/or the Engineer.

Measurement of conductor resistance

Meggering

Measurement of capacitance

Measurement of tan δ

Withstand voltage test

Bending test

2.6.4 CONSTRUCTION

2.6.4.1 CV CABLE

(1) Conductor

The conductor shall be the round compact stranded wire type or the segmental compact stranded wire type consisting of annealed copper wires.

(a) Round compact stranded wires

The round compact stranded wires shall

comprise wires which are stranded into a concentric round form and compression-molded.

(b) Connection of conductors

The conductors shall have no connected portions, nor shall it have two or more connected portions over the length of 30 cm at any optional portion of the outermost layer.

All annealed copper wire shall be carefully connected so as not to cause deterioration in electrical and mechanical characteristics.

(c) Others

The external surface of the conductor shall be smooth and free from any cracks, protrusions, etc.

(2) Internal semiconductor layers

The internal semiconductor layer shall be formed uniformly over the conductor by simultaneous extrusion molding of the insulator. The internal semiconductor layer shall have a smooth surface and be free from any void hazardous to use.

(3) Insulation

The insulation shall be formed by coating crosslinked polyethylene or its mixture into a concentric round form over the internal semiconductor layer.

The surfaces of the insulator that comes into contact with internal and extenal semiconductor

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layers shall be smooth and free from any separation of the layers. No foreign matter or void hazardous to use shall be allowed.

(4) External semiconductor layers

The external semiconductor layer shall be formed uniformly over the insulator by simultaneous extrusion molding of the insulator. The surface of the external semiconductor insulator that comes into contact with the insulator shall be smooth and free from any void hazardous to use.

Fabric tapes shall be wound over the extrusion-molded external semiconductor layer, and the thickness of the tapes shall be included in the thickness of the external semiconductor layer.

(5) Shielding layers

Annealed copper wires shall be wound over the extenal semiconductor layers at a pitch of eight times or less the layer diameter, and copper tape shall be wound flatly over the annealed copper wires at an appropriate pitch.

The annealed copper wires and the copper tape shall be wound in opposite direction, and holding tapes shall be applied on the copper.

(6) Sheaths

Black polyvinyl chloride tape with a suitable anti-termite shall be applied in a concentric round form over the shielding layer.

(7) Indication

The nominal voltage, symbols, nominal sectional area of conductor, date of manufacture and manufacturer's name shall be indicated by continuous printing at appropriate positions of the sheath so that these indications can be identified clearly for a long period.

(8) Connection

The cable shall be once-through (no connection).

2.6.4.2 CABLE HEADS

The cable head at the transformer side shall be connected with the bushing in the oil. However, the cable head at the 11 kV grid station side shall be connected with the bushing in the atmosphere.
The bushings shall be able to withstand the voltage rising of sounding phases after one phase grounding under a salt contamination condition of 0.03 mg/cm^2 when the humidity of the air around bushings is 100 percent.

(1) Mounting structures

The mounting structure with anchor bolts shall be of hot dipped galvanized material

(2) Grounding lugs

The 250 mm^2 compression type grounding lug shall be attached to the structure.

2.6.4.3 TEMPERATURE RECORDER

The temperature recorder shall be provided and mounted on the

panel inside the substation control room, and shall be used to measure the sheath temperature of the cable.

Measurement of the sheath temperature shall be carried out at two (2) points for each cable.

2.6.4.4 CABLE FOR TEMPERATURE MEASUREMENT

Since the cable for temperature measurement is applied to connect the heat element attached on the surface of the CV cable with the temperature recorder, the cable shall be of a construction giving consideration to prevention of static and electromagnetic induction interference.

2.6.4.5 ARRESTERS FOR CABLE SHEATHS

The arrester for cable sheath shall be mounted on the sheath on the cable head on the side of the switchyard in order to restrain abnormal voltage in the sheath produced at the time of abnormality in the circuit. Cable sheath on the side of the transformer shall be grounded.

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3. OUTDOOR EQUIPMENT AT NO.1 TOWER

3.1 LIGHTNING ARRESTER

3.1.1 RATING

Rated voltage, kV	:	198
Rated discharge current, kA	:	10
Short-circuit capacity, kA	:	40 (rms)
Maximum residual voltage, kV	:	649
Impulse withstand voltage, kV	:	950 (peak)
Power frequency withstand voltage, kV rms	:	395

The insulators of the lightning arresters shall be designed for a minimum creepage distance of 45 mm/kV.

3.1.2 CONSTRUCTION

The lightning arresters shall be of the zinc oxide gapless type, and shall comply with the latest revisions of IEC 99-1 and of these Specifications.

The lightning arresters shall be of the outdoor type located at the end of 220 kV overhead line at the No.1 tower, and shall be housed in porcelain containers sealed against the entry of moisture and oxygen.

Internal components shall be designed to minimize internal corona and to ensure minimal capacitive coupling with any conducting layer pollutant on the outside of the porcelain housing.

The lightning arresters shall be entirely suitable for operation under the system conditions specified regarding system voltage rises on unloading long transmission lines,

and shall have sufficient capacity to discharge the system charging currents without damage.

All lightning arresters shall be equipped with surge counters to register the number of operations. The arresters shall be connected to the grounding.

The terminal connectors for the lightning arresters shall be suitable for conductors with ACSR/AS 330 mm^2 x 2.

The terminals shall be supplied and fitted by the Contractor of Lot II A. All mounting structures shall be provided.

The mounting structure with anchor bolts shall be of hot-dipped galvanized materials.

On the leg part of structure, 250 mm^2 compression type grounding lug shall be attached.

3.2 GANTRY

The gantry steel structures shall be applied for anchoring of the 220 kV transmission lines at the No.1 tower.

For the steel structures, hot-dipped galvanized steel materials shall be provided.

The steel structure shall be of truss construction and assembled with bolts.

For inspection and maintenance, traps shall be attached at a minimum of six spots.

On the leg part of the structure, 250 mm^2 compression type grounding lug shall be attached.

4. BALDIA GRID STATION

Two (2) sets of 220 kV transmission bays shall be extended with existing facilities of the 220 kV Baldia Grid Station in order to receive electrical power from the West Wharf Thermal Power Station Units No.1 and No.2.

4.1 220 kV SF_6 GAS INSULATED SWITCHGEAR

4.1.1 APPLICABLE STANDARDS AND CODES

The following applicable standards and codes of the latest edition shall be applied.

International Electrotechnical Commission (IEC)

IEC-519 "Gas-insulated Metal-enclosed Switchgear for Rated Voltages of 72.5 kV and Above"

IEC-56 "High Voltage Alternating Current Circuit Breaker"

IEC-99 "Lightning Arresters"

IEC-129 "Alternating Current Disconnectors (Isolaters) and Earthing Switch"

JEC-206 "Disc Type Suspension Insulators" (Normal Type and Anti Pollution Type)

JEC-207 "Hardware of Insulator Set for Overhead Power Lines."

Other pertinent International electrotechnical Commission (IEC) standards and international standards shall be applied for electrical machinery and apparatuses.

4.1.2 SCOPE OF SUPPLY

One (1) set	220 kV SF_6 gas insulated switchgear with accessories
One (1) set	220 kV line control panel with accessories
One (1) set	220 kV line protective relay panel with accessories

One (1) set Outdoor equipment with accessories

4.1.3 TECHNICAL INFORMATION

4.1.3.1 DESIGN AND PERFORMANCE

The design and performance of the metal enclosed switchgear shall comply with these Specifications, the latest revisions of relevant IEC standards and other equivalent intenational standards. The switchgear shall be of modular construction, wholly metal enclosed and shall offer maximum flexibility from the point of view of design, operation, maintenance and repairs.

Insulating medium shall be SF_6 gas.

The equipment offered shall comply with the following design principles.

a) Similar parts shall be strictly interchangeable without special adjustment or individual fittings.

b) The design shall be such that malfunctions cannot occur due to ingress of foreign bodies, dust or moisture or to variations in temperature within the normal limits of switchgear design.

c) The performance of the equipment and of its individual components shall be adequately proven by tests carried out under normal operating conditions and also at conditions above and below normal to establish that adequate margins are available to cover manufacturing tolerances and all service conditions.

d) Prior to shipping, routine tests shall have been performed to ensure that the equipment has been completely assembled and that all components are functioning properly.

e) All mechanical parts and linkages shall be durable and require a minimum of maintenance.

f) Where the Contractor offers a design which is generally well proven in service, he shall draw attention to any components, major or minor, which may in fact be newly designed.

The equipment shall be designed to ensure unrestricted, reliable operation continuously at a maximum ambient temperature of 50°C, with possible temperature fluctuations of 25°C (day/night) and a relative himidity of 90%. No air conditioning shall be provided for the switchgear building, but air ventilation system shall be installed. The maximum temperature rise shall not exceed 50°C for the conductors and 35°C for the enclosure.

The design of the 220 kV switchgear and the coordination of the protection equipment with the corresponding equipment of the power supply network shall ensure that faults of any kind in the 220 kV network cannot lead to faults or damage to the installation as a whole or to individual sections of it or endanger operating personnel.

The installations at the Baldia Grid Station shall be equipped with apropriate grounding wtitches, grounding studs and all other necessary protective devices to

ensure that during repair and maintenance on any paticular section of the switchgear there will be no possibility of personnel or equipment being endangered at any time.

Control and supervision of the 220 kV switchgear shall be exercised from the control rooms of the control building of the Baldia Grid Station as well as the local control panels of the switchyard. All switchgear, control and measuring devices shall be equipped with auxiliary contacts, etc., as required.

The painting colour schedule of the switchgear, including the control and protection panels, shall correspond with the existing equipment of the Baldia Grid Station.

The type of enclosure for the local control and protection system panels shall be at least IP 32 of IEC 529 (Enclosures for Electrical Apparatus).

The cabling inside the control and protection panels of the SF_6 switchgear shall conform to the relevant IEC standards and other equivalent international standards. The panels shall be verminproof, weatherproof and resistant against ingress of moisture, dust, etc.

4.1.3.2 LAYOUT

The switchgear and all panels shall be installed on sub-frames specially provided for this purpose.

The switchgear shall be of the SF_6 gas insulated metal enclosed type suitable for indoor installation in the

extended 220 kV switchgear building of the exiting Baldia Grid Staion, and shall be capable of continuous operation under the climatic conditions at the site.

The switchgear shall be extended to the existing bus bar of the SF_6 gas insulated metal enclosed switchgear as shown in the relevant tender drawings.

The switchgear shall be designed to permit the removal and extension of any part, without unnecessary outages or disturbance, to adjacent items of plant, and it shall be possible to maintain a supply from one section of bus bar while extending the other.

The Contractor shall ensure that the equipment layout supplied in his main offer or alternative offer is a satisfactory and workable layout that complies with the substation layout.

If necessary, the Contractor may, upon approval by the Owner/ Engineer, modify the layout provided that the basic bus configuration, with section and coupler and the correct number of switchbays, is retained.

Whichever design and layout the Contractor offers, the design and layout shall be consistent with the available space in the switchyard building so that operation, maintenance, repairs and safety aspects are not compromised.

All equipment to be supplied shall be similar to the equipment already installed at the Baldia Grid Station.

The Contractor may aproach the Owner/Engineer to obtain any further information for the existing installations at the Baldia Grid Station.

The Contractor shall set out in writing any departures from these Specifications regarding the equipment offered. Particulars of any deviations and shortcomings in respect of the specified requirements for operating, erection, testing, maintenance or dismantling of the equipment shall be provided together with a statement of the advantages and disadvantages of any altenative arrangement offered by the Contractor.

4.1.4 COMMON FEATURES

4.1.4.1 RATING

Rated voltage, kV	:	220
Maximum working voltage, kV	:	245
Rated frequency, Hz	:	50
Rated short-time current, kA	:	40
Impulse withstand voltage (peak), kV	:	950
Power frequency withstand voltage, kV	:	395
Insulation medium	:	SF_6
Rated bus bar current, A	:	3150
Bus configuration	:	Double bus system
Bus bar enclosed tubing	:	Single phase
Start point	:	Solidly grounded

4.1.4.2 CONSTRUCTION

(1) SF_6 Gas Pressure

The rated working pressure of the SF_6 gas inside the switchgear shall be kept as low as possible to minimize the leakage of gas.

Nevertheless, it shall be at least 15% above the minimum value necessary to ensure safe and continuous operation of the switchgear. Dependable operation of the switchgear shall be ensured at the maximum possible pressure of the gas.

(2) SF_6 Gas Monitoring and Alarm Circuits

Each compartmented section of the GIS shall be equipped with temperature compensated gas density/pressure monitoring devices. The characteristics of the monitoring devices shall be shown on the gas vapour graph. The gas monitoring device shall be fitted with electrical contacts for alarm and automatic tripping. These shall be set in two stages. The first stage shall operate an alarm to warn that the gas density/pressure is falling to a critical level to indicate the need of adding gas to the particular section.

If the density/pressure of the gas drops further to a limit below which the insulation of the gas is insufficient, a second stage shall initiate automatic isolation of the gas section concerned by tripping associated circuit breakers and isolators as required. Tripping shall be wired into main protection circuits and shall only be initiated when both alarm and trip conditions exists.

The gas density/pressure alarms shall be generated at the control room as well as local contol panels.

(3) SF_6 Gas Treatment

Under normal operating conditions, treatment of the SF_6 gas shall not be necessary between major overhauls. A self-sealing vacuum coupling shall be provided on each separately compartmented section to allow renewal and filling of SF_6 gas.

To minimize the moisture content of SF_6 gas, moisture absorbers shall be installed in each compartmented section of the switchgear.

All insulators in each section of the gas shall be manufactured from a material whose surface remains entirely unaffected by the corrosive acids formed due to reaction of the decomposition products of the SF_6 gas with the traces of moisture.

Permanently effective filters shall be installed in the quenching chambers of the circuit breaker to remove SF_6 gas decomposition products produced by arcing. The filters shall remain fully effective throughout the period between overhauls.

(4) Enclosure

The material and design of the switchgear enclosure shall be the same as for the existing installation being extended under this Contract. In case the diameter and gas pressure of the GIS to be provided is different than tha existing installations, suitable adapters shall be provided to ensure safe and satisfactory installations.

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Each separately compartmented section of the enclosures shall be provided with an automatic pressure relief device to release the gas in case of increased internal pressure due to internal arcing. These devices shall be designed so that the gas is exhausted away from operating personnel.

The minimum time required for the pressure relief device to operate shall be less than the time specified below for burning-through/puncturing of enclosure.

The Contractor shall provide that no burning-through/puncturing occurs of the metal cladding of the switchgear due to arc formed by the rated breaking current of the installation within a time of 200 ms. (minimum), and that the total trip time of the first-stage protection is less than 150 ms.

Suitable measures shall be employed between the individual sections of the switchyard to compensate for thermal expansion and expansion in the building structure.

Each separately compartmented section of the insulation shall be grounded separately. The enclosure shall be of gas tight construction with gas tight flanges. The various parts of enclosures shall be electrically interconnected with each other to avoid development of dangerous potential differences in case of faults.

The enclosures shall be designed to withstand the earthquake stresses specified in Part I of these

Specifications.

(5) Maintenance

For operating safety, reliability and ease of maintenance, the following minimum requirements shall be provided.

- o Maintenance of any circuit breaker in the installation, e.g. the changing of contacts, shall be possible without having to switch-off any other outgoing feeders of the installation.
- o In the event of extensions being made to the switchgear, one of the two bus bar systems shall always remain serviceable.
- o In the event of damage to one of the bus bar systems, it shall be possible to replace it without having to switch off any other sections of the switchgear.
- o During the whole of the repair time, it shall be possible to continue operating the switchgear with the remaining bus bar system.

(6) Gas Sealing

The Contractor shall describe the principles and materials of his sealing arrangements in his tender. The maximum annual gas loss and the total gas loss which still allows trouble-free operation shall be provided by the Contractor.

(7) Bus Bar and Conductors

The installation shall have double bus bars. Plug-in contacts shall be provided for inter-

connecting the individual sections of the bus bars and other parts of the switchgear. Silver plated copper shall be used as the contact material.

The bus bars and all other conductors shall be able to withstand the stipulated rated currents, thermal and initial short-circuit currents without dangerous temperature rise or other damage.

The maximum conductor temperature at rated current shall not exceed the values stipulated in IEC-56 at the condition of 50°C ambient temperature.

(8) Type of GIS

The primary components of 220 kV GIS, except the main bus bar, shall be segregated from primary component of other phases. The main bus bar shall be of the three phase common enclosure type.

4.1.5 CIRCUIT BREAKER

The circuit breakers shall be of the single-pressure puffer type designed and tested for the following ratings.

4.1.5.1 RATING

Nominal system voltage, kV	:	220
Maximum design voltage, kV	:	245
Rated frequency, Hz	:	50
Rated normal current, A	:	1250
Rated short circuit breaking current, kA	:	40

Rated short circuit making current, kA	:	100
Rated maximum breaking time, msec.	:	50
Rated out-of-phase breaking current, kA	:	10
Rated operating sequence	:	0-0.3 sec-Co-3min-CO
Rated line charging breaking current, A	:	125
First pole-to-clear factor	:	1.3
Rated transient recovery voltage for terminal faults (for 2.0 kV/micro sec. rate of rise), kV	:	365
Rated transient recovery voltage for short line faults (for 2.0 kV/micro sec. rate or rise), kV	:	280
Rated power frequency withstand voltage, kV, r.m.s. (one minute)	:	395
Rated lightning impulse withstand voltage kV, (peak)	:	950
Rated control voltage, V, (D.C.)	:	220

The circuit breakers shall meet the following transmission line characteristic for any type of fault or fault location, including line charging and dropping, when used on 220 kV effectively grounded system.

	Double Circuit 220 kV Overhead Lines
Line length	24.0 km (Tower No. 1 - BALDIA G/S)
Conductor configuration	Vertical double circuit
Material	ACSR/AS.330mm^2
No. of sub-conductors	2
Dia of sub-conductors	25.3 mm
Phase-to-phase spacing	6.4 meters

	Double Circuit 220 kV Underground Lines
Line length	1.1 km (WEST WHARF S/S - TOWER NO. 1)
Material	Oil-filled cable
Size	1,200 mm^2 x 1C

4.1.5.2 CONSTRUCTION

(1) The circuit breakers shall meet the following switching requirements.

(a) Circuit breakers shall be suitable for single shot, high speed, single pole and three pole automatic reclosing.

(b) Circuit breakers shall be suitable for switching on transmission lines for any type of fault.

(c) Circuit-breaking shall be accomplished without restriking with the overhead lines off-load.

The interrupting time at 25% of interrupting current rating with normal control voltage applied shall not exceed the rated interrupting time.

(d) No restrikes at the main contacts shall be permitted under any operating performance.

(e) Circuit breakers shall be capable of making and breaking currents associated with out of phase switching, auto reclosing and the switching of magnetising or capacitance currents without sustaining damage and without generating transient

overvoltage in excess of 2.5 times the peak value of the rated phase to neutral before the switching operation.

(f) Circuit breakers shall be capable of handling the short line fault conditions associated with line switching in accordance with IEC Publication 56-2 Clause 8.

(2) The circuit breakers shall meet the following constrcutional requirements.

(a) Circuit breakers shall be electrically and mechanically trip free.
"Pumping" of the circuit breakers shall be prevented by suitable measures.

(b) All similar contacts of three-pole circuit breakers shall close or open within a period of one half of a cycle or less with respect to each other, except where single pole operation is required.

(c) The circuit breaker operating mechanism shall be of the spring/hydraulic/pneumatic type. The Contractor shall study the existing operating mechanism of the Baldia Grid Station, and shall check whether it is sufficient for the extended switchgear. A completely new operating mechanism system shall be provided, if so required by the above study.

(d) The operating mechanism shall be capable of

performing the specified duty cycle.

(e) All circuit breakers shall be able to perform an O-CO switching cycle when the auxiliary voltage is lost.

(f) Hand operation shall be possible in energencies.

(g) The mechanism shall be able to operate satisfactorily on a direct voltage between 170 and 270 volts.

(h) The design of operating mechanism shall be capable of normal synchronized three pole operation during multi-phase faults.

(i) The design of the operating mechanism shall permit selective single pole tripping and reclosing of any of the three phases for phase-to-ground faults.

(j) Electrical tripping facilities for the operating mechanism of each pole shall be duplicated to include, but not necessarily limited to, the following.

a) Two electrically independent and identical trip coils for each pole of the breaker arranged such that the probability of the failure of one trip coil affecting the operation of the second trip coil is minimum.

b) Two electrically independent and identical sets of wiring, terminals and protecting

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equipment for connection to two 220 V DC independent control/and/or tripping power circuits.

(k) Each circuit breaker shall be equipped with a sufficient number of auxiliary contacts for annunciation locally and to the control room and for all necessary interlocks.

(l) The following indications shall be provided for each circuit breaker.

The SF_6 gas density in the circuit breaker section shall be constantly indicated by a gauge and monitored by a density monitor on each pole of the circuit breaker. The density shall be sensed in two stages. The first stage (gas density low) shall initiate an alarm at the control switchboard. The second stage (gas density too low) shall prevent closing or tripping of the breakers, and shall give visual and audible annunciation on the control switchboard. The closing or tripping of the breakers shall not be prevented should the density drop too low after the closing or tripping operation has started. The design shall ensure the identification of the breaker pole having low SF_6 gas density, and no damage shall be caused to any component of the circuit breaker in case of low gas density.

(3) Spring charged mechanisms

Circuit breakers fitted with power spring operated closing mechanisms shall meet the following requirements.

(a) The mechanism shall be charged automatically for further operations as soon as the circuit breaker has completed a closing operation. The time required to power charge the spring shall not exceed 30 seconds.

(b) The spring shall be fully charged before it can be released to close the circuit breaker. It shall not be possible for the breaker to close while the spring is being charged.

(c) Spring closing mechanisms shall be designed so that it is not possible for fully charged spring to be released inadvertently due to external shock or vibration caused by the breaker opening under short circuit conditions or any other cause.

(d) The mechnisms shall be provided with means for charging the spring by hand. This operation shall be carried out with the doors of the cubicle opened. During this process, no electrical or mechanical

operation of the mechanism shall endanger the operator or damage the equipment.

(e) A mechanical indicating device shall be provided to indicate the state of charge of the spring, and shall be visible with the doors of the cubicle closed.

(f) An alarm shall be provided at the local control panel and in the main control room to indicate a spring failing to be charged by a pre-set time after circuit breaker closing.

(g) The spring mechanism shall be fitted with a local manual release, preferably by a shrouded push button, to avoid inadvertent operation. Means shall be provided for discharging the spring when the circuit breaker is in the open position without the circuit breaker closing.

4.1.6 ISOLATORS

4.1.6.1 RATING

Nominal system voltage, kV	:	220
Maximum design voltage, kV	:	245
Rated lightning impulse withstand voltage		
a) Across the isolating distance, kV (peak)	:	1050
b) To ground and between poles, kV (peak)	:	950
Rated power frequency withstand voltage (1 sec)		
a) Across the isolating distance, kV rms.	:	460
b) To ground and between poles, kV rms	:	395
Rated frequency, Hz	:	50
Rated normal current, A	:	1250
Rated short time withstand current, kA	:	40
Rated duration of short circuit, Sec.	:	1.0
Rated peak withstand current, kA	:	100

4.1.6.2 CONSTRUCTION

All isolators shall be provided with motor-driven operating mechanisms which shall work reliably from a direct voltage of 170-270 volts, and shall open and close all three phases simultaneously.

It shall not be possible for the isolators to open or close inadvertently due to forces which may occur in service or under short-circuits.

The operating mechanisms shall be capable of being locked and secured by padlock in the open or close position.

In the event of driving motor failure, means for hand operation shall be provided.

Each isolator shall be provided with a window for visual inspection of the contact positions.

For isolators having three mechanism (i.e. one per phase) it shall be possible to electrically interlock all three phases to ensure that all three phases open or close if any one phase is to be electrically operated either by remote or local means. Such isolators shall be provided with a time delayed discrepancy alarm having a normally open, potential free contact to indicate that one or more phases failed to operate correctly.

All isolators shall be fully interlocked with associated circuit breakers, isolators and grounding switches to ensure safe operation of the equipment under all service conditions.

Full electrical interlocking shall be provided for maintenance and operation. Mechanical interlocking shall be provided for maintenance purposes only. The insulation level for the isolating distance between isolator contacts shall be able to withstand 115% of the impulse withstand voltage as specified by IEC.

In the event of gas leakage, the isolator shall be capable of withstanding twice the phase to ground voltage at normal

atmospheric SF_6 gas pressure. Alternatively, automatic means shall be provided to electrically isolate any faulty isolator.

The isolators shall be capable of switching load currents when shunted by parallel path and capacitance charging currents associated with open bus bars, bushing and capacitor voltage transformers.

Isolators unable to comply with the required switching duties with the isolating medium at atmospheric pressure shall be automatically blocked from operation.

The contacts shall be of the high pressure contact type and shall open and close positively, but shall not cause galling of the contact surfaces. Full contact and current carrying capacity shall be secured during reasonable overtravel or undertravel of the mechnism. Gravity, vibration, reasonable shocks or accidental handling of the connecting rods of the operating mechanism shall not cause the isolators or grounding switches to disengage from their open or close position. All main contacts, male and female, shall either be silver plated or shall have silver inserts.

4.1.7 EARTHING SWITCH

The switchgear shall be equipped with two different types of grounding switches as given below.

High speed grounding switches

Working grounding switches

4.1.7.1 RATING

Nominal system voltage, kV	:	220
Maximum design voltage, kV	:	245
Rated lightning impulse withstand voltage, kV (peak)	:	950
Rated power frequency withstand voltage kV, r.m.s. (1 sec)	:	395
Rated frequency, Hz	:	50
Rated short-time withstand current, kA	:	40
Rated duration of short circuit, sec.	:	1.0
Rated peak withstand current, kA	:	100
Rated making current, kA	:	100

4.1.7.2 CONSTRUCTION

The grounding switches integrally mounted with isolators or separately mounted shall be provided for grounding already isolated sections of gas insulated switchgear in order to ensure safety during maintenance.

The grounding switch, when in the closed position, shall have a short-time current withstand as specified with a minimum duration of three seconds. No burning or welding of contacts shall occur.

All grounding switches shall be interlocked with associated circuit breakers and isolators so that it shall not be possible to close a grounding switch onto a live circuit or to make the circuit alive when the grounding switch is closed. Interlocking for maintenance and operation shall be by

mechanical and electrical fail-safe means.

(1) High speed grounding switches

The high speed grounding switches shall have motor operated mechanisms. The motor shall work reliably from a direct voltage of 170-270 volts. It shall be possible to close the switch manually even when the auxiliay voltage has failed. An interlock between the manual and power operated drive shall be provided so that, when the manual operation is being carried out, the motor operated drive shall not operate.

The grounding switches shall be suitable for high speed operation. It shall be impossible to slowly close the grounding switches.

The high speed grounding switches shall be capable of interrupting induced currents as may be necessary where the grounding switch is used for grounding one out of two or more long parallel circuits with mutual coupling.

The high speed grounding switches shall have a position indicator mechanically connected to the operating mechanism of the switch. The switch position shall be indicated at the local control panel and in the control room.

All grounding switches shall be in full accordance with the requirements for maintenance working grounding switches.

(2) Working grounding switches

The working grounding switches shall have hand operated mechanism, and shall be mechanically interlocked with the associated isolators and electrically interlocked with other isolators.

4.1.8 CURRENT TRANSFORMER

The current transformers shall be of dry type design using epoxy resin as insulation, and shall comply with the latest revisions of IEC 185 and these Specifications.

Facilities shall be provided for primary injection whether current transformers are installed in SF_6 filled chambers.

The current transformers shall be installed in the positions indicated in the Drawings.

Where multi-ratio current transformers are required, the various ratios shall be obtained by changing the effective number of turns on the secondary winding.

Rating and diagram plates shall be provided. The information to be supplied on each plate shall be as specified in the relevant IEC specifications, which shall be in accordance with the tapping for which the rated performance is specified and for each transformer core.

The position of each primary terminal in the current transformer SF_6 gas section shall be clearly marked by two plates permanently fixed to the metal cladding at each end of the current transformer section.

The beginning and end of each secondary winding and all secondary taps shall be wired to suitable terminals

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accomodated in a terminal box mounted directly on the current tansformer section of the SF_6 switchgear.

Provision shall be made for the grounding of all secondary windings inside the terminal box.

External mounted current tansformers, if provided in the overall protection scheme, shall be provided as required.

The ratings, ratios and number of cores of different current transformers shall be as shown in the table below.

The Contractor shall make detailed calculations to determine the ratios and burden ratings most suitable for protection and metering.

	220 kV line bay
Number of secondary cores	: 4
Rated transformation ratio	
Core 1, 2 & 3	: 700-1250/1
Core 4	: 3000/1
Accuracy class	
Measuring core	: Class 0.2
Protective core	: 5P 20
Rated burden, VA	
Measuring core	: 30
Protective core	: 30

Core 1 shall be designed for measuring, while cores 2, 3 and 4 shall be designed for protective relaying.

4.1.9 VOLTAGE TRANSFORMER

The voltage transformers to be installed in SF_6 gas insulated metalclad switchgear shall be inductive type and

shall comply with the latest revisions of IEC 186 and of these Specifications.

The voltage transformers shall be connected line-to-ground The beginning and end of each secondary winding and all secondary taps shall be wired to suitable terminals accomodated in a terminal box mounted directly on the voltage transformer section of the SF_6 switchgear. Secondary outputs shall be taken out via HRC fuses in the terminal box.

The ratings of the voltage transformers for 220 kV shall be as follows.

Rates secondary voltage (L-L), V, rms	:	100
Number of secondary windings	:	2
Rated output of each winding, VA		
a) Measuring core	:	200
b) Protective core	:	75
Rated voltage factor		
a) Continuous	:	1.2
b) 30 seconds	:	1.5
Burden power factor	:	0.8
Accuracy class		
a) Measuring core	:	0.2
b) Protective core	:	3P

4.1.10 LOCAL CONTROL PANEL AND MONITORING

Separate local control panels shall be provided for each 220 kV transmission line bay for local control and monitoring of the 220 kV switchgear in the switchyard

building.

The local control panels shall be of sheet steel and of free-standing construction. They shall be supplied directly from the factory ready-wired.

The local control panels shall contain the following minimum equipment.

- o Control switches for circuit breaker, isolators and high speed grounding switches,
- o Mimic diagram with position indicators for all circuit breakers, isolators, high speed grounding switches and working grounding switches. Control switches and positions indicators for all circuit breakers, isolators, etc., shall be combined in the form of push-buttons.
- o All alarms and indicators associated with SF_6 gas monitoring, protection tripping, circuit breaker trip, power supply failure, etc., and all auxiliary relays, contactors, MCBs with the necessary auxiliary contacts, fuses, etc., for the control monitoring, remote control, protection and interlocking circuits,
- o Terminal strips each with 15% spare capacity after handover for the connection of the measuring, control and interlocking circuits, etc., and DC supply and other connections to the switchgear and to the control room.

It shall be possible to exercise complete control and supervision of the equipment from the control room as well as the local control panels.